

Reflective Dialogue for On-the-Job Training in Emergency Services

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Submitted in accordance with the requirements for the degree of
Doctorate of Philosophy



UNIVERSITY OF LEEDS

The University of Leeds
School of Computing

May, 2011

The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Acknowledgements

Without the encouragement and support of many people the completion of this thesis might not be possible. I would like to extend my sincere appreciation to them, even though this gesture is inadequate to measure my appreciation.

I would like to express my deep gratitude and respect to my supervisors *Dr. Vania Dimitrova* and *Dr. David Allen* who support me throughout my thesis. They encourage me to work hard. They make a great effort to help me improve the research skill and writing skill. I owe a great debt of appreciation to them for the valuable time they offered.

Thanks to the people in the *Intelligence Augmentation group* at School of Computing, University of Leeds, for giving an opportunity to discuss my work and related research including helping in my evaluation study.

Thanks to *my wife and son* for their patience and support.

Publications

Eamsinvattana, W; Dimitrova, V; Allen, D (2008). Activity-Based Adaptive Mobile Learning in Fire and Rescue Services. Workshop on Technologies for Mobile and Wireless Adaptive Elearning Environments, 5th International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems, Hannover, Germany, pp.37-45. 2008.

Eamsinvattana, W; Dimitrova, V; Allen, D (2009). Personalised Support for Reflective Learning in Fire Risk Assessment in: Dimitrova V, Mizoguchi R, Boulay BD, Graesser A (editors), Artificial Intelligence in Education, Building Learning Systems that Care: From Knowledge Representation to Affective Modelling, pp.765-766. IOS Press. 2009.

Eamsinvattana, W; Dimitrova, V; Allen, D (2009). A Framework for Personalised Reflective Learning in Fire Risk Assessment. Doctoral Consortium, 1st and 17th International Conference on User Modeling, Adaptation, and Personalization (UMAP), Trento, Italy. 2009.

Abstract

A challenge to on-the-job training is to find creative ways for integrating training within the context of human activity at the work practice. This challenge is addressed in a case study in the emergency services. Emergency workers learn mainly experientially from their every day work practices. Mobile technologies have brought major changes in emergency services practices, and may provide new ways for on-the-job training.

The thesis examines a new way for combining mobile technology with on-the-job training to provide activity-based dialogue for reflection. This research has developed a new framework for personalised on-the-job reflective mobile learning (PORML), illustrated in fire risk assessment. The framework is underpinned by Activity Theory, and uses a location-based context and risk assessment (RA) domain ontology to provide a personalised dialogue to collect information about risk assessment activity the user has performed.

A prototype is implemented to validate the framework. An evaluation study has been conducted with firefighters at Avon FRS, Bristol, UK. The study has shown that the prototype can be applied to the FRS work practice as a part of training or as supplementing existing training. It could be used mainly in debrief session after an incident has been completed.

Contents

Acknowledgements	ii
Publications	iii
Abstract	iv
Contents	v
Figures	xi
Tables	xiv
Chapter 1 Introduction	1
1.1. Research Questions	2
1.2. Research Methodology.....	3
1.3. Thesis Output and Main Contributions	4
1.4. Thesis Overview.....	4
Chapter 2 Literature Review	7
2.1. Introduction	7
2.2. Workplace Training/Learning	7
2.3. Technology-Enhanced Learning for On-the-job Training.....	10
2.4. Rationale of Reflective On-the-job Training	17
2.5. Training in Emergency Services	19
2.5.1. Characteristics of training in emergency services	20
2.5.2. Training in fire and rescue services.....	21
2.6. Activity Theory	22
2.6.1. Activity modelling theories	22
2.6.2. Activity Theory model	24
2.6.3. Activity Theory and modelling context.....	29
2.7. Tutorial Dialogues.....	31
2.7.1. Relevant tutorial dialogue approaches	32
2.7.2. Dialogue to promote reflection	40
2.7.3. Dialogue model for this thesis.....	40
2.8. Summary	42

Chapter 3 PORML Framework and Main Component of the Model	43
3.1. Introduction	43
3.2. Goal and Main Characteristics	43
3.3. PORML Architecture	44
3.4. Outline of the Main Components	46
3.5. A Case Study of Fire Risk Assessment in PORML	48
3.6. Location Context Data Query.....	49
3.6.1. Location context data using GML.....	49
3.6.2. Querying location context data	57
3.7. Discussion	60
3.8. Summary	61
Chapter 4 Ontological Model of Risk Assessment Activity.....	62
4.1. Introduction	62
4.2. Ontological Creation Methodology.....	62
4.2.1. Ontological models	62
4.2.2. Relevant methodologies	64
4.2.3. Methodology followed in this project	66
4.2.4. Ontology authoring tools used	67
4.3. Requirements Specifications	69
4.3.1. Identifying purpose.....	69
4.3.2. Identifying scope	69
4.3.3. Gathering knowledge sources	72
4.4. Conceptualisation.....	76
4.4.1. Use of Activity Theory to identify concepts and relationships	76
4.4.2. Building conceptual knowledge glossary.....	84
4.5. Coding.....	90
4.5.1. Converting to structured English sentences	90
4.5.2. Building a logical model	92
4.6. User Current Activity Model.....	96
4.7. Discussion	98
4.8. Summary	103

Chapter 5 Dialogue Manager and Planner	105
5.1. Introduction	105
5.2. Activity Review and Reflective Learning Dialogue – Main Characteristics	105
5.2.1. Activity review	105
5.2.2. Reflective questions	107
5.3. Dialogue Structure	108
5.4. Dialogue Games for Activity Review and Reflective Learning.....	111
5.4.1. Definitions of PORML dialogue games.....	111
5.4.2. Sequential DG episodes: activity model	111
5.4.3. User Interruption DG episodes.....	118
5.4.4. System Interruption DG episodes.....	120
5.5. Dialogue Management	122
5.5.1. Utterances.....	123
5.5.2. Analysing user utterances.....	124
5.5.3. Generating agent utterance	125
5.6. Adapting Dialogue to User Current Activity Model.....	126
5.6.1. Querying the UCA model	127
5.6.2. Updating the UCA model.....	131
5.7. Summary	133
Chapter 6 PORML Prototype.....	134
6.1. Introduction	134
6.2. Technical Specifications for the PORML prototype.....	134
6.2.1. Hardware specifications	135
6.2.2. Software specifications	136
6.2.3. Utility tools and libraries for PORML implementation	137
6.3. PORML User Interface	138
6.4. Examples of Interaction in PORML.....	143
6.4.1. Example 1: InitialActionsDG with ReflectionDG	143
6.4.2. Example 2: InitialControlMeasuresDG with ReflectionDG	146
6.4.3. Example 3: IdentifyRiskAssessmentDG with FeedbackDG and ReflectionDG.....	148

6.4.4. Example 4: SituationAssessmentDG with FeedbackDG and ReflectionDG	150
6.4.5. Example 5: ModeAndSystemDG with FeedbackDG.....	155
6.4.6. Example 6: AdditionalControlMeasuresDG with ReflectionDG	157
6.5. Summary	159
Chapter 7 PORML Evaluation	160
7.1. Introduction	160
7.2. Overview of Relevant Evaluation Approaches and Methods	160
7.3. Formative Evaluation	163
7.3.1. Aim and objective	163
7.3.2. Pilot study.....	164
7.3.3. Experimental study to improve the prototype	164
7.4. Summative Evaluation	175
7.4.1. Aim and objective	175
7.4.2. Experimental design.....	176
7.4.3. Findings regarding the usability of PORML prototype.....	180
7.4.4. Findings regarding the applicability of the PORML prototype.....	184
7.5. Discussion	189
7.5.1. Usability of PORML prototype.....	189
7.5.2. Applicability of PORML prototype in FRS	190
7.5.3. Further improvements	193
7.5.4. Limitations of study	194
7.6. Summary	196
Chapter 8 Conclusion	199
8.1. Synthesis	199
8.2. Generality of Our Approach.....	202
8.3. Contributions.....	204
8.3.1. Contribution to Technology-Enhanced Learning.....	204
8.3.2. Contribution to Artificial Intelligence in Education	205
8.3.3. Contribution to Ontology Engineering.....	205
8.4. Future Work	205

8.4.1. Immediate improvement of the PORML prototype	206
8.4.2. Possible future extension of the PORML framework	207
8.4.3. More elaborated knowledge base using activity-based approach	208
8.4.4. Conducting an extended experimental study	210
8.4.5. Applying PORML to other activities in emergency services	210
Reference.....	212

Appendices

Appendix A	Authentic Accident Description and Generic Scenario
Appendix B	Knowledge Glossary Table
Appendix C	Formative Evaluation Materials
Appendix D	Summative Evaluation Materials
Appendix E	Transcripts of Interview with Firefighters
Appendix F	Questionnaire with Firefighters
Appendix G	Copy of Ethical Approval Letter

Figures

Figure 2.1 Basic AT model in the first generation	25
Figure 2.2 Extended AT model in the second generation.....	25
Figure 2.3 Two activity systems and shared object in the third generation	27
Figure 3.1 The context of two activities for a job and its review to learn on-the-job reflection.....	44
Figure 3.2 Performing personalised on-the-job reflective mobile learning activity	44
Figure 3.3 The proposed PORML architecture	45
Figure 3.4 Querying location context data using Geographic Location Database.....	51
Figure 3.5 Querying location context data interacting with maps service providers or geo-spatial vendors.....	51
Figure 3.6 A map specified by two coordinates corresponding to the downloaded GML data.....	52
Figure 3.7 Using PORML Working Area to find and choose the incident place position	57
Figure 3.8 Using Interest Area to specify the boundaries which buildings and places are involved for location context data collection	58
Figure 4.1 Gathering list of fire risk assessment sources.....	72
Figure 4.2 Two separate activity stages for activity model construction	76
Figure 4.3 General diagram of risk management (HM Stationary Office 2002)	78
Figure 4.4 Applying AT system for initial activity model	79
Figure 4.5 An excerpt of diagram of applying the hierarchical structure of AT to the initial activity model for chimney fire; it is assumed that the order of actions and operations are left to right	79
Figure 4.6 Applying AT system to RA activity model	80
Figure 4.7 An excerpt of diagram of applying the hierarchical structure of AT to the RA activity model of chimney fire: it is assumed that the order of activities, actions and operations are left to right	83
Figure 4.8 Examples of classes and subclasses in RA logical model.....	93
Figure 5.1 The structure of dialogue plan of PORML dialogue game episodes	109

Figure 5.2 The state network diagram of InitialActionsDG episode.....	112
Figure 5.3 The state network diagram of InitialControlMeasuresDG episode	113
Figure 5.4 The state network diagram of IdentifyRiskAssessmentDG episode	114
Figure 5.5 The state network diagram of SituationAssessmentDG episode	115
Figure 5.6 The state network diagram of ModeAndSystemDG episode.....	117
Figure 5.7 The state network diagram of AdditionalControlMeasuresDG episode	118
Figure 6.1 Architecture of the PORML prototype.....	135
Figure 6.2 An example of the content in the Reflection Template, reflection.txt.....	138
Figure 6.3 User authentication page on an iPhone3G and a Laptop.....	139
Figure 6.4 Context information page	140
Figure 6.5 Dialogue interaction page for Sequential DG episodes	141
Figure 6.6 Dialogue interaction page for the ReflectonDG episode	142
Figure 6.7 Dialogue interaction page for the FeedbackDG episode	142
Figure 6.8 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to initial actions.....	145
Figure 6.9 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses of control measures....	147
Figure 6.10 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to risk assessment activity	149
Figure 6.11 A part of the UCA model (derived from the RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to risk assessment action/activity	152
Figure 6.12 A summary of the risk calculation	154
Figure 7.1 Experimental study timeline	163
Figure 7.2 Interface to utter communication act: before correction	167
Figure 7.3 Interface to utter communication act: after correction (only specify).....	167
Figure 7.4 The agreement/disagreement with characteristics of the dialogue	169
Figure 7.5 Dialogue presentation layout: before correction.....	169
Figure 7.6 Dialogue presentation layout: after correction	170

Figure 7.7 Input selection method: before correction.....	170
Figure 7.8 Input selection method: after correction	171
Figure 7.9 A sample screen output on iPhone3G after font size is enlarged ...	172
Figure 7.10 A summary of understanding the aim of the interaction with PORML	173
Figure 7.11 The Procedure of PORML summative evaluation.....	178
Figure 7.12 Participants' opinions about usability of PORML prototype. The numbers represent how many participants agreed or disagreed with the statements listed in the questionnaire.....	180

Tables

Table 3.1 Excerpt of GML data output of the map in Figure 3.6.....	55
Table 3.2 Examples of location context data inserted in Geographic Location Database.....	56
Table 3.3 Examples of location context data (LCDI) that might impact the user activity of incident extracted from Geographic Location Database.....	59
Table 4.1 An example of Rabbit sentence written by ROO editor.....	68
Table 4.2 Advantages and disadvantages of three commons of RA.....	71
Table 4.3 A scenario using real incident record at Cambridgeshire to define the scope of RA domain ontology.....	72
Table 4.4 List of knowledge sources and collected data.....	74
Table 4.5 Constructing the knowledge glossary table.....	75
Table 4.6 Severity and likelihood level.....	82
Table 4.7 Weight of risk rating, and risk score.....	82
Table 4.8 Level of hazards/risks.....	82
Table 4.9 The control measures used to reduce likelihood level of hazards/risks.....	82
Table 4.10 The context from community (people nearby and environments) and the impacts on likelihood level of hazards/risks.....	83
Table 4.11 Examples of knowledge glossary of concepts derived from initial activity model and RA activity model using AT system.....	85
Table 4.12 Examples of relationships derived from initial activity model and RA activity model using AT system.....	86
Table 4.13 Examples of defined concepts for activities, actions, operations, and control measures.....	86
Table 4.14 Examples of knowledge glossary concepts derived from initial activity model using hierarchical structure of AT in Figure 4.5.....	87
Table 4.15 Examples of knowledge glossary relationships derived from initial activity model using hierarchical structure of AT in Figure 4.5.....	87
Table 4.16 Examples of knowledge glossary concepts derived from RA activity model using hierarchical structure of AT in Figure 4.7.....	88
Table 4.17 Examples of knowledge glossary relationships derived from RA activity model using hierarchical structure of AT in Figure 4.7.....	88

Table 4.18 The knowledge glossary concepts of control measures for chimney fire	89
Table 4.19 Examples of knowledge glossary relationships between RA activities and control measures	89
Table 4.20 The knowledge glossary relationships between RA actions and hazards	90
Table 4.21 Examples of structured English sentences using Rabbit for describing concepts and relationships.....	91
Table 4.22 Examples of Rabbit sentences created using ROO and the results in Manchester syntax.....	92
Table 4.23 Examples of object properties in RA logical model in RA domain ontology corresponding to examples in Table 4.22	94
Table 4.24 Datatype properties of individuals of hazards/risks for chimney fire	95
Table 4.25 Datatype properties of individuals of chimney fire control measures.....	95
Table 4.26 Datatype properties of context parameters from community impacts	96
Table 4.26 Examples of relationships between instances in RA domain ontology and inserted instances in UCA for experiences of situation 1 and 2 with the incident ID no.1	97
Table 4.27 Examples of instances for user activities and their properties inserted by dialogue agent to UCA	98
Table 5.1 Examples of feedback message.....	121
Table 5.2 Examples of reflective question used to interrupt Sequential DG episodes	122
Table 5.3 The type of inflexion created and used in PORML.....	124
Table 5.4 The characteristics of user utterance corresponding to the type of inflexion	125
Table 5.5 The characteristics of the agent utterance corresponding to the type of inflexion	126
Table 5.6 Prefix declaration in query string examples	127

Chapter 1

Introduction

Workplace training (also workplace learning) has been increasing rapidly and becomes a crucial part in modern organisations. It provides various forms for learning or training undertaken in the workplace, such as on-the-job training under operational conditions or on-site training, conducted in training conditions (e.g. courses). Workplace training can be divided in several forms, including off-the-job training versus on-the-job training, and informal versus formal training. The training process can be organised in several levels, e.g. training of individuals, training of groups, and training of communities. Information technology growth is a major driver in workplace training. In the past decade, on-the-job training and informal learning are coming into the spot light of technology-enhanced learning (TEL) research and development. The research community is now seeking for innovative technological solutions that can provide training models which are universal, inclusive, cost-effective, and seamlessly integrated in everyday job practice.

This PhD explores the development of innovative technological solutions, focusing on informal on-the-job training - a specific type of workplace training that combines the form of informal learning with on-the-job workplace training. There are several approaches that adopt technology-enhanced learning solutions for informal on-the-job training for work practices, and provide learning environments that create a social context in which novel skills can be learned and applied. The existing approaches cover a range of domains, for example medical training, teacher training, social sector workers training, knowledge workers training. Technological solutions include simulated environments (which enable a learner to practice an activity that resembles a real job activity), collaborative environments (which provide means for learners to engage in collaborative learning activities), social knowledge creation and sharing (which enable learners to share experience and knowledge), communities of practice (which extend from knowledge sharing to collective knowledge building and learning).

One of the widely used models for workplace training aims to encourage experience-based learning – learning by reflecting on one’s experience at the job. Recent technological approaches start to look at providing effective experiential learning environments which promote reflection on job activities (i.e. reflection-on-action). Current technological solutions extend simulated environments or games with intelligent features to promote reflection-on-action. Current application

domains include mainly interpersonal communication (e.g. interacting with patients, conducting job interviews).

This PhD contributes to technology-enhanced learning for reflection-on-action by examining a novel intelligent TEL solution for reflective on-the-job training in dynamic job environments in the emergency services (e.g. police, fire and rescue services, emergency medical services). Informal on-the-job training embedded in work practice is highly relevant to the training practices of emergency services. The study in this PhD thesis explores a new TEL approach to promote reflection-on-action after the main mission of emergency practice is complete. The approach will be designed, developed, and evaluated in a case study of emergency services, namely training in Fire and Rescue Services (FRS). The training will focus on an operational personnel who is a junior officer, namely crew commander or crew manager. At the smallest incident all three levels of command decision making – strategy, tactics, operations – will be the responsibility of one individual, likely to be the first arriving crew commander assumed in the case study. The main characteristics of the case study are:

- Training is linked to the real emergency activity the learner has been engaged in.
- There are existing sources which provide descriptions of the job practice (e.g. manuals/guides), which allow the development of an activity model.
- Reflection is used as a main method for training.
- Training is embedded in work practice.

To design a novel computational framework for reflective on-the-job training, the thesis explores a theoretical model - Activity Theory (AT) - and a computational model - tutorial dialogue with reflection. The concept of AT will be used to model the activity context, in terms of classes and relationships, in a domain ontology. The descriptions of these classes and relationships will be used to structure the interaction of an intelligent dialogue agent with a learner. The tutorial dialogue will be firstly used to review recent activity of the work practice which consists of a series of actions of a specified activity taking place before a review session. Secondly, the tutorial dialogue will be used to promote reflection integrating episodes with post-practice reflective questions based on reflection templates.

1.1. Research Questions

This PhD thesis will propose a novel computational framework that supports reflective dialogue for on-the-job training in emergency services work practices. The study is driven by the following research questions:

- Can a computational framework of reflective dialogue for on-the-job training be used to support training by reflection on action in emergency services work practices?
- Can the Activity Theory be used to design an ontological model?
- Can tutorial dialogue be used to facilitate reflective on-the-job training?

Assuming the questions above are true.

- What are the main components of a framework of reflective dialogue for on-the-job training in emergency services?
- How to utilise the Activity Theory to design and develop an ontological model that defines the context of a job activity in a specific use case?
- How to design an intelligent dialogue agent that facilitates reflective on-the-job training in a specific use case?
- Is the computational framework of reflective dialogue for on-the-job training useful and applicable for supporting training in emergency services?

1.2. Research Methodology

To address the research questions, this study includes the following steps:

- Identify an activity where mobile application can facilitate reflective on-the-job training for firefighters. ‘Fire risk assessment’ will be chosen as the focus activity for workplace training.
- Identify which tasks are related to the chosen activity. For this, we will analyse data and learning materials obtained from representative FRS, including manuals, references, documents, reports, existing ontology, interview with an FRS representative, questionnaire with firefighters, and available online information.
- Develop scenarios for reflective on-the-job training to show how a dialogue agent on a mobile device can be embedded in work practices of firefighters.
- Develop a conceptual model of user activities based on Activity Theory to define the context dimensions and integrate this model with topographic feature data to identify relevant objects (e.g. petrol station, car park, public place) and the user current activity (e.g. fire risk assessment).
- Design a framework of novel reflective on-the-job training which utilises a user and a context model and provides adaptive interactions to help the user become aware how they have performed the activity (focusing on risk assessment).

- Implement a prototype of the framework using intelligent pedagogical dialogue-based agent for reflective on-the-job training to provide the training embedded in firefighters' work practice.
- Evaluate the potential of the new pedagogical dialogue-based agent framework which provides reflective-on-action for on-the-job training in FRS work practice with real firefighters using scenario-based settings.

1.3. Thesis Output and Main Contributions

The output of this thesis is a computational framework that consists of an activity context model, in the form of an ontology, and a mechanism for planning the dialogue interactions with embedded reflection episodes. The framework is underpinned by several hypotheses:

- The Activity Theory, which is used in social sciences for analysing and modelling goal-driven human activities, can provide a methodology to create an activity-based ontological model.
- Engaging a learner in a review-like dialogue which revisits the activity the learner has been engaged in can be useful for on-the-job training in emergency services.
- Intelligent technological solutions can be developed to support reflective on-the-job training in work practices at emergency services.

This thesis is expected to contribute to the following research areas:

- Technology-Enhanced Learning (TEL) – a novel framework to support informal on-the-job training in work practice by promoting reflection, by engaging a learner in a post-practice activity review dialogue;
- Artificial Intelligence in Education (AIED) – an intelligent pedagogical agent which integrates a tutorial dialogue and an ontological model;
- Ontology Engineering (OE) – exploitation of the concept of Activity Theory for ontology authoring to construct a domain ontology which represents an activity context.

1.4. Thesis Overview

The PhD thesis is organised into eight chapters.

Chapter 2 will justify the need for providing an intelligent agent to support reflective dialogue for on-the-job training at the work place. It will start with

reviewing general workplace training/learning approaches, and then will focus on TEL for on-the-job training. Relevant TEL projects which involve informal on-the-job workplace training will be reviewed to justify the research gap addressed in this thesis. A rationale of using reflective on-the-job training and training in emergency services will be presented. Furthermore, the two main aspects of the research methodology in this thesis - Activity Theory and tutorial dialogue – will be reviewed, justifying their suitability for the computational framework developed in this thesis.

Chapter 3 will introduce a computational framework for reflective on-the-job training, and will outline its main components. The Personalised On-the-job Reflective Mobile Learning (PORML) framework will be proposed following an activity-based model. The data resources and the main PORML components will be described. A case study of fire risk assessment in Fire and Rescue Services, used to scope the activity and to implement the PORML prototype, will be introduced. The PORML Location Context Data Query will also be presented, providing details about location context data using Geography Markup Language (GML)¹, and how to model and query the location context data.

Chapter 4 will explain how to create an ontological model of a risk assessment activity. Relevant ontology engineering methodologies will be reviewed to find and adapt the appropriate methodologies, which meet the ontology development requirements for this PhD thesis. Ontology authoring tools used in the thesis will be introduced. Our methodology will be outlined, including: requirements specifications, creating a conceptual model, and coding a logical model. Requirements specifications, including identifying purpose, identifying scope, and gathering knowledge sources, will be described. The ontology conceptualisation step will utilise Activity Theory to identify key concepts and relationships, defined in a conceptual knowledge glossary. The coding step will be explained by starting from converting data from knowledge glossary to structured English sentences, and then building a logical model. Finally, a User Current Activity model will be introduced and illustrated with examples.

Chapter 5 will present the dialogue management in the PORML framework. The main characteristics of the dialogue – activity review and reflection - will be discussed. The dialogue structure and dialogue planner will be presented, followed by a description of the dialogue mechanism based on dialogue games that represent dialogue episodes. A mechanism how to analyse user utterances and how to generate

¹ <http://www.opengeospatial.org/standards/gml>

agent utterances will be introduced. The chapter will also explain how to use the dialogue agent to query and update the User Current Activity model.

Chapter 6 will present a prototype that implements the PORML framework. Technical specifications (hardware, software, utility tools and libraries) and the architecture of the PORML prototype will be presented, pointing out how the implementation corresponds to the PORML framework. The user interaction with the prototype will be illustrated with examples.

Chapter 7 will present the evaluation of the PORML prototype to validate the PORML framework and examine its applicability in FRS practice. Relevant evaluation approaches and methods will be reviewed to select appropriate evaluation methods for the PORML prototype. Formative evaluation and summative evaluation of the prototype will be presented. The formative evaluation will be conducted by starting from providing pilot study to make sure that the proposed evaluation method is viable before embarking on a real study. Then, the formative evaluation study will be presented. Following the formative evaluation, the prototype is improved. The summative evaluation will be presented using the improved prototype with firefighters in Fire and Rescue Services. The participants, procedure, materials, and data collection and analysis will be presented. The findings, in terms of usability and applicability of the PORML prototype, will be presented to assess the benefits and drawbacks of the prototype. Further improvements will be pointed out.

Chapter 8 will conclude the work done in this thesis. The chapter will describe the key achievements, outline the main contributions, address the work's limitations and make suggestions for future work.

Chapter 2

Literature Review

2.1. Introduction

The use of technology for training and learning has various impacts on the forms of education systems and skill development in work practice. There are a number of projects that develop technology-enhanced learning for workplace training/learning and provide learning environments that create a social context in which novel skills can be learned and applied e.g. simulations, serious games. However, the existing environments suffer from a major deficiency, because they incorporate a limited understanding of the learner based on skills and knowledge acquired and diagnosed only within the simulated world and disconnected from the learner's real job experiences. A major challenge to workplace training/learning is to find creative ways for integrating training/learning within the context of human tasks or activities in day-to-day work practice. The goal of this thesis is to design and develop a computational framework that contains a new intelligent dialogue-based agent to support reflective on-the-job training in work practice. This intelligent dialogue-based agent will be used to capture the users' real job experiences related to the context of job activities.

This chapter aims to present the key challenge which motivates our research questions listed in Chapter 1. We will review training approaches and relevant research involved in order to (a) identify the gap this thesis addresses and (b) justify the methodologies that will be used.

Sections 2.2, 2.3 and 2.4 will review relevant training approaches and will present a rationale for the use of technological solutions that promote reflection for training at the work place. Section 2.5 will address and justify a case study in emergency services. Sections 2.6 and 2.7 will provide the methodologies to solve the problem addressed in the gap - Activity Theory (AT) and tutorial dialogue.

2.2. Workplace Training/Learning

Training and learning at workplace become more crucial as we move into a knowledge society that emphasises the knowledge building (Vaughan 2008). The research interest and application in the area of workplace training/learning have expanded since 1990s and have been increasing rapidly both wide-ranging and

interdisciplinary (Tynjala 2008). Due to wide spread of research in the field, as shown in recent literature reviews (Tynjala 2008; Vaughan 2008), there is no one-size-fits-all approach for research study to workplace learning, and it can be analysed in several levels: the learning of individuals (Boulton-Lewis, Pillay et al. 2006), the learning of groups, the learning of communities (Kleanthous and Dimitrova 2010), the learning of organisations, the learning of inter-organisational networks (Billett, Ovens et al. 2007) and the learning of regions (Gustavsen, Nyhan et al. 2007). Vaughan emphasises that more empirical studies are needed to get better understanding of workplace learning in different and specific contexts and industry areas. He considers the broad context by analysing previous research, such as reconceptualising learning at work (Bryans and Smith 2000), the rise of a new creative class (Florida 2002), knowledge society and future of education (Gilbert 2005), adolescent work and vocational development (Zimmer-Gembeck and Mortimer 2006), as well as reviewing government documents (The Office of the Prime Minister 2002; Organisation for Economic Co-operation and Development 2007; New Zealand Treasury 2008) involving the workplace learning and knowledge society. Vaughan classifies the training/learning at workplace in general into several categories, as follows (Vaughan 2008):

- *Off-the-job training*: the off-the-job training/learning is undertaken at the site away from the actual work environment and “*where learning assignments are related to problem-solving and task-centred activities linked to the strategic business intent of the organisation*” (Vaughan 2008) (p.4). This is often also referred to as formal training, for example, off-the-job training to the development of apprentices and trainees (Smith 2002) or off-the-job training in the form of seminars outside work (Veum 1995).
- *Structured learning*: the structured training/learning is managed and validated by external educational providers collaborating with employers (or managers, supervisors), learning professionals and learners. Normally, there are links between classroom training/learning and relevant labour market activities that the learning and motivation are mediated through activities embedded in contexts that are easy to understand by the learner. For example, structured workplace learning is done via structured workplace learning courses (e.g. (Queensland Studies Authority 2009)) or a structured workplace learning program (e.g. providing senior secondary students with work placement opportunities in a real work environment (Sydney Business Education Partnerships 2010)).
- *Informal and pervasive learning*: the informal training/learning is a semi-structured and “*forms the foundations of the context informing work practices,*

routines, and behaviours so that communities are formed or joined and personal identities are changed' (Vaughan 2008) (p.4). The informal training/learning takes place as a part of everyday work activities, promotes learning from experience, and produces mainly tacit knowledge (Eraut 2004; Slotte, Tynjala et al. 2004; Tynjala 2008). In the context of corporate training, the term informal learning is widely used to describe various forms of learning that are independent from instructor-led programs, e.g. self-study programs (Bell, Fonarow et al. 2000; Dinkelman 2003), communities of practice (Wenger 2003), learning competence (Schulz and Robnagel 2010).

- *On-the-job training*: the on-the-job training/learning is undertaken at the place of work while the learners are doing the actual job. The on-the-job training/learning is in the forms of intentional, structured and organised training/learning that aim to develop competencies of employees. The training/learning is supported, structured and monitored via different principles such as job rotation, group working together, social learning. The training/learning has a general reputation as most effective for vocational work. Usually, a professional trainer or an experienced employee acts as the course instructor and employs the principles of learning often supported by formal classroom training. Examples of on-the-job training are given in examining the probability of receiving job-related formal training and the returns to on-the-job training in Europe by (Salas-Velasco 2009), and studying the effects of on-the-job skill accumulation on average hours (Hansen and Imrohoroglu 2009).

Based on Tynjala's reviews (Tynjala and Hakkinen 2005; Tynjala 2008), the workplace learning can be classified into three basic modes: (1) incidental or informal learning (2) intentional, non-formal learning activities related to work (3) formal on-the-job and off-the-job training. Tynjala's informal learning definition seems close to Vaughan's one, and Tynjala's formal on-the-job and off-the-job training seem to correspond to Vaughan's on-the-job and off-the-job training. Training and learning at work indeed take various forms. On the basis of the survey in the USA (Carnevale and Gainer 1993), the amount of money for employee informal training was spent more than the one for employee formal training triple a year and the employers initially developed their engineers by upgrading the skills of supervisors and machine operators with informal on-the-job training and, later, formal training. Globally and traditionally, informal training/learning corresponds to on-the-job training/learning while formal training/learning corresponds to off-the-job training/learning (Jong 1996; Fuller, Ashton et al. 2003). In this research, on-the-job training in our case is defined and used in terms of informal training taking part of everyday work practice at the place of work to promote the reflection-on-action on

tasks or activities (see Section 2.4) after learners have done the actual job or main mission of work practice (see Figure 3.1).

2.3. Technology-Enhanced Learning for On-the-job Training

Since the research in workplace training/learning is very broad, we need to narrow down the scope for the study research study conducted in this thesis. The primary focus of the research in this PhD thesis is **on-the-job training/learning** (to promote **reflection** with employee's own experiences) in the form of **informal training** (or called **informal on-the-job training**) encompassing **technology-enhanced learning environments**.

There is a need to move the attractive market of adaptive and intuitive systems outside the mainstream educational environments to adult education and informal workplace learning to provide innovative learning models that are universal, inclusive, lifelong and seamlessly integrated in everyday practice (ImREAL 2010). Following this approach, there are a significant number of informal workplace training/learning research projects, entailing technology-enhanced learning environments for adult training/learning, that have developed a solid baseline of socio-cognitive and technological research, for example, APOSDLE, KP-Lab, MATURE, PALETTE, MIRROR, ALPS and ImREAL:

APOSDLE

The APOSDLE (Advanced Process-Oriented Self Directed Learning Environment) project (APOSDLE 2006) aims at providing technical support for informal self-directed work-integrated learning in the context of knowledge workers' everyday work processes and computerised work environments (Lindstaedt, Ley et al. 2007; Aehnelt, Hambach et al. 2009). The self-directed learning is defined as "*a process in which individuals take the initiative in designing learning experiences, diagnosing learning needs, locating resources, and evaluate learning*" (Knowles 1975) (p. 18). Resources for supporting informal self-directed work-integrated learning are the existing documents in the organisational repository, such as texts, images, or videos, and interaction with other people.

The project develops a software platform and tools that seamlessly integrate and support the three roles a knowledge worker fills in the workplace (Bonestroo, Ley et al. 2007; Lokaiczny, Godehardt et al. 2007; Lindstaedt, Scheir et al. 2008): worker, learner and expert. The project is domain independent and provides individual learning to support people who work with information and contribute new content to a knowledge pool of the organisation. The knowledge workers include researchers, engineers, consultants, designers and software developers who apply

knowledge to tasks in value creating activities. The learner looks for information, learns, seeks help, advances his/her knowledge. APOSDLE follows a Learn@Work approach that means that the learning occurs in the user's immediate work environment and context. The learning goals are represented as competencies. The competency model is firstly designed to map onto a domain ontology and, then embedded into a domain ontology (Bonestroo, Ley et al. 2007). The expert offers help or advice using context-aware approach through communication or changing content in a workplace embedded e-learning environment.

The APOSDLE approach supports informal on-the-job learning and collaboration activities with integrating worker, learner and expert together based on existing technical systems within an organisation. APOSDLE provides self-directed learning to turn experiences into knowledge. However, the informal learning in APOSDLE approach is not linked or connected to the real job experiences or activities since the simulated environment is based on a 'snapshot' in time as seen by a group of designers, workers, and pedagogical experts which the contents of the simulated environment is drawn from a fairly static and limited knowledge pool.

ALPS

The ALPS (Assessment and Learning in Practice Settings) project (ALPS 2005) is a collaboration between five Higher Education Institutes in the UK including 16 health and social care professions across the partnership. The ALPS aims at supporting students who graduate from health and social care courses to be able to perform confidently and competently at the start of their professional careers. The research and development in ALPS cover the areas of mobile learning, competency mapping, inter-professional assessment, and reflective tools development. Some aspects of these areas also involve informal on-the-job workplace training/learning, especially in mobile learning environments (Dearnley, Haigh et al. 2008; Taylor, Dearnley et al. 2010), in health and social care domain.

In workplace learning using mobile devices in ALPS (Taylor, Dearnley et al. 2010), learners are encouraged to take feedback from a variety of sources, reflecting on that feedback to learn from the reflection, and deduce further actions to improve performance. These activities/actions are reflection on and in action addressed by (Schon 1983) and enhance the quality of the students' reflection in their practice. However, a main deficiency of the ALPS approach for reflective on-the-job workplace learning, is using a mobile device in a 'passive way' – the learners are asked to fill in a form with predefined questions. There is no direct interaction with the learner which prompts the reflection, and it can well happen that the learner does not revisit all relevant aspects of their job activity. This limitation may be addressed

by adding some knowledge about the activity and making the interaction dialogue-like, so that the learner is taken through relevant activity aspects.

ImREAL

The ImREAL (Immersive Reflective Experience-based Adaptive Learning) (ImREAL 2010), started on October 2010, is an EU project in the work programme topic of technology-enhanced learning involving informal workplace training/learning for adult learning. The main goal of ImREAL project is to develop a novel conceptual framework and innovative semantic-enhanced intelligent services to augment existing simulated environments with adaptive meta-cognitive scaffolding in a cost effective way.

The objectives of ImREAL are to (1) develop a methodology and innovative services to model real world activities and capture semantically-enhanced collective content of job-related experiences (2) develop novel services to derive an extended model of the simulated situation context and a model of the learner (3) develop a pedagogically-driven technological solution to generate adaptive affective meta-cognitive activities in simulated environments (4) provide a flexible way to tune the augmentation services by using feedback from learners, trainers, and tutors (5) develop an integrated architecture of services for augmented simulated experiential learning and implement robust demonstrators to augment existing simulated experiential learning environments (6) evaluate how augmented simulated experiential learning affects learning efficacy in the representative domain (7) assess how ready the innovative approach is for commercialisation and deployment in practice. The ImREAL project promises that it will develop three key services (Hetzner, Steiner et al. 2011): (1) real world modelling and semantic content annotation (2) augmented user model (3) meta-cognitive scaffolding.

ImREAL stresses the importance of real, authentic experience for workplace learning. As main sources of such experiences, the project considers social spaces – both open social spaces (e.g. youtube, twitter) and socially-inspired environments (e.g. story telling). The domain is interpersonal communication, which can be modelled in simulated dialogic environments. It is not clear whether the ImREAL approach could be applicable in other domains (the work is still in an early stage). More importantly, there is no direct connection between the experience at the workplace and the experience in the learning environment, which requires approaches to capture a learner's current activity immediately after the job practice.

KP-Lab

The KP-Lab (Knowledge Practice Laboratory) is a five-year (2006-2011) EU-funded project (KP-Lab 2006a). The project aims at developing theories, tools, and practice

models which elicit deliberate knowledge advancement and knowledge creation to support the form of learning called 'trialogical learning' as a basis for collaborative learning in the social context of knowledge practices (Paavola and Kai 2009). There are three general objectives of the project (KP-Lab 2006b). First, the objective of theoretical development and modelling is to develop and explicate the theoretical foundations of the trialogical approach on learning in education and work practices. Second, the objective of educational and professional knowledge practices is to develop a set of pedagogical methods to foster knowledge creation in educational and workplace settings and to specify possibilities of their implementation. Third, the objective of technological development and research is to design and implement a modular, flexible, and extensible ICT system that supports the KP-Lab pedagogical methods to foster knowledge creation in educational and workplace settings.

Trialogical learning concentrates on interaction and is based on the knowledge creation processes on shared objects which extend the link between individualistic learning and collaborative learning, based on three metaphors of learning: knowledge acquisition, participation and knowledge creation (Lakkala and Paavola 2009). This interaction happens through shared objects on the basis of other people's efforts. To model the knowledge practice framework, the cultural-history activity theory (Leont'ev 1978) and theory of social systems (Luhmann 1995) are introduced to outline the underlying rationale of the modelling approach of socio-technical systems in the project (Allert and Richter 2008).

Regarding research on KP-Lab (KP-Lab 2008b), in terms of educational institutions the courses are designed to encourage the crossing of boundaries between educational and professional communities, using actual or simulated contacts with professional knowledge practices. In terms of workplace practices, the specific development cases aim at providing tools which can be used to reflect and improve workplace practice, organisational routines and to identify underlying problems.

When we consider the KP-Lab project in terms of informal on-the-job workplace training/learning, the project provides methods such as engagement of workplace communities in active reflection, and tools such as shared space tools, mobile tools, multimedia tools and meeting tools with the trialogical learning ontology using the KP-Lab service-oriented platform for knowledge creation practices (Kotzinos, Christophides et al. 2007) to capture and create knowledge that can support the improvement and reflection in workplace practices. The training/learning is seen as shared effort in developing ideas, artefacts, and social practices. Examples of case studies of knowledge practice in workplace entail crossing professional and organisational boundaries (Morch, Moen et al. 2008) e.g.

KIKK (Andersen and Morch 2009) – explore multiple dimension of developer-user relation, DiCAP-UIIer – focus on professional learning in school as workplace learning for teachers in institution etc.

The dialogical approach emphasises and concentrates on the interaction through collaboratively developing and transforming the experiences to knowledge creation with developing shared objects in learning community. The approach is not learning development for an individual learner himself/herself in the form of dialogical system which the learner converses with the computer/human tutor using dialogues. The learner for reflective learning also seems to be reflected by the learning community via the social processes that may not directly correspond to the learner's job activities and experience.

MATURE

The MATURE project (MATURE 2008) is a large-scale integrating project in technology-enhanced learning running from 2008 until 2012. The project team considers different levels of interaction that accompany the knowledge maturing process in modern organisations. This covers a progression from the level of individuals to the level of communities, and, finally, to the level of organisation. During the maturing process from expressing ideas to formalisation, patterns in the flow of knowledge from the individual to the organisation level are identified. The knowledge assets: contents, semantics, and processes are the three mains of MATURE. These three mains are closely related in a complicated way depending on each other in various respects. Semantics are required by contents and processes for communication. Therefore, semantics is the base for every community-based approach and supports collaboration between individual knowledge workers.

The phases at the beginning of the knowledge maturing process consist of almost informal learning, whereas the late phases are dominated by formal learning (Maier and Schmidt 2007). The knowledge maturing process uses both knowledge management and e-learning approaches, which can support both on-the-job and off-the-job training/learning, to improve construction, preservation, integration, transfer and the use of knowledge and competencies. The knowledge maturing process consists of five phases (Schmidt 2005): (1) emergencies of ideas – develop new ideas by individuals, (2) distribution in communities – develop common terminology shared among community members, (3) formalisation – purpose-driven structured documents are created, (4) ad-hoc training – prepare topic in a pedagogically way, and (5) formal training – ultimate maturity phase puts together individual learning objects to complete course.

In the motivational aspects of knowledge maturing in technology-enhanced learning, the MATURE approach addresses three perspectives on motivation (Ravenscroft, Schmidt et al. 2010a): Psychology, Serious Games, and Social Software and Digital Literacy. These issues lead into the methodological direction and approaches, initially applied to the development of Digital Dialogue Games (Ravenscroft, McAlister et al. 2010), to design complex systems to support informal learning and knowledge maturing in the Web 2.0 workplace (Ravenscroft, Schmidt et al. 2010b). The employees' motivation is considered as a main key for achievement in implementation of knowledge management systems which concentrate on incentives, but it is usually problematic involving genuine knowledge worker environment e.g. short-term in the effects, counter productive (Lin 2007). Motivational design of software systems has the goal of integrating motivational aspects into the design process of software tool, and within the MATURE project a motivational model has been developed that identifies three different dimensions (Kunzmann, Schmidt et al. 2009): individual, inter-personal, and work context.

When we consider in terms of informal on-the-job workplace training/learning, although MATURE provides complex systems to support this type of training/learning, the project does not provide opportunities for reflection on the real job experiences. Instead, the focus is mainly on capturing and cultivating organisational knowledge.

MIRROR

The MIRROR project started in July 2010 (2010-2014) (MIRROR 2010), focuses on the creation of learning environments which enable employees to learn from their own and other's experiences to improve better performance in the future. The project uses collaboration and reflection technologies and facilitates on-the-job workplace learning. The project aims at engaging and empowering employees to reflect on past work performances and personal learning experiences so as to learn in real time and to solve pressing problems immediately. Employees can increase their level and experience significantly within short time period using capturing experiences from other workers in MIRROR that they can learn directly from tacit knowledge without the need for making it explicit.

Reflection at work in scientific perspective can be seen as a return to experience via which the experience is re-evaluated in order to promote continuous learning. Reflection includes addressing emotional aspects e.g. angry, confused etc., or ideas generated during worker's experience. Reflection at work in business perspective can be seen as the way to find out how to learn from experience as a whole. Workers could be shared with all co-workers in order to avoid making the

same mistakes again and to improve their performance when they do those tasks again e.g. solving problems or providing feedback to a customer.

MIRROR provides methods and tools for capturing learning experiences automatically and storing them in a semantic repository. This repository will keep a history of learning experiences as a basis for reflective learning. The learning experiences include context information about specific learning situation – task context at workplace, interaction, collaboration, stress (user's physical and emotional stress). MIRROR promises to provide the output: (1) conceptual model of holistic continuous learning by reflection involving training critical thinking, awareness of emotions, collaborative knowledge construction and creative problem solving and innovation (2) interoperable learning applications (in a bundle of real-time) for collaborative and social work environment (3) prove of learning effectiveness by evaluation. The existing researches such as APOSDLE project and MATURE project will be made enriched by combining them with MIRROR applications.

MIRROR is a large project which is in its initial state. The direct relevance to this PhD is the key argument for reflective learning based on real job experiences. MIRROR considers a social dimension in capturing real world job experiences. In that way, reflection can happen by referring to job activities from the learner or from other learners. An individualised approach which aims at capturing and reflecting on the learner's experiences immediately after performing a job activity can be considered as complementary to the tools being developed in MIRROR.

PALETTE

The main goal of the PALETTE (Pedagogically sustained Adaptive Learning Through the exploitation of Tacit and Explicit knowledge) (PALETTE 2008) project is to facilitate and enhance both individual and collective learning via Communities of Practice (CoPs). The CoPs are groups of people who share a concern, a set of problems, or a passion for something about topic they do or learn how to do it better, which deepens their knowledge and expertise (Wenger 2003). The interaction of participation taking places in CoPs is a form to support the informal workplace learning that participants can learn from others at work (Boud and Middleton 2003; Gray 2004). The CoPs are involved in the PALETTE project including professional organisations in the academia (e.g. teacher associations).

The PALETTE project allows the CoPs to analyse their current situation and make possible effective improvements via the experimentation of new activities and tools, e.g. the creation of social link, the availability of decision making processes, the efficient retrieval of the created knowledge, the management and use of

documents (PALETTE 2006b). The PALETTE project designs and develops Palette services (i.e. information services, knowledge management services and collaboration services) to fulfil the requirements of CoPs including supporting *participation* – social and verbal interactions, *constitution of common resources* – formalise tacit knowledge, and *commitment of participants* – realise participants' activities (PALETTE 2007).

The PALETTE project uses social software to foster active participation and collaboration incentives in terms of Computer-Supported Collaborative Work or Learning approaches facilitated by Web 2.0 applications (Gillet, Helou et al. 2008; Helou, Tzagarakis et al. 2008). In terms of informal workplace training/learning the project uses social software as a versatile support for collaboration learning activities. However, PALETTE does not explicitly emphasise or tend to promote any reflective learning in participation and collaboration to individuals at workplace.

In summary, the projects reviewed here all involve or support informal on-the-job workplace training/learning for adult training, encompassing technology-enhanced learning environments. The APOSDLE, ALPS, KP-Lab, ImREAL, MIRROR projects provide socio-pedagogical models for self-directed learning or self-regulated learning or reflective learning to capture or turn experiences into knowledge. The KP-Lab and PALETTE projects provide design methodologies adapted for adult learners and workplace contexts. The MATURE is generic and widely applicable models of competences and skills. The APOSDLE and PALETTE seem to be technological solutions for intuitive knowledge capture and sharing, and provide flexible architectures for self-directed and community-based learning. From these projects, only ImREAL and MIRROR projects support the training activities linked to the real world or real job experiences. In our PhD we will follow the approach that supports the pedagogical model with reflective learning and the training activities are linked to the real job experiences. In contrast to tools developed in ImREAL and MIRROR, we will focus on reflection via dialogue immediately after a job activity. The dialogue will enable also to capture the user current activity in a knowledge structure that could be utilised by tools ImREAL and MIRROR develop.

2.4. Rationale of Reflective On-the-job Training

Dewey defined reflective thought as “*active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends*” (Dewey 1933). This can be linked to

Schon's (Schon 1983) view of reflective practice which educators focus on problems and experiment with situations. The impact of reflective practice has been significant with a considerable amount of training and education programmes for teachers and informal educators adopting Schon's core notions both in organising experiences and in the teaching content. Schon describes two types of reflection: reflection-in-action and reflection-on-action (Schon 1983a).

- **Reflection-in-action** can help us while we complete a task. It is the process that allows us to reshape what we are working on while we are working on it. If something is not working correctly then you reflect in the action-present.
- **Reflection-on-action** refers back on what we have done in order to discover how our knowing-in-action may have contributed to an unexpected outcome. The act of reflecting-on-action enables us to spend time exploring why we acted as we did, what were happening in a group and so on (Schon 1983b).

In some situations, it is hard to reflect-in-action on tasks or activities, for example, the day to day work practice in emergency services (addressed in section 2.5) because time is extremely short, decisions have to be rapid, and the scope for reflection is extremely limited (Munby and Russell 1989; Eraut 1994). In such cases, reflection-on-action appears more appropriate.

It is noted that the informal on-the-job work practices including workplace training/learning in certain areas e.g. emergency services, civil construction, geological survey etc., mobile technologies can play a key role for information technology application development to support employees' work practices. Therefore, reflective practice in this PhD, which uses a case study in emergency services, is usually involved with mobile devices, mobile learning, use of location device – global positioning system (GPS) etc. The use of mobile technologies is designed in our framework (see Chapter 3) and implemented in terms of user interface for application in our prototype (see Chapter 6).

In this PhD

Our PhD approach seems to correspond to the approaches of two projects, MIRROR and ImREAL. These two projects involve the area of informal on-the-job workplace training encompassing technology-enhanced learning environments to promote the reflection that the activities is linked to the real world or real job experiences. This PhD has been started since October 2006 before these two projects have been begun around 2010. The main explicit difference between MIRROR and our approach is the notion of the reflective learning using workers' experiences in real time environments. The MIRROR promises that it is to engage workers to reflect on past work performances and personal learning experiences in order to learn in real time to

solve problems immediately by using the experiences captured from other workers. In contrast our approach has not used the experiences from the other workers to reflect on individuals and the reflection does not take place during performing main mission of practice, i.e. does not solve any problems in real time. The main explicit difference between ImREAL and our approach is the notion of linking and synchronisation between simulated environment and real world. The real world activities or real job experiences grounded in job practice are mapped and synchronised to the simulated environment. Our approach is an initiative underpinning the ImREAL project. In our case, the activities are linked only to real job experiences and do not directly link to simulated environments. Instead, our project uses activity review which takes place after the main mission of practice is complete, and provides the means for reflection-on-action. The reflective answers are recorded in the form of a text file for later review. Dialogues for activity review and reflective dialogues are used and combined in episodes of an interactive dialogue session (see Chapter 5). The user's experiences or recent activities/actions (in the practice) are captured by activity review process and recorded in a User Current Activity model, built and initially derived from a domain ontology (see User Current Activity model and domain ontology in Chapter 4).

To date, no research has been conducted to develop a pedagogical agent that supports reflective dialogue for on-the-job (workplace) training which is linked to real job experience with activity review after main mission of work practice is complete. It enables the training to be embedded in the work practice. This study attempts to fill this gap by developing an integrated platform combining an ontology presenting an activity model and intelligent dialogue agent which supports reflective on-the-job training. The design of our computerised framework considers emergency services as a case study, outlined in the next section.

2.5. Training in Emergency Services

Emergency services are organisations which ensure public health and safety by addressing different emergencies. There are three main emergency service functions: police, fire and rescue services, emergency medical emergency services (ambulance). In UK, these three functions are performed by three separate organisations, and other emergency services are provided by one of main services or private companies e.g. mountain rescue, coastguard, mine rescue, animal control etc (Tourist Information UK 2011). Training is a crucial part of emergency services for workforce development to support their practices and normally takes place in workplace (e.g. fire station, fire service training centre, hospital, police station)

separated from the actual practices (e.g. near fire building, on the road) or in simulation environment.

The job activities in emergency services are dynamic and very heavily depend on location and context. Hence, emergency services are an interesting and challenging domain for informal on-the-job training embedded in work practice linked to real job activities. We will consider the training in emergency services in terms of technological support using information technology to help workers' development. The characteristics of the training in emergency services could be defined in order to impose the aspect of application in the training addressed in the next section.

2.5.1. Characteristics of training in emergency services

In terms of technology-enhanced learning, the most common technologies normally used to support training in emergency services are related to virtual realities and simulations. For instance, in a police training ExpertCop system (Furtado and Vasconcelos 2005) uses a geosimulator to support training of how to deal with crime in an urban area. The goal is to help the trainee understand the consequences of his/her allocation and the cause-and-effect event relations. The simulations are integrated in a learning environment along with graphical visualisations that help the student's learning. ExpertCop uses intelligent agents in simulation environments to promote reflection and improve learning. Another example is CACTUS (Command And Control Training Using knowledge-based Simulations) project (Hartley, Ravenscroft et al. 2008) that was concerned with command and control training of large incidents where public order may be at risk, such as demonstrations. CACTUS provides the trainer not only with a simulation program, but also tools to allow it to be customised to meet the local requirements. However, ExpertCop system and training using CACTUS exploit virtual situations and simulations rather than reflective on-the-job workplace training embedded in work practice.

Recently UK initiatives led to wider deployment of mobile devices in the emergency services: police, fire and rescue services (FRS), ambulance services, which brought changes to the existing emergency services work practices (Allen and Shoard 2005; Ferneley and Light 2006; Ferneley and Sobreperez 2006). This creates new opportunities for training, and will be exploited in the computational framework developed in this thesis.

To impose the aspect of training corresponding to our informal on-the-job workplace training approach, the main characteristics of training in emergency services are defined as follows:

- It uses an activity-based training which the activities/actions have been performed by the learners/workers;
- There are guides or descriptions of what activities/actions learners/workers do;
- The training/learning is informal, on-the-job, and is related to activities/actions of work practice;
- Reflection is used as a main method for training;
- Informal on-the-job training is a part of work practice or embedded in work practice.

In emergency service work practices, activities or actions in workers' operations are normally recorded as the steps in a procedure of those operations which the workers could perform to deal with a situation in the incident. A case of FRS (see Chapter 4) is chosen as our case study which is one of the main emergency services for informal on-the-job workplace training. The training in FRS will be addressed in the next section.

2.5.2. Training in fire and rescue services

FRS is considered as a case study of an interesting research challenge when comparing with other main emergency services in terms of impact scale and dynamic change of workers. The impact of decision making in FRS operations on people and assets involved in an incident can vary from small scale (e.g. a small part of building is burnt) to very large scale (e.g. dozens people are risky to be killed under large fire or collapse of building). On the other hand, a significant number of firefighters often change their job and often may lack skills or experiences to deal with critical tasks. The training using this approach, (informal) on-the-job (workplace) training with reflection, might be a quick way to help firefighters' skills development.

However, currently FRSs uses information technologies to support their work in both during practices (on-the-job) for helping and supporting operations and decision making using laptop and mobile application systems e.g. Lynx-Fire², Inca System³, Cyfas Systems⁴, Infoterra⁵, and training/learning using simulation e.g. ProQA⁶. Research projects have developed technologies are used to support FRS practices in operations and decision making, for example, MONA project

² <http://www.wpcsoft.com>

³ <http://www.gaist.co.uk>

⁴ <http://www.cyfas.co.uk>

⁵ <http://www.infoterra.co.uk>

⁶ <http://www.prioritydispatch.net>

(Holtkamp, Weissenberg et al. 2005) and FLAME2008 platform (Weissenberg, Voisard et al. 2004; Weissenberg, Gartmann et al. 2006), and support FRS training using simulation e.g. ACTIVE project (Romano 2001), DC-Train (Bulitko and Wilkins 1999) and SCoT-DC Tutor (Peters, Bratt et al. 2004).

In this PhD, we will use technology-enhanced learning to support reflective on-the-job (workplace) training **embedded in FRS practices**. The main difference with existing technologies is that we consider the job activities the learner has been involved in as the focus for learning via reflective review.

The main tools and methods which underpin our approach are Activity Theory, which is used to analyse and capture the main aspects of job activities, and dialogue, which is used as the main means for reflective debrief. The Activity Theory will be reviewed in Section 2.6, and tutorial dialogue and dialogue to promote reflection will be reviewed in Section 2.7.

2.6. Activity Theory

In studying the context in which the users work, we consider which approach could be chosen for modelling the context in human computer interaction (HCI) used in our project. Three alternative theoretical frames were identified in the review of the literature: distributed cognition, situated action and activity theory (AT). These three frames were also identified by Nardi (Nardi 1996) as the most promising theoretical frames for modelling HCI. Each approach proposes the unit of analysis and the support of the description of context.

2.6.1. Activity modelling theories

The **distributed cognition** approach was developed by Hutchins and his colleagues (Hutchins 1987; Hollan, Hutchins et al. 2000) as a new branch of cognitive science concerning interactions between people, artifacts and both internal and external (material or environmental) structure. The distributed cognition is identified by a unit of analysis of a cognitive system composed of individuals and the artifacts they use (Hutchins 1995). The distributed cognition provides the detailed analyses which combine the formal or cognitive properties of artifacts with observations on how artifacts are used can lead to understandings useful for design (Norman 1988; Hutchins 1995; Nardi 1996). The distributed cognition has been productive of analyses of work practices relating to the specific situational contexts e.g. a study of computer mediated work in engineering work practice (Rogers and Ellis 1994), a study of the coordination of work during neurosurgery afforded by video located

within the operating room and at remote locations in the hospital (Nardi, Schwarz et al. 1993).

The **situated action** emphasises the emergent, contingent nature of human activity, focusing on situated activity or practice which opposes to the study of formal or cognitive properties of artifacts or structural social relations (Nardi 1996). The everyday activity of persons in a setting (Lave 1988) occurs at a fine-grained level of observed activities. This is reflected in Suchman's statement (Suchman 1987) "*the organization of situated action is an emergent property of moment-by-moment interactions between actors, and between actors and the environments of their action*". Lave (Lave 1988) identifies the basic unit of analysis for situated action as "*the activity of persons acting in setting*" which this setting is a relation between acting persons and the arenas, stable institutional frameworks – e.g. a supermarket is an arena within which activity takes place, in relation with which they act. Nardi (Nardi 1996) analysed that the situated action approach provided a much-needed corrective to the rationalistic accounts of human behaviour from traditional cognitive science and it became clear that rigid mental representations, e.g. conceived notions of inflexible plans and goals, could not account for real human activity.

Recent movements consider Activity Theory as a model for analysing goal-driven human activities. It was found that traditional conceptual approaches can not provide an appropriate basis for addressing a significant number of crucial aspects of HCI e.g. computer supported cooperative work, cross-cultural aspects of computer use (Artemeva and Freedman 2001; Roth 2007) etc. In this period there has been a growing interest in AT stimulated by Bodker (Bodker 1989; Bodker 1991), the first Western researcher who presented the basic ideas and potential benefits of AT to the HCI community. Bodker defined the concept of practice as "*the ways of doing work, grounded in tradition and shared by a group of workers*" that seems to be applicable to on-the-job activities. Furthermore, in a different application approach of HCI, Roussou (Roussou, Oliver et al. 2006; Roussou, Oliver et al. 2007) applied AT as a tool for analysis of user interaction in virtual reality for learning in virtual environments for children. There are indicators to show dramatic growth between year 2000 and 2005 from the increasing interest for the future of AT shown in cultural historical AT over the past three decades based on citation frequencies in the Institute for Scientific Information's citation database (Roth and Lee 2007; Engstrom 2008a).

In light of the discussion above the AT approach is chosen because it distinguishes between artifacts and people using artifacts as mediator, puts much needed attention to social and contextual factors necessary to HCI studies, and there

is substantive body of knowledge and practice available which can both be drawn upon and contributed to. The AT is used to test the concept of the application for on-the-job training in the design of our PORML framework (see Chapter 3). AT is used to develop a representational framework that will help us to capture current work practice corresponding to our application in emergency work practice in order to inform the design of an intelligent agent to support reflective debrief on-the-job activities.

2.6.2. Activity Theory model

The AT is a descriptive tool based on psychological theory of Vygotsky and Leont'ev (Leont'ev 1978; Vygotsky 1978), focusing on understanding human activity and work practices (Allert and Richter 2008). The basic unit of analysis of AT is the human activity that can be described as a system whose components include those who carry out the activity (Turner, Turner et al. 1999). The main idea of AT is the notion of mediated action by artifacts (first generation of AT) and the activity system (second generation of AT). The AT proposes a very specific notion of context that the activity itself is the context and anything that occurs in an activity system composed of object, actions, and operations, is the context (Nardi 1996). The third generation of AT, emerging in the last decade, built on the idea of multiple interacting activity systems focused on a partially shared object that open new possibilities for analysing hierarchical power relations in the activity systems and managing the activity systems of primary productive work (Engestrom 2008a).

Nardi (Nardi 1996) concluded that the AT and distributed cognition were very close and the two approaches would mutually inform, and even merge, over time, though AT would continue to probe questions of consciousness outside the purview of distributed cognition as it was presently formulated. The notion of artifacts as mediator in AT seems a more reasoned way to discuss relations between artifacts and people. Nardi argued that the main differences that should be concerned were between AT and situated action. The AT approach seems to be considerably richer and deeper than the situated action approach.

The evolution of AT has been seen in terms of three generations (Engestrom 2008a). The first generation model of AT was built on Vygotsky's notion of mediated action (Vygotsky 1978) linked a subject (e.g. learner), an object (e.g. an object of learning) and tools (e.g. a tutoring system). In early work of Vygotsky the unit of analysis was object-oriented action mediated by cultural tools and signs and there was no recognition of part played by other human beings and social relations in triangular model of action. The limitation of the first generation was the unit of analysis focusing on individual and the AT triangular model is shown in Figure 2.1.

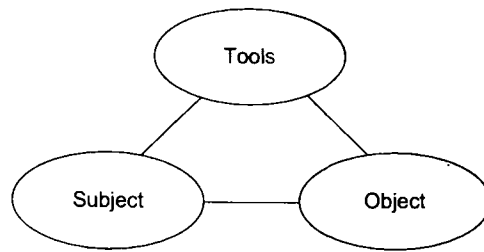


Figure 2.1 Basic AT model in the first generation

The second generation model was built on Leont'ev's notion of activity system (Leont'ev 1978) extended the theory by adding several features based the need to separate individual action from collective activity. In order to progress the development of activity theory, Engestrom (Engestrom, Miettinen et al. 1999) used the notion of activity system and developed an expanded activity model considering social context and adding rules (e.g. rule for the use of tutoring system), community (e.g. group of employees in an organisation) and division of labour (e.g. an officer in an organisation). The notion of internal contradictions within activity systems was also emphasised as the driving force of change and development in activity systems (Engestrom 2001). The expanded activity model is shown in Figure 2.2.

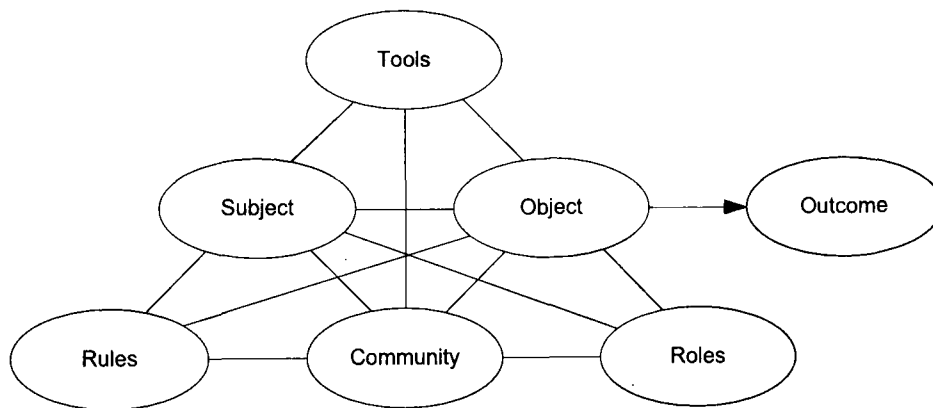


Figure 2.2 Extended AT model in the second generation

- *Subject*: the subject is a person that undertakes an activity, either individually or as part of a team;
- *Object*: the object of an activity is that which is modified and explored by a subject, based on the goal of the activity. Objects can be material things or intangibles;
- *Tools or Artifacts*: the tools can be either physical or mental tools that shape the way that people interact with reality;
- *Rules*: the rules refer to domain specific knowledge that must be captured;
- *Community*: the community refers to virtually all of the people directly involved in the particular activity being analysed;

- *Roles or Division of Labour*: the roles refer to how cooperation and specialisation occurs in an activity;
- *Outcome*: the outcome of an activity may or may not be one that accomplishes the object.

The key concepts or basic principles of AT that constitute a general conceptual system (Kaptelinin and Nardi 1997) can be applied to the analysis of problems of HCI in practical skills. These key concepts can be summarised as follows:

- *Hierarchical structure of activity*: the AT differentiates between processes at various levels (activity, action, operation) taking into account the objects to which these processes are oriented (Kaptelinin 1996). The unit of analysis is an activity directed at an object which motivates activity. Activities are composed of goal-directed actions. Actions are conscious and composed of operations, and different actions may be undertaken to meet the same goal. Operations are non-conscious and do not have their own goal.
- *Object-orientedness*: the human beings live in a reality that is objective in a broad sense and the things that constitute this reality have not only the properties that are considered objective but also socially/culturally defined properties.
- *Internalisation and externalisation*: AT differentiates between internal and external activities. It emphasises that internal activities (mental processes) can not be understood if they are analysed separately, in isolation from external activities (interaction with the outside world).
- *Mediation*: AT emphasises that human activity is mediated by tools or artifacts which their use is accumulation and transmission of cultural knowledge and social experience. The use of these tools shapes the way people act and influences the nature of external behaviour and mental development (Kaptelinin 1996; Kaptelinin and Nardi 1997).
- *Development*: the development in AT is not only an object of study, but it is also a general research methodology which is the formative experiment combining active participation with monitoring of the developmental changes of the study participants (Kaptelinin and Nardi 1997). The principle of development provides an opportunity to conduct thorough, scientific analysis of complex phenomena while avoiding mechanistic oversimplifications (Kaptelinin 1996).

To look in more details of hierarchical structure, three level notion of Leont'ev's model was diagrammed with three levels' correspondence as: activity → motive, action → goal, and operation → conditions. The examples of three levels in the hierarchical structure of an activity can be described as follows:

- *Activity level:* An individual activity is for example to perform a chimney fire risk assessment (RA) activity (in FRS RA activity); to perform a chimney fire risk assessment reflective training activity by post incident review (in FRS RA reflective training activity);
- *Action level:* An activity consists of a collection of actions. An action is performed consciously, for example, preparing water pump, performing fire extinguishing with water (in FRS fire activity); to review risk assessment procedure (in FRS RA reflective training activity);
- *Operation level:* Actions consist of themselves of collections of non-conscious operations, for example, handle a jet of water, release valve, jet water to the front of fire building (in FRS fire activity); to choose 'Fighting Fires' from a list on mobile display screen (in FRS RA reflective training activity).

The third generation of AT was proposed by Engestrom in order to develop conceptual tools to understand dialogues, multiple perspectives, and multiple interacting activity systems focused on shared object (Engestrom 2001). Figure 2.3 shows minimally two interacting activity systems with shared object. Two interacting activities are initiated by two different subjects and bound by shared object that has the relationship each other and can trigger a chain reaction of mediated actions within the individual activities and lead to inner contradictions and tensions for the individual activity and the joint activity (Yamagata-Lynch and Haudenschild 2009). The analysis of AT was expanded in several dimensions to tackle the issues of, for example, subjectivity, personal sense, emotions, experiencing, identity and moral commitment (Engestrom 2008a). The third generation of AT is still in the stage of development that is opened to the researchers to diversify the AT and its application.

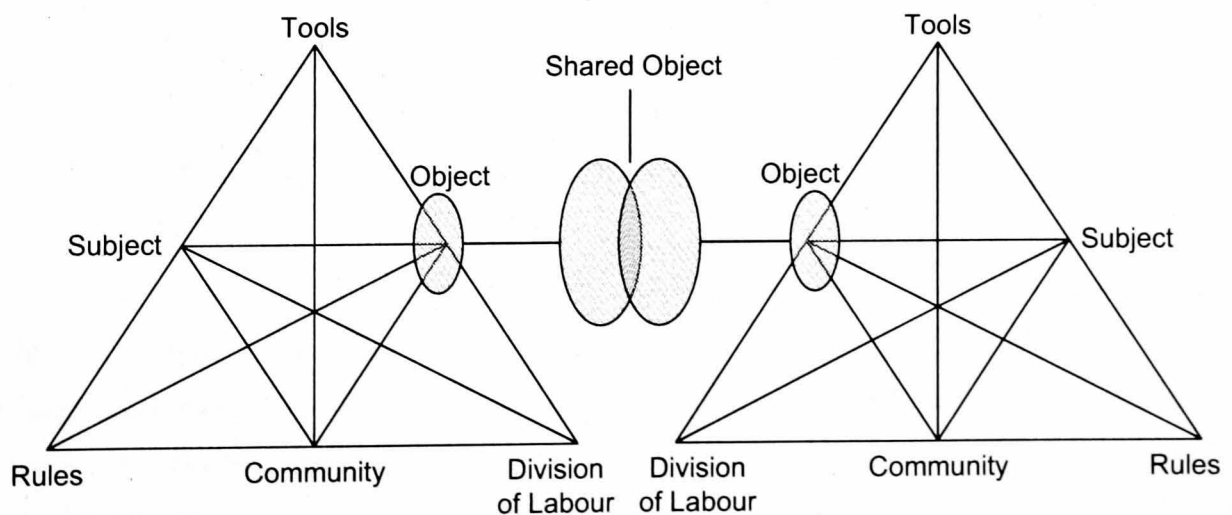


Figure 2.3 Two activity systems and shared object in the third generation

An interesting approach of further AT development proposed by Gonzalez in his doctoral dissertation (Gonzalez 2006) involving multiple activities in workplace, he suggests a new intermediate concept and calls this new level (an intermediate level) 'working sphere/engagement' in the hierarchical framework of AT. The term 'working spheres' is used to indicate social worlds concerned with the work in an organisation: *"Each working sphere has a unique constellation of colleagues, collective experience, organisational and environmental conditions, and tasks."* The term 'engagements' is also used when this work is referred to by Kaptelinin and Nardi (Kaptelinin and Nardi 2006). The notion of working sphere concept, appearing to have emerged from that of social worlds which is a unit of collective action, is referred to Strauss and Corbin (Strauss and Corbin 1998). They assert that *"a social world can refer to any type of collective unit, such as an academic department, a program committee, or a university."* In Gonzalez's notion the hierarchical framework should be modified the levels (becoming four levels) from highest to lowest level as: activities, engagements (working spheres), actions and operations, and their correspondence as: motives, purposes, goals and conditions, respectively. He defines the notion of working sphere as follows:

"A working sphere is a unit of work that, from the perspective of the individual, thematically connects a number of actions and their goals towards the achievement of a specific purpose, has a unique time frame, and involves a particular collaborative structure."

Gonzalez also emphasised that *"the time frame of a working sphere is defined from the perspective of the individuals, and is based on his or her active participation in a work effort through the enactment of a working sphere."* To indicate the meaning of this statement, an example of a fire incident can be given as follows: a firefighter deals with a working sphere *"entering a building that is on fire to rescue people"* at an incident place involving his participation in this fire incident to extend that he can rescue the people from this building to complete a section, rescue people, of dealing with this fire incident. When the fire incident is completed and his involvement ceases, the purpose of his working sphere for fighting the fire and saving people's life is achieved.

There are a number of discussion papers (Aboulafia 2008; Bedny and Harris 2008; Cockton 2008; Diaper 2008; Engestrom 2008; Rogers 2008; Souza 2008) regarding adapting AT for HCI and CSCW applications that comment the notion of 'working spheres/engagements'. These discussion papers may help us consider possible benefit/problems and appropriateness of application in our thesis. Diaper and Lindgaard (Diaper and Lindgaard 2008) conclude these papers (only selected papers), for example, as follows: Aboulafia (Aboulafia 2008) in *Understanding Work Units and Activities: A Perspective from General Psychology* discussed the

potential of AT in a general psychology and stressed the importance of development to AT. However, she pointed out that Gonzalez's "*justification for the proposed new level of investigation and subsequent solution is grounded on a somewhat loose methodology.*" Engestrom (Engestrom 2008b) concludes that "*The term 'engagement' is suggestive and may well become part of the conceptual repertoire of activity theory.*" However, "*serious work is needed to relate the notion of an intermediate level to central concepts and methodological principles of cultural-historical activity theory.*" He questions the difference between levels of goals and purposes, and points out four problematic shortcuts in the way Gonzalez develops his argument: (1) outcomes (2) dimensions and types of working spheres/engagements (3) linear-temporal and socio-spatial aspects (4) importance of contradictions, alienation and expansion in the analysis of working spheres/engagements.

2.6.3. Activity Theory and modelling context

AT has been used to model context in a number of different ways: Kofod-Petersen and Cassens (Kofod-Petersen and Cassens 2006) used the expanded AT model (second generation) to acquire contextual information in mobile scenarios by mapping the activity system to a taxonomy of contextual knowledge. Kaenampornpan (Kaenampornpan and O'Neill 2004) applied the extended AT model to deal with the time changes in context by taking into account that the occurrence of events in the past may affect the present and the future. Tan and Mellis (Tan and Mellis 2010) used the basic AT model (first generation) for the context of problem-solving process of graphic design practice within an AT framework, focusing on data collecting using ethnographic methods concerning tool-mediated activities and strategies undertaken by three mid-weight freelance graphic designers. Yamagata-Lynch and Haudenschild (Yamagata-Lynch and Haudenschild 2009) used the activity system analysis with shared object of interacting activity systems (third generation) to identify (four level of) inner contradictions and tensions in teacher professional development. Roth (Roth 2007) provided the evidence from a 5-year ethnographic study of a fish hatchery that shows emotions are integral to what people do and know in the workplace and proposed a way in which emotions and the associated dimensions of motivation and identity can be incorporated into cultural-historical AT as part of its third generation expansion and development.

In our thesis, the concept of AT is used to model the context and to structure the interaction in the reflective debrief on-the-job activities with the user. We use the AT as a 'loosely specified ontology' to model the context in our thesis in terms of classes in the domain ontology. The 'loosely specified ontology' is defined by (O'Leary 2010) as an ontology which specified at the class level and the AT is

available to define those classes, but that the classes have not been fully fleshed out. The 'loosely specified ontology' provides class level definitions, but it does not provide individual subclass level knowledge and terms. In other words, we apply the AT as a high level descriptive use for our application scope and use only the extended AT model in the second generation that seem to cover general and simple construction of social context in order to study and test our specific domain. In contrast, a 'tightly specified ontology' is fully specified to the lowest subclass level knowledge necessary for organisations to fully share and use the ontology in a computer-based application (O'Leary 2010).

Following (O'Leary 2010), we exclude contradictions, tensions and co-ordination/cooperation mechanisms captured in the third generation of AT, and focus on first and second generation of AT to flesh out classes or define a number of subclasses events (Engestrom 1987; Turner, Turner et al. 1999; Engestrom 1999a; Artemeva and Freedman 2001).

In the design of the research, elements from second generation AT which could support the development of a 'loosely specified ontology' are selected. In addition, the ontology developed is utilised in a prototype in a specific domain. While the use of further concepts could have provided a richer understanding of the domain and enabled a tightly specified ontology to be developed, this was not possible within the time available and would have precluded moving to the development stage. The approach taken within this thesis to AT and ontology development was used by (O'Leary 2010) who similarly used high level concepts for ontology development. Third generation AT emerged in at the start of the thesis (2006) and was reviewed and the concepts identified as potentially useful. The use of third generation AT was not considered at this point as it was considered to be both under-developed, highly contentious and fluid (arguments which still stand today).

When considering our main characteristic of work practice i.e. interactive review on a mobile device for reflecting the work practice with proximity to the workplace, the notion of AT working spheres/engagements seemed to be applicable to our reflective on-the-job training. Following the notion of working spheres/engagements, the use of mobile device application for on-the-job training could be engaged with and embedded at the end of the current FRS work practice. However, there were certain issues to be considered about the application of working spheres/engagements in our thesis: (1) The main characteristic of working spheres/engagements in the project or work was the achievement of the same specific purpose (of work) of that individual. Generally, the purpose of, for example, the fire risk assessment of a fire incident at the workplace was not a learning or training whilst the purpose of interactive review on a mobile device for fire risk

assessment was on-the-job training. To make this issue correspondently, it was possible to provide, for example, the case of small incident that a junior or a small experience crew commander who dealt with a fire incident and was trained at the same incident to reflect his work practice for improvement (2) The working spheres/engagements from Gonzalez's original work needed to be further developed. Some well-known researchers (Aboulaflia 2008; Cockton 2008; Diaper 2008; Engestrom 2008) claimed the problems of the proposed working spheres/engagements stated in previous section that could be improved and developed e.g. methodology, analysis etc. With these reasons, we could, therefore, accept the idea of working spheres/engagements in our application for multiple activities in general, but we did not consider the implementation of the systems in the intermediate level of interacting activity systems as it was still under-developed and contentious. We modelled the context of (working sphere of) interactive review on-the-job training using the extended AT model in the second generation using high level concepts in order to create a domain ontology used to provide contents to intelligent agent for using with FRS work practice as follows:

- Identify activity where mobile technologies can facilitate reflective on-the-job training of firefighters e.g. risk assessment activity closed to an incident place;
- Identify which tasks are related to the chosen activity e.g. chimney fire risk assessment task.
- Gather training/learning materials including manuals, training documents, questionnaires, online information, and the analysed data;
- Identify the concepts that could be contextual information in activity system and their relationships, and construct the AT hierarchical structure (activity level, action level and operation level);
- Use these concepts, relationships and information in the AT hierarchical structure to build domain ontology.

The details of creating ontological model of risk assessment activity based on AT model are described in Chapter 4.

2.7. Tutorial Dialogues

The goal of this section is to review relevant dialogue approaches and identify a methodological approach that can be followed in this thesis. We will first consider relevant tutorial dialogues which are used for pedagogical agents. Reflective dialogue or dialogue to promote reflection will be addressed in Section 2.7.2, followed by a selection of a dialogue model for this thesis described in Section 2.7.3.

2.7.1. Relevant tutorial dialogue approaches

In this section, we discuss relevant approaches for dialogue-based pedagogical agents. We determine which approaches can be applied and extended to the purpose of building our tutorial dialogue agent for reflective review on a job activity.

Atlas

Atlas (Freedman 1999) is a plan-based dialogue manager that can conduct a mixed-initiative dialogue using typed text and/or graphics interface. The goal of Atlas is to allow both student-led and tutor-led interactions or to support tutoring systems where either the student or the system can take the initiative at any time (mixed initiative dialogue), using natural language and/or GUI actions (multimodal dialogue). It is based on a hierarchical task network style reactive planner (Yang 1990; Erol, Hendler et al. 1994). A key component of Atlas is the Atlas Planning Engine – a dialogue manager for easy construction and quick generation of organised dialogues. The Atlas was developed for use with intelligent tutoring systems that is domain- and task-independent system and could be used to communicate with any tutoring system.

Atlas-Andes (Freedman 2000; Freedman, Rose et al. 2000; Rose, Freedman et al. 2001), an intelligent tutoring system, is built by integrating the Atlas Planning Engine within the Andes Physics tutor (Gertner, Conati et al. 1998) as a host and natural language understanding (NLU) component as dialogue extended system. The NLU, provided by CAMEL system (Rose 2000a), is used in the Atlas-Andes to interpret the student's input and it uses the spelling correction algorithm invented by (Elmi and Evens 1998). The Atlas-Andes uses Knowledge Construction Dialogues (KCDs), a finite state machine (FSM) and reactive planner (APE) approaches for dialogue management, which are the main mechanism to initiate and carries out a dialogue plan for helping the student to recognise and repair a misconception or to elicit a more complete explanation from the student (Rose, Freedman et al. 2001; Rose, Roque et al. 2002).

Why2-Atlas (Jordan and VanLehn 2002; Rose, Roque et al. 2002; VanLehn, Jordan et al. 2002; Jordan, Makatchev et al. 2006), a physics tutoring system using Atlas framework with a library of KCD dialogues, aims at coaching students for qualitative physics essay writing as they explain physics systems in natural language in response to short essay questions. It creates and utilises a proof-based representation of student essays that gives the output of sentence-level understanding and uses the proofs to give student feedback.

ProPL (Lane and VanLehn 2005) is a dialogue-based tutoring system which is an application of Atlas framework using the plan-based Atlas dialogue management

system and the KCD. It aims to support effective pre-planning activities, highlight the crucial problem-solving, and teach the tacit knowledge of programming for novice programmers by exploiting the properties of natural language tutoring.

These types of dialogue using Atlas framework: Atlas-Andes, Why2-Atlas and ProPL, require NLU from Rose's CARMEL system or KCD dialogue system, which contains a corpus of its dialogues, and spelling correction algorithm invented by Elmi and Evans. They seem to be unsuitable to apply to our dialogue management because we don't have any corpus of the KCD in the Atlas dialogue management system and can't use or adapt this NLU and spelling correction algorithm to our dialogue management system. The development of such components from scratch requires extensive time and effort which is beyond the time scope of one PhD thesis. We therefore will consider alternative dialogue planning approaches.

AutoTutor

AutoTutor (Wiemer-Hastings, Graesser et al. 1998; Graesser, Lu et al. 2004) is developed for introductory computer literacy and Newtonian physics. It is a learning environment which communicates interactively with a student in a natural language using dialogues, and produces a wide range of responses. The primary contribution of this research in technology is on formulating helpful discourse contributions based on an analysis of human-human tutoring sessions. AutoTutor engages a learner to help him/her in the evolution of an improved answer. The AutoTutor is a mixed-initiative dialogue that each dialogue partner can ask questions and start new topics of discussion. It uses Latent Semantic Analysis (LSA), a key component which is a high dimensional statistical technique approach in dialogue management, for its conceptual pattern-matching algorithm using for matching the expectations and anticipated misconceptions (Graesser, Lu et al. 2004). The AutoTutor is extended and evolved for content creators and developers (Chipman, Olney et al. 2005) and applied in detecting learners experience emotions (affective states) that are relevant to learning and selecting tutor actions that maximize learning while influencing the learner's affect (D'Mello and Graesser 2007; D'Mello, Graesser et al. 2007).

Why2-AutoTutor (Graesser, Jackson et al. 2003) is a descendent development of AutoTutor that is specifically designed to help college students learn Newtonian qualitative physics with qualitative explanations (Graesser, VanLehn et al. 2001), whereas the previous AutoTutor systems are on topics of introductory computer literacy and military tactic reasoning. It responds students with an animated conversational agent while students type in their answers via keyboard.

Why2 is a joint project involving both the Atlas and AutoTutor group that a corpus of explanations from students is collected and analysed to see what kinds of misconceptions and language the students are using (Graesser, VanLehn et al. 2001). Therefore, Why2-Atlas and Why2-AutoTutor use the same idea for analysing the student essays: a set of mandatory points and a set of misconceptions. The main difference is that Why2-Atlas uses symbolic analyses, whereas Why2-AutoTutor uses a statistical technique (LSA) to determine if a point has been mentioned.

These tutors use dialogues as principal method of teaching conceptual knowledge in the domains of computer literacy, scientific reasoning and Newtonian qualitative physics, but a general framework has not been developed (Weerasinghe, Mitrovic et al. 2009). It may be possible to adapt these dialogues to other tutorial dialogues with different areas if we can implement the structure of dialogues in the same technique using LSA. This approach is unsuitable for dialogue management in the framework developed in this PhD, because there is no available (relatively large) corpus of reflective dialogues to run LSA.

BEETLE

BEETLE (Zinn, Moore et al. 2002) is designed to teach students involving basic electricity and electronics concepts. It uses information state update approach for dialogue management, which captures the overall dialogue context and interfaces with external knowledge sources, and generic components for deep NLU and generation in its tutorial dialogue system (Callaway, Dzikovska et al. 2007).

BEETLE II (Dzikovska, Bental et al. 2010; Dzikovska, Moore et al. 2010; Dzikovska, Steinhauser et al. 2010) is a descendent version development of BEETLE tutor designed to overcome the limitations (Callaway, Dzikovska et al. 2007) in the previous version in order to allow unrestricted language input and support experimentation with different tutorial planning and dialogue strategies. A deep parser and generator with domain reasoning (Dzikovska, Callaway et al. 2006) and diagnosing (Dzikovska, Campbell et al. 2008) are used to produce detailed analyses of student utterances and generate feedback automatically.

This type of tutorial dialogues uses information state update, which captures the overall dialogue context and interfaces with external knowledge sources, for dialogue management and generic components for deep natural language understanding and custom utterance generation. However, these types of dialogue may be unsuitable to apply to our dialogue management because we don't have any corpus. BEETLE uses 36 dialogues collected with 3 different tutors, including the structure of the corpus and the way how to implement this structure and build the corpus. This corpus is outside the purpose and domain in our case.

Betty's Brain

Betty's Brain (Biswas, Leelawong et al. 2005) is a teachable agent in the domain of river ecosystems that combines learning by teaching with self regulation mentoring to promote deep learning and understanding. Teachable agent is a computer agent that a student teaches and learns himself/herself in the process. The self regulated learning (SRL) system can provide feedback on domain knowledge concepts to promote the development of cognitive skills and problem-solving ability (Biswas, Leelawong et al. 2005; Tan and Biswas 2006; Wu and Looi 2008). Betty's Brain attempts to support three critical aspects of effective interactions: (1) develop structured networks of knowledge that have explanatory value, (2) help students take responsibility and make decisions about learning, and (3) develop reflection or meta-cognition skills that include monitoring the quality of knowledge and learning decisions (Biswas, Leelawong et al. 2005; Schwartz, Chase et al. 2009).

The notion of reflection with self regulation mentoring to promote deep learning and understanding, which uses reflective dialogue to respond to a learner or student, in Betty's brain seems to be beneficial to our reflective learning approach. However, we can not use the reflective dialogue related to its agent prompts generation system. We apply the idea of triggering the different types of thinking for question prompts activation to our conditions of actions or state of actions during activity review for extracting and prompting reflective questions from reflection template in our dialogue episodes.

CIRCSIM-Tutor

CIRCSIM-Tutor (Evens, Brandle et al. 2001) is an intelligent tutoring system that helps medical students to learn to solve problems in cardiovascular physiology system dealing with human blood pressure. The CIRCSIM-Tutor consists of the planner, the text generator, the input understander, the student model, the knowledge base, the problem solver and the screen manager (Woo 1992). The dialogue planner of original CIRCSIM-Tutor uses a finite state machine. The CIRCSIM-Tutor is based on a qualitative model of blood pressure regulation that students are asked to make qualitative predictions about the direct response of core variables telling whether each will increase, decrease, or stay the same (Evens, Brandle et al. 2001). These predictions are assessed and the tutor starts a tutoring dialogue.

CIRCSIM/APE (Freedman 2001; Mills 2001; Mills, Evens et al. 2004) is a CIRCSIM-Tutor version 3 up that uses the Atlas Planning Engine developed as part of the Atlas project (Freedman 1999), as a platform. The results of using APE platform are fast, robust, and easy to use and to extend. The planner part of CIRCSIM/APE consists of curriculum planner that determines the set of problems

the student may solve, turn planner that uses an opportunistic planning strategy to plan the next tutorial turn, and discourse planner that chooses a method of teaching content, a level of interactivity between tutor and student and a coherent set of sentences. The conversation is divided into problems and stages that each stage starts with an optional initial dialogue segment dedicated to task management (Freedman 2001). A very influential part of the dialogue analysis to other researches in the CIRCSIM-Tutor system is a Directed Line of Reasoning (DLR) which is a multiturn dialogue sequences for helping student reason about problems using a series of questions, prompts and hints to deliver information and to remedy misconceptions (Mills, Evens et al. 2004; Eugenio and Green 2010).

The core of the dialogue model of CIRCSIM-Tutor system (CIRCSIM-Tutor and CIRCSIM/APE) is mainly based on FSM/APE planning as well as Atlas-Andes in Atlas framework. It may be beneficial to adapt the DLR with APE planning to our dialogue model. However, similar reason to Atlas-Andes, a main point is that it seems to be unsuitable to apply these tutors to our tutorial dialogue management because, firstly, they are designed to support and facilitate learning in domain of cardiovascular physiology which is different from our domain, and secondly, we don't have any corpus of the DLR and the way how to create and analyse this corpus in order to adapt it to the domain in our dialogue management.

Dialogue Games

Dialogue Games are interactions between two or more players and each player moves according to a defined set of rules using the utterances that player makes (McBurney and Parsons 2002). Dialogue Games can be represented as a set of knowledge structure and be specified in terms of the goals, roles, intentions, openers and rules of interaction (Levin and Moore 1977; Ravenscroft 2006). Dialogue Games seem to be more flexible in terms of agents' autonomy (e.g. keeping track of the state of dialogue) than a traditional protocol using finite state machine (FSM) (Abowd, Wang et al. 1995) for communicative acts that agents can perform when conversing (Maudet and Chaib-draa 2002).

The Dialogue Games were proposed by several researchers such as (Levin and Moore 1977), (Dastani, Hulstijn et al. 2001), (Dignum, Dunin-Keplicz et al. 2001), (Maudet and Chaib-draa 2002), (McBurney and Parsons 2002), and have been applied in several areas including philosophy – e.g. study fallacious reasoning (Hamblin 1970), computational linguistics and artificial intelligence – e.g. explain sequences of human utterances (Levin and Moore 1977), support human-human crosslingual dialogue (Piwek, Hardcastle et al. 2007), relate the dialogue game to change information state of a participant in a dialogue (Pulman 2002), map persuasive dialogue game onto argumentation structure (Ravenscroft, Wells et al.

2009), apply dialogue game to maintain diagnostic interactions that extract models of the users' cognition (Dimitrova 2003c), use semantic-based dialogue game to enable interoperability of user-adaptive systems in a ubiquitous environment (Cena and Aroyo 2007).

The Dialogue Games tend to be flexible to construct the dialogues containing the knowledge information and other information which are asserted for their goals and intentions to elicit something from the user by interaction. For application to our activity-based interaction, the Dialogue Games seem to be applicable to our approach by creating knowledge base information related to activities/actions as a main part of dialogues or utterances using semantic- or ontology-based dialogue game so as to produce the dialogues closing to natural language or the dialogues as controlled natural language stated in Chapter 4, Section 4.2.4.

Geometry Explanation Tutor

Geometry Tutor is a computer tutor loosely based on the advanced computer tutoring (ACT*) theory which explains a learning process with the description in different types of knowledge acquisition (Anderson, Corbett et al. 1995). Geometry Explanation Tutor, an extension of PACT Geometry Tutor (Aleven, Koedinger et al. 1998), is a Geometry Tutor based on the standard cognitive tutor architecture, augmented with facilities for natural language understanding (NLU) that can perform fine-grained analysis of students' explanations (Aleven, Popescu et al. 2001). The architecture of Geometry Explanation Tutor supports self-explanation, and consists of user interface component, cognitive tutor component and NLU component. Self-explanation is a metacognitive strategy that can be supported effectively in a cognitive tutor for geometry problem solving (Aleven, Koedinger et al. 1999; Aleven and Koedinger 2000; Aleven, Popescu et al. 2001; Aleven, Koedinger et al. 2003).

In the Geometry Explanation Tutor, the knowledge-based NLU component is used to classify students' explanations with respect to a set of categories of correct and partially correct explanations while the cognitive tutor component is used to check whether the student's explanations are correct and to determine what feedback to present to the student, based on the classification of the explanation determined by the NLU component (Aleven, Popescu et al. 2001). Suitable problems are selected on an individual basis and feedback is provided, as students enter solutions or intermediate steps. The explanation of the students' answers to geometry problems are required in their own words to justify the step in the geometry definition or theorem and the tutor checks the accuracy and complete statement of an appropriate geometry rule of this explanation to provide the appropriate feedback.

The Geometry Explanation Tutor classifies the student's explanation and the feedback is based on the classification of this self-explanation, which is a kind of promoting reflection, to facilitate the identification and removal of misconceptions. This tutor looks benefit to a learner for understanding the learning courses in terms of improving good explanation of these courses by his/her self-explanation. However, this tutor may not be suitable to apply to the purpose of our tutorial dialogue management because, in our scope of tutorial dialogue application, we consider the learner's explanations in terms of reflective questions/answers but we do not consider the analysis of the answers of these explanations to generate any feedback corresponding to them.

ITSPOKE

ITSPOKE (Litman, Rose et al. 2004; Litman and Silliman 2004) is a speech-enabled tutoring system that uses Why2-Atlas text-based tutoring system as its back-end and uses FSM and reactive planner approaches for dialogue management. A student's speech via microphone input is digitised and sent to an automatic speech recogniser, whereas the tutor's text output is sent to a text-to-speech system and played via a speaker. The improved two versions of ITSPOKE for uncertainty adaptations to improve performance on learning efficiency and user satisfaction called ITSPOKE-OWZ, a semi-automatic version using a Wizard of Oz to perform speech recognition, NLU and uncertainty annotation, and ITSPOKE-AUTO, a fully automated spoken dialogue computer tutoring corpus version (Forbes-Riley and Litman 2009; Forbes-Riley and Litman 2010; Forbes-Riley and Litman 2011).

When we compare ITSPOKE-OWZ and ITSPOKE-AUTO with Why2-Atlas, they are no difference in terms of learning and they also use the same dialogue management, FSM and reactive planner. Therefore, similar to the reason in the application of Atlas systems stated above, the ITSPOKE system seems to be unsuitable to apply to our tutorial dialogue management involving the corpus of KCD in the Atlas dialogue management.

SCoT

SCoT (Spoken Conversational Tutor) (Schultz, Bratt et al. 2003) is a human-to-human tutorial interaction that uses meta-communicative information conveyed through spoken utterances to gauge student uncertainty and respond accordingly. Human tutors can use meta-communicative features to gauge student understanding and student affect such as hedges, prosodic features – intonation, temporal features – pauses, speech rate etc (Pon-Barry, Schultz et al. 2006). SCoT is developed by the use of architecture for Conversational Intelligence in terms of handling dialogue move in structured discourse and Activity Tree derived from the technique of

dialogue games (Lemon, Gruenstein et al. 2002), which supports multimodal and mixed-initiative dialogue. SCoT-DC tutor (Peters, Bratt et al. 2004) is an instantiation of SCoT tutorial system applied to the shipboard damage control training, DC-Train simulator (Bulitko and Wilkins 1999), concerning the task of containing and eliminating the effects of fires, floods and other critical events in emergency response area by speaking with simulation system.

The structure of SCoT dialogue manager is an aspect of Dialogue Games technique which collaborates with Activity Tree module, a hierarchical representation of the past, current, and planned activities. The dialogue management of this tutor seem to be possible to apply to our dialogue model. However, this dialogue management approach emphasises dialogue move, called Dialogue Move Tree, and uses a set of abstract dialogue move classes linked to nodes on the Activity tree through activity tag, this approach is different from our idea of using the Dialogue Games that the activities/actions are formed as a part of dialogue (utterance) construction, which contains the combination of its components (Aroyo, Denaux et al. 2006). The activities/actions in our idea are extracted from an ontology base which looks systematic to build contents in any domains and seems to be more flexible for dialogue construction.

TuTalk

TuTalk (Jordan, Ringenberg et al. 2006; Jordan, Hall et al. 2007) is a dialogue system that provides a dialogues system shell and content authoring tool to support the rapid development of dialogue systems to be used in learning studies involving KCD. All of the dialogue features of the previous system in Atlas framework are included in the TuTalk with added new capabilities. Nevertheless, the dialogue agent in TuTalk is re-implemented with a modular architecture for a good experimental platform which consists of a coordinator and a set of natural language understanding (NLU), natural language generation and dialogue management. TuTalk uses FSM and reactive planning approaches in dialogue management as well as Atlas framework.

The core of TuTalk is tools supporting KCD which is based on Atlas dialogue manager, FSM and APE approaches. Although it is different from previous tutorial dialogues using Atlas framework in flexibility of application because TuTalk provides an authoring environment to author tutorial dialogues in order to support tutorial experts who are unlikely to be proficient at programming a dialogue manager to build their dialogues easily in any domain (Eugenio and Green 2010), it seems to be too simple to build in our domain and has limitation to combine with other dialogue approaches such as reflection.

2.7.2. Dialogue to promote reflection

In recent two decades, several researchers in intelligent tutoring systems (ITS) have developed modules to support reflection (Roberts 1993; Pioch, Roberts et al. 1997; Chan and Ridgway 2006). A significant number of developers incorporate natural language into tutorial systems to use natural language dialogue during the problem-solving session (Aleven, Koedinger et al. 2003; Graesser, Lu et al. 2004; Litman and Silliman 2004; Biswas, Leelawong et al. 2005; Schwartz, Chase et al. 2009; Forbes-Riley and Litman 2010), whereas a small number of work has focused on using reflective dialogue after problem-solving (Katz, Allbritton et al. 2003; Pon-Barry, Clark et al. 2005; Katz, Connelly et al. 2007). Besides, the reflective dialogues often involve interchanges in the form of multi-step between tutor and student (Moore 1996). The term 'reflective dialogue' or dialogue to promote reflection can refer to a process or place where we are willing to think about the rules underlying what you do, and it is related to our thoughts and actions that we begin to create entirely new possibilities and new levels of interaction (Isaacs 1999).

The design and use of dialogue to promote reflection can support learning from experience that people learn to reflect on the way they make decision (Aakhus 2001). The reflective dialogue helps participants, tutor and learner, recognise the information from communication and the learner's experiences to promote reflective learning via formulating their contributions to an unveiling distributed interaction. In addition, (Freed 2003) also uses reflective dialogue to examine how adult learners use an online bulletin board to reflect on and expand their experience in higher education, whereas the (Granberg 2010)'s study looks at the students' understanding of the process of reflection as an educational concept and the engagement in reflective dialogue using blogs and provides insight into the relationships between students' understanding of reflection and their participation in reflective dialogue.

In the study for the use of reflective dialogue after practice or problem-solving, the term 'post practice reflection' or 'debrief' or 'post-mortem' is used to refer to a significant part of apprenticeship training which takes place *after* a task or an activity and it is a reflective conversation to highlight its temporal and instructional aspects (Katz, O'Donnell et al. 2000). Certain researches provide evidence that the dialogues to promote reflection taking place after practice or problem-solving may be better than reflection during practice or problem-solving at eliciting student explanations (Katz, O'Donnell et al. 2000; Katz, Connelly et al. 2007).

2.7.3. Dialogue model for this thesis

The combination of the notion of Dialogue Game approach represented as a set of knowledge structure which is specified in terms of goals, intentions, openers and

rules of interaction (Levin and Moore 1977; Dimitrova 2003a; Ravenscroft 2006) and the notion of a finite state approach (McTear 2002; Jordan, Ringenberg et al. 2006), which is appropriate to system-led, are adapted to our dialogue management. This combination seems to be appropriate to natural language application (using dialogue game) and information/actions state (using finite state network) with goals, roles, intentions and openers (using dialogue game). Our dialogue model mainly uses Dialogue Game, which is an agent-based dialogue, whereas the structures of dialogue planning or dialogue strategy mainly uses finite state network, which is a finite state-based dialogue, appropriate for the sequences of predetermined steps or states (in terms of sequences of actions) (McTear 2002; Jordan, Ringenberg et al. 2006) in an activity review session addressed in Chapter 5. In addition to model the dialogue including the reflective way in our thesis, we consider a reflective dialogue approach that uses the dialogue to promote reflective learning after a task or an activity was complete or uses the dialogue in terms of post-practice reflective questions (Katz, O'Donnell et al. 2000; Katz, Allbritton et al. 2003; Katz, Connelly et al. 2007) stated in the previous section to apply to the case of emergency services. These dialogues will be generated in the form of agent utterance and user utterance and be modelled in two kinds of patterns: (1) dialogues for activity review, and (2) reflective dialogue (for post practice).

Dialogues for activity review in our approach are inquiries for a series of actions of a specified task/activity taking place before review session or explanations issued by the dialogue agent (agent utterances) and the corresponding answers selected by the user (user utterances), which the purpose of these questions/answers is to review the previous/recent activity of work practice. These dialogues also include feedback (explanations from dialogue agent corresponding to the user's answers), initial message of an episode, skip turn message, end dialogue message. The major components of these dialogue relating to activity model (concepts or classes) are extracted from model of domain ontology or user current activity. Chapter 4 describes how to create model of domain ontology and user current activity. Sections 5.5.1 – 5.5.3 in Chapter 5 explain components of dialogues (utterances) which will clarify the structure of dialogue model and Section 6.4 in Chapter 6 shows some examples of interaction which consist of a series of dialogues during interactions constructed by dialogue agent and user's response.

Reflective dialogues are post-practice reflective questions issued by the dialogue agent (agent utterances) and reflective answers in free text answering typed by the user (user utterances), which the purpose of these questions/answers is to reflect on those activity/actions or experiences related to the user's thoughts and actions (Isaacs 1999) in order to learn them from those experiences. The reflective

questions are prepared in the form of sequences of question sentences as text lists contained in a reflection template text file. The reflective questions related to conditions of parameters determined by dialogue agent will be retrieved from the reflection template (see how to extract from the reflection template in Section 5.4.4 in Chapter 5 and Figure 6.2 in Chapter 6, Section 6.2.3).

2.8. Summary

Workplace training/learning using technology-enhanced learning is an interesting area in the educational research, especially in informal on-the-job training to support adult training (andragogy) and learning outside curriculum. It is growing continuously in both research and educational software industry. On the basis of survey in past years the amount of money for employee informal training was spent more than the one for employee formal training, and currently it continues in this way. Several projects, e.g. APOSDLE, ImREAL, ALPS, KP-Lab, MATURE and MIRROR, make a significant contribution to this kind of training to provide innovative training/learning models that are universal, lifelong and integrated in everyday work practice. This thesis comes to fill in a gap of missing approaches that are suitable for reflective on-the-job training in emergency services.

The aim of this thesis is to design a framework which contains an intelligent dialogue-based agent to support on-the-job training with reflective learning approach in work practice. Certain theories and techniques, i.e. Activity Theory, reflection theory, tutorial dialogue, are analysed and applied as methodologies for the development of the computational framework. The next chapter will present the design of framework following in this approach.

Chapter 3

PORML Framework and Main Component of the Model

3.1. Introduction

The main goal of our work is to develop a new personalised approach to enable reflective mobile learning in fire risk assessment to support training in Fire and Rescue Services (FRS). The previous chapter discussed the theories and technologies, e.g. reflective learning, Activity Theory and dialogue model, to support personalised on-the-job reflective mobile learning (PORML) in order to describe how the theories and technologies could be used in PORML framework. In this chapter, the architecture of PORML framework will be presented. The goal and main characteristics will be presented in Section 3.2. The PORML Architecture will be briefed in Section 3.3. Then, the main components of the framework will be outlined in Section 3.4. A case study in a fire risk assessment is briefed using the PORML framework in Section 3.5. In Section 3.6 the location context data query will be described and how to collect the location context data to be used in the dialogue manager and planner of PORML framework. The PORML framework will be discussed in Section 3.7.

3.2. Goal and Main Characteristics

The goal of the PORML framework is to present a general architecture of a dialogue assistance for mobile learning which provides reflection on action and illustrates for fire risk assessment. The main characteristics of the framework are as follows:

- The ubiquitous access is as close as possible to the activity and ensures debrief within the activity sphere addressed in Chapter 2, Section 2.6.2;
- It uses proactive system-driven interaction;
- It provides opportunities for on-the-job training by reflecting on action;
- The user activity is affected by the location and the environment in close proximity (e.g. weather, buildings and places);
- There is available topographic data which indicates and describes the place where the activity is conducted.

3.3. PORML Architecture

The PORML framework is based on an activity model. Considering two activities at a workplace, a user performs the first activity for a job e.g. emergency response, risk assessment, fire extinguishing etc. and afterwards the user performs the second activity to review the first activity for reflective learning. The context of the activities to learn on-the-job reflection can be shown in Figure 3.1.

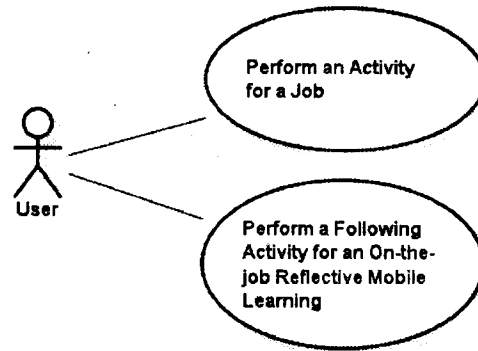


Figure 3.1 The context of two activities for a job and its review to learn on-the-job reflection

The framework is used for the second activity that considers a review of the first activity in order to perform on-the-job reflective mobile learning. Figure 3.2 shows more detail of the on-the-job reflective mobile learning activity that a user interacts with when using PORML. The PORML contains four steps in a session to complete the learning activity: (1) authenticate user and collect basic user profile (2) query location context data (depend on location and job characteristics e.g. fighting fire, police patrol etc.) (3) start and interact with dialogue planner and management (4) end dialogue and save dialogue interactions. These steps are a guideline to build the PORML architecture.

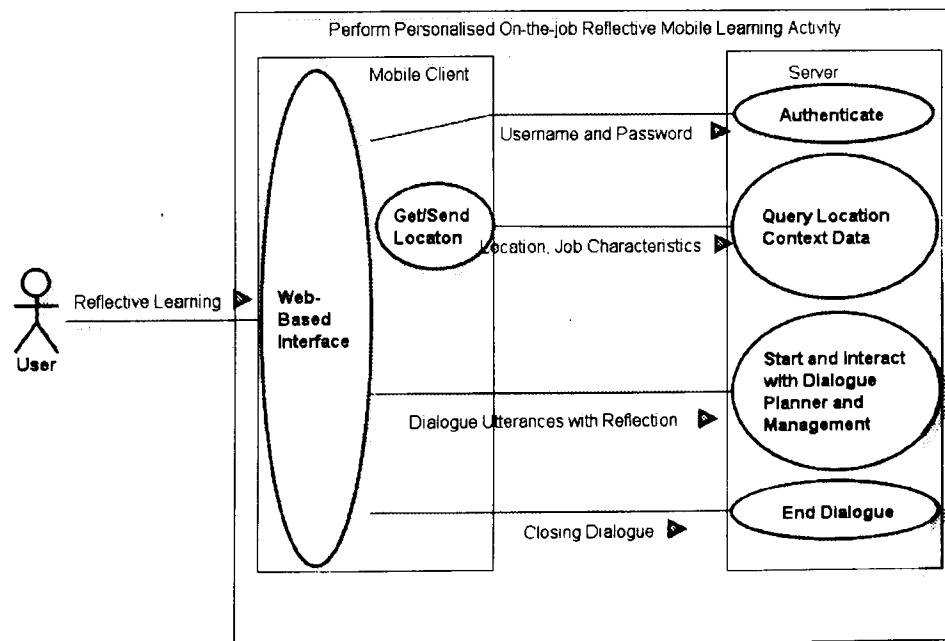


Figure 3.2 Performing personalised on-the-job reflective mobile learning activity

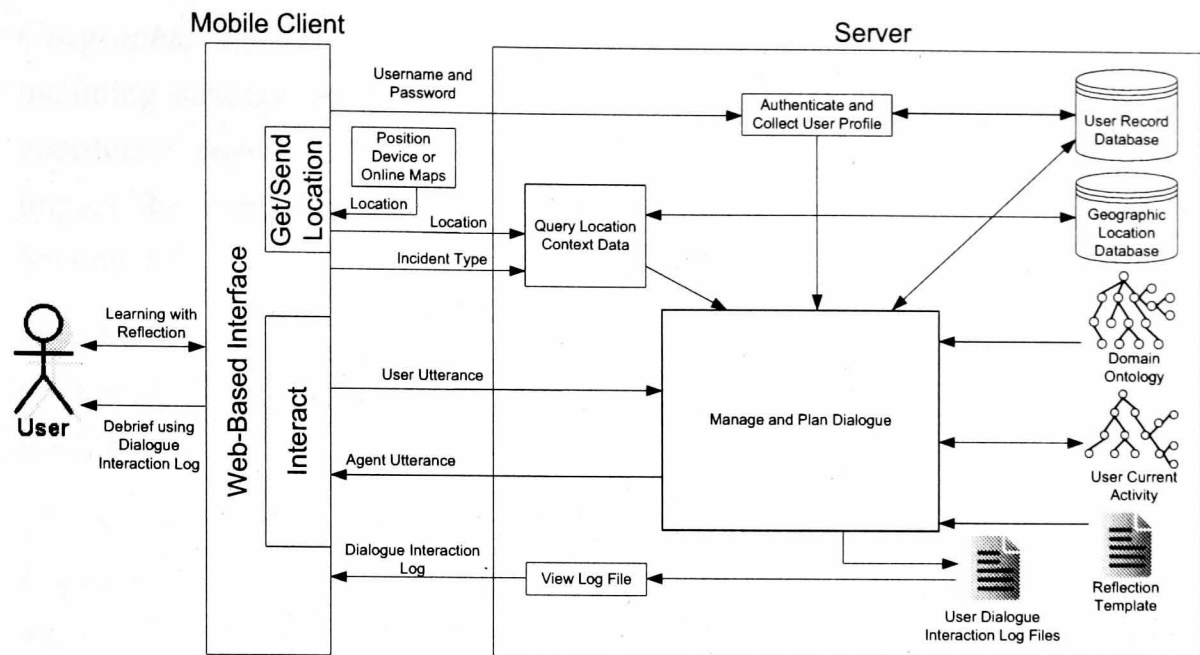


Figure 3.3 The proposed PORML architecture

The proposed PORML architecture is shown in Figure 3.3. It has two parts: mobile client and server. It consists of the following main components: Web-Based Interface, User Authentication and User Profile Collection, Location Context Data Query, Dialogue Manager and Planner, and Log File Viewer. The mobile client component is a mobile device that uses a smart-phone (or a small laptop) and that has an Internet connection and a web browser, for the Web-Based Interface component. It could also have either: a position detector e.g. GPS (Global Positioning System)⁷ receiver to detect a coordinate of the device position or online maps to select a target place. The remaining components appear on the server component. The details of these components are described in the next Section.

The following data resources in the PORML architecture: User Record Database, Geographic Location Database, Domain Ontology, User Current Activity (UCA), Reflection Template and User Dialogue Interaction Log Files, are used or produced by the main components. The details of the data resources can be described as follows:

- *User Record Database* contains basic user profiles e.g. username, password, firstname and lastname, home address etc., and other user information that relates to a user's job or work practice e.g. role, organisation, work experiences and weather conditions for particular work practice etc. The user record may be an existing organisation's database that provides personnel and their work practice information;

⁷ GPS is a U.S. space-based radio navigation system that provides reliable positioning, navigation, and timing services to civilian users on a continuous worldwide basis – freely available to all. For anyone with a GPS receiver, the system will provide location and time. (<http://www.gps.gov/>)

- *Geographic Location Database* provides geographic location context data including surrounding the target place or incident place location, e.g. place name, coordinate position, type of place and topographic features etc., that might impact the user activity. The Geographic Location Database is described in Section 3.6;
- *Domain Ontology* for domain knowledge represented in OWL. It provides information used for dialogue planning. The creation of the Domain Ontology is described in Chapter 4 using a case study of RA domain ontology in FRS;
- *User Current Activity* is specified in OWL resembling an ontology specification. It is created by the dialogue agent when a dialogue interaction session of a user is started. It is maintained during dialogue interactions what the user has experiences in his job by inserting instances of the concepts that represent user activities or actions and by using these instances for planning the dialogue move. The User Current Activity model is described in Chapter 4;
- *Reflection Template* is a text file that contains a considerable number of reflective questions. Each question is selected by the dialogue agent relating to particular episode and previous answer;
- *User Dialogue Interaction Log Files* are groups of user log files that record dialogue interactions. A group is related to a user. A user can have a considerable number of log files corresponding to dialogue interaction sessions. Data in a log file is represented in a text-based format that contains a series of dialogue interactions between a user and the dialogue agent for a session.

3.4. Outline of the Main Components

Web-Based Interface

The Web-Based Interface provides the user interface to access the PORML server including a user login page for user authentication, a location collection page, a set of dialogue interaction pages and a dialogue interaction log viewer page. Furthermore, the Web-Based Interface is used to notify the current coordinate of mobile location in case of using a position detector and to provide an incident type e.g. chimney fire accident, road traffic accident, rescue from height etc. The current location, specified by coordinates, is detected by GPS (a guide to coordinate system in Great Britain and GPS standards can be read from (Ordnance Survey 2008)). The coordinates and the incident type are sent to the PORML server for querying the location context data. Alternatively for the location, the user might use online maps via Web-Based Interface to choose a target place or incident place and send its

location to the PORML server for querying the location context data instead. The applications and the Web-Based Interface of the PORML prototype are shown in Chapter 6.

User Authentication and User Profile Collection

The User Authentication and User Profile Collection component deals with user authentication in order to allow authorised user access the PORML server and maintain a model of UCA. It checks a username and password received from the user login page of the Web-Based Interface component against a user profile stored in User Record Database. After logging in successfully, the basic user profile is collected (e.g. username, firstname and lastname etc.), ready to be used by the Dialogue Manager and Planner component.

Location Context Data Query

The Location Context Data Query component uses the location received from the PORML client specified by coordinate to query the target place in a Geographic Location Database. After the target place is found and accepted, the user provides an incident type of the target place in order to find which location context data impacts the incident. The target place is sent to the Geographic Location Database to query the location context data of the target place surroundings related to its incident type. The retrieved location context data, the target place and incident type are then ready to be used by the Dialogue Manager and Planner component. The retrieved location context data may be relevant to the corresponding user activity. For the fire RA case, the target place is where an incident occurred that the user assessed the risk and dealt with a fire. The details of Location Context Data Query is discussed in Section 3.6.

Dialogue Manager and Planner

The Dialogue Manager and Planner component of PORML framework used for managing and planning the dialogue interaction with the user. It contains a dialogue game-based agent that is the core of interaction of the component controlling other parts in the component e.g. user utterance analyser, dialogue episodes, user current activity model manager etc. to manage the dialogues and plan the dialogue episodes for dialogue interaction. Initially, the Dialogue Manager and Planner checks the input: (1) the retrieved location context data, target place and incident type received from Location Context Data Query component (2) the basic user profile received from User Authentication and User Profile Collection component (3) results of querying User Record Database regarding user's job or work practice e.g. weather conditions and time for the being considered incident and (4) Domain Ontology to issue the first agent utterance and to build an initial UCA (output). Then, the additional input: (5) user utterances (6) reflection questions from Reflection

Template and (7) recently recorded UCA are involved during dialogue interactions to issue agent utterances and maintain UCA (i.e. record instances and their relationships and read them). Finally, the whole dialogues between user utterances and agent utterances are recorded into User Dialogue Interaction Log Files after the interaction has ended. The details of Dialogue Manager and Planner is described in Chapter 5.

Log File Viewer

The Log File Viewer component is a small component in the PORML server and is used to view the whole dialogue interactions for a user session after the dialogue interactions completed. The component reads a log file of dialogue interactions corresponding to the user session. The series of dialogue interactions are presented on the PORML client via the Web-Based Interface.

3.5. A Case Study of Fire Risk Assessment in PORML

The aim of this section is to brief the application of PORML framework using a case study of fire risk assessment in FRS to implement the PORML. The implementation is described in Chapter 6. The application of PORML framework can be described using the activity for a fire incident in the case study of fire RA as follows. A crew of firefighters⁸ arrives at the incident place. A user, incident commander⁹, who is a member of the crew having overall responsibility for dictating tactics and resource management in the incident, assesses the risk and performs something regarding fighting fire. After the fire fighting activity is complete for a few minutes later at or near the incident place, the incident commander spends time using an Internet web browser on his/her mobile device, such as smart-phone, to review and to reflect on the RA activity he/she performed. The mobile device at the incident must have the availability of Internet connection to access the PORML server via Web-Based Interface. To interact with the PORML server faster, the design of PORML Web-Based Interface uses the text-based dialogue interface rather than graphic-based dialogue interface to access the PORML server and perform the dialogue interactions.

The incident commander starts from user authentication via login web page. If the username and password is valid, he is allowed to access a dialogue interaction session and his basic user profile is collected from user records. Then, the Location

⁸ Persons whose job are to put out fires. (Oxford English Dictionary)

⁹ The officer having overall responsibility for dictating tactics and resource management. Overall responsibility for a fire remains with the senior fire brigade officer present under the Fire Service Act Section 30(3), but subject to this a more junior officer may retain the role of Incident Commander. (Fire Service Manual Volume 2 – Incident Command)

Context Data Query component checks the coordinate of device position (in case of using position detector) derived from the PORML client and calculates it using assigned distance parameters to find the places and their properties which are the incident place surroundings. The basic user profile and other user information in the User Record Database, the places and their properties, the user utterances, the Domain Ontology called risk assessment (RA) domain ontology and the Reflection Template will be employed by Dialogue Manager and Planner component for managing and planning of dialogue contents. The dialogue agent will generate agent utterances, build and maintain User Current Activity (UCA) according to incident commander experiences or activities during the dialogue interactions. The incident commander can learn with reflection during dialogue interactions. After the dialogue interactions are ended, the dialogues between incident commander and dialogue agent will be recorded in User Dialogue Interaction Log Files. The incident commander afterwards can view the dialogue interaction log that has been his recent experiences. The viewing of dialogue interaction log can help him for clarification in RA debrief to higher management and writing a work practice report.

3.6. Location Context Data Query

The aim of this section is to explain what is the location context data stored in Geographic Location Database, how the Location Context Data Query component extracts the location context data from Geographic Location Database.

3.6.1. Location context data using GML

It is possible that the geographic location context data can be extracted by the use of interactive location-based data services provided by maps service providers such as Google Maps, Ordnance Survey (OS) MasterMap (Ordnance Survey 2010a) etc. The Location Context Data Query component can be designed to extract location context data either corresponding to particular maps service providers or corresponding to standard geographic information interface e.g. Geography Markup Language (GML) (OGC 2010) that certain maps service providers (e.g. Ordnance Survey) use to provide the interface for geographic application. GML is based on a common model of geography which has been developed and agreed to by the vast majority of all GIS vendors in the world (Lake 2010). The PORML framework considers the standard geographic information interface using GML. GML is an XML-based encoding standard for geographic information developed by the Open Geospatial Consortium

(OGC)¹⁰ represented in the form of text that is easy to inspect and easy to change. GML describes the world in terms of geographic entities called **Features**. A feature is a list of properties and geometries. Properties have name, type and value description. Geometries are composed of basic geometry building blocks e.g. points, lines and polygons etc. Generally, the encoding of the geometries and properties of a feature might look like this:

```
<Feature fid="121" featureType="school">
  <Description>"headingley school"</Description>
  <Property name="NumStudents" type="Integer" value="1350"/>
  <Polygon name="extent" srsName="epsg:25643">
    <LineString name="extent" srsName="epsg:25643">
      <CDATA>
        546605.25,258402.31 546610.12,258405.08
        546620.35,258410.15 546623.11,258411.98
        546628.54,258375.22</CDATA>
      </LineString>
    </Polygon>
  </Feature>
```

In case of using GML, the location context data in the PORML framework can be used in the form of a PORML Geographic Location Database disconnected from the maps service provider or in the form of a GML data (features) from a GML data server (Web Feature Server or WFS) provided by a maps service provider or a geo-spatial vendor. Therefore, the Location Context Data Query component may be used to query the location context data (the features and their properties) from a PORML Geographic Location Database which is embedded in the PORML architecture as shown in Figure 3.4 or to interact with the GML data server provided by a maps service provider or a geo-spatial vendor as shown in Figure 3.5. There are a significant number of geo-spatial vendors e.g. CubeWerx Ltd., Ionic Software, ESRI, Laser Scan and Oracle Corporation etc. providing the GML data in order to extract the GML features online.

¹⁰ <http://www.opengeospatial.org/>

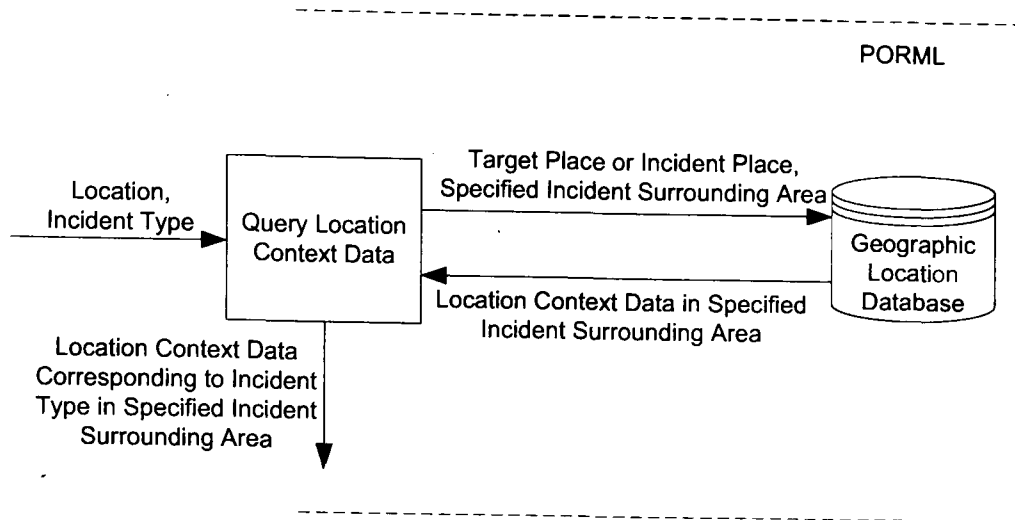


Figure 3.4 Querying location context data using Geographic Location Database

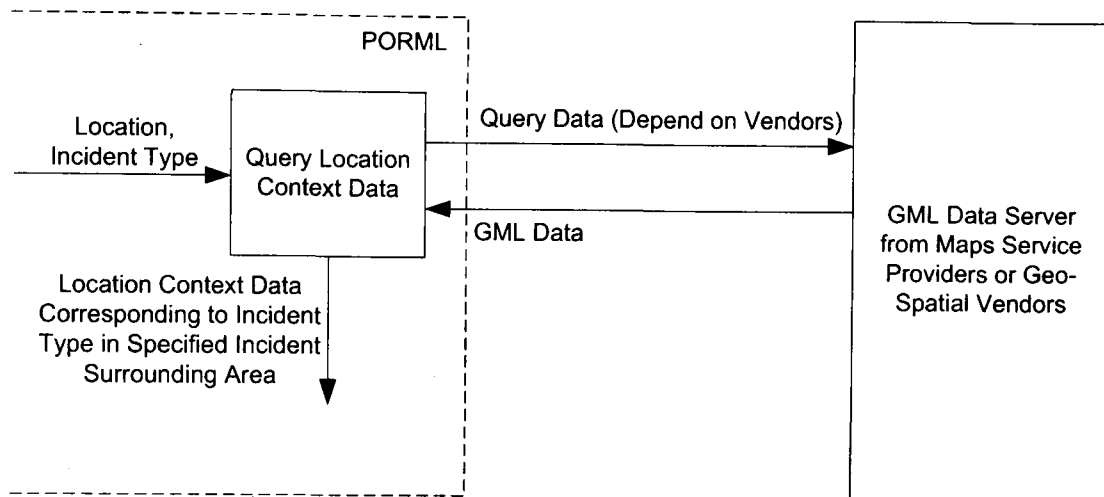


Figure 3.5 Querying location context data interacting with maps service providers or geo-spatial vendors

The implementation of the Location Context Data Query component for PORML Geographic Location Database (Figure 3.4) and for GML features online using GML data server (Figure 3.5) will be different. The Location Context Data Query component for the latter needs a GML parser. The latter is more complicated to develop but it is used in practice for GIS applications. Furthermore, the latter might not provide certain specific feature properties to the application of PORML such as feature business names of building or place (e.g. Chemist, The SixBells Pub, The SixBells Car Park, Kiren Chinese Food etc.), feature types (e.g. Public House, Car Park, Fire Station etc.). They must be created in advance in the PORML framework and mapped to the parsed GML data from geo-spatial vendors. However, in our implementation of PORML framework we do not implement and use the latter for online interaction with any maps service providers or any geo-spatial vendors for a PORML prototype.

The Location Context Data Query component for the former is implemented to prove the concept of PORML framework only. A GML data file is downloaded beforehand from a geo-spatial vendor or a maps service provider e.g. Ordnance Survey. The downloaded GML data is provided by specifying a map area e.g. specifying two coordinates in an Ordnance Survey maps service as shown in Figure 3.6. The Figure shows a map area that contains geographic features e.g. buildings, places, streets etc. Afterwards the features and their properties (the Dialogue Manager and Planner component of PORML prototype uses only a small number of feature properties in GML data) are selected and entered manually into the Geographic Location Database. The specific feature properties to the application described above are also inserted into the database. The database is then ready to use for query. However, it is also possible to use a GML data file directly instead of the Geographic Location Database in order to parse the GML data using a GML parser and map specific feature properties to query the desired feature properties for location context data automatically.



Figure 3.6 A map specified by two coordinates corresponding to the downloaded GML data

The specific feature properties for the application of PORML are not only related to the location input from the web-based client but also they are related to the incident type input provided by the user. For example, a building fire RA incident in a city is an incident type in FRS practice that can have surrounding building properties that might impact the fire RA e.g. a petrol station (one of surroundings) near the fire incident building (incident place that is a building) might cause higher risk to firefighters in the fire incident during fire operations.

To clarify what feature types can be extracted from GML data for the PORML framework, we will use a GML data created by Ordnance Survey maps service using

OS MasterMap topography layer to explain the structure of geographic data in a downloaded GML data file. However, the GML data from other vendors may be different from that found in the Ordnance Survey maps service e.g. URI namespace, Coordinate Reference System, feature types etc.

OS MasterMap topography layer (Ordnance Survey 2009)

The OS MasterMap is designed for use as a digital map within Geographic Information System (GIS) and database systems. The data specification works within the existing structure of OS MasterMap are represented as **layer**, **theme**, **feature** and **attribute**. A **layer** is a set of related OS MasterMap themes that can be used together for end-user applications. A **theme** is a logical collection of features that have been grouped according to their classification or relationship with other features. **Features** are digital representations of real world concepts. An **attribute** is any item of information packaged in an OS MasterMap feature (most feature attributes are encoded as GML properties – property means a GML property).

The OS MasterMap consists of four separate (topography layer¹¹, address layer¹², integrated transport layer¹³, and imagery layer¹⁴) in addition to complementary layers that provide detailed topographic, cartographic, administrative, address, aerial imagery and road network features positioned on the National Grid¹⁵(Ordnance Survey 2008). In our case, only topography layer has sufficient information to be employed for PORML prototype. The OS MasterMap topography layer product is supplied in GML version 2.1.2. Querying the data, each GML data output provided by Ordnance Survey is in response to a request for data from a data user. The Table 3.1 shows an excerpt of GML data output of the map in Figure 3.6 generated by providing a user query of two National Grid easting and northing coordinates.

When a query request is made for GML data from maps providers, data is always returned in FeatureCollections. For the case of Ordnance Survey, they are represented in the form of <osgb:FeatureCollection>...</osgb:FeatureCollection>. The ‘osgb’ is a URI namespace of Ordnance Survey. Each OS MasterMap topography layer feature is represented as either a point, line or a polygon. There are three types of point feature: topographic point¹⁶, cartographic symbol¹⁷, cartographic

¹¹ The topography layer was the first layer to be produced. The features within this layer are mainly features that appear in the landscape, such as buildings, land, water and roads. It also includes administrative boundaries.

¹² The address layer contains postal addresses with a unique identifier and references to OS MasterMap topography layer feature.

¹³ The integrated transport layer (ITN) contains the Road Network and Road Routing Information for Great Britain.

¹⁴ The imagery layer contains aerial images.

¹⁵ A unique referencing system that can be applied to all Ordnance Survey maps of Great Britain at all scales. It provides an unambiguous spatial reference for any place or entity in Great Britain.

¹⁶ Represent topographic detail and spot heights.

text¹⁸; two types of line feature: topographic line¹⁹, boundary line²⁰; one polygon feature: topographic area²¹. The feature types of this map contain cartographic members (cartographic symbol, cartographic text), and topographic members (topographic area, topographic line, topographic point) except boundary line feature. Each feature has a unique reference (fid) known as a TOID. The TOID is a number with a prefix of 'osgb'. The TOID stays the same throughout the life of a feature. A building feature of incident place, for example, namely 'The Six Bells' is represented as the topographic area of a feature object in GML data with the TOID 'osgb1000010224782'. Actually, the feature name 'The Six Bells' is a business name that does not appear on this sample map or this GML data. Certain maps providers or geo-spatial vendors e.g. Google Maps provide this feature name. In this case we must add the specific feature properties such as the feature name 'The Six Bells' into the Geographic Location Database for querying the location context data.

17 Store information about the location and type of symbology used when rendering OS MasterMap graphically.

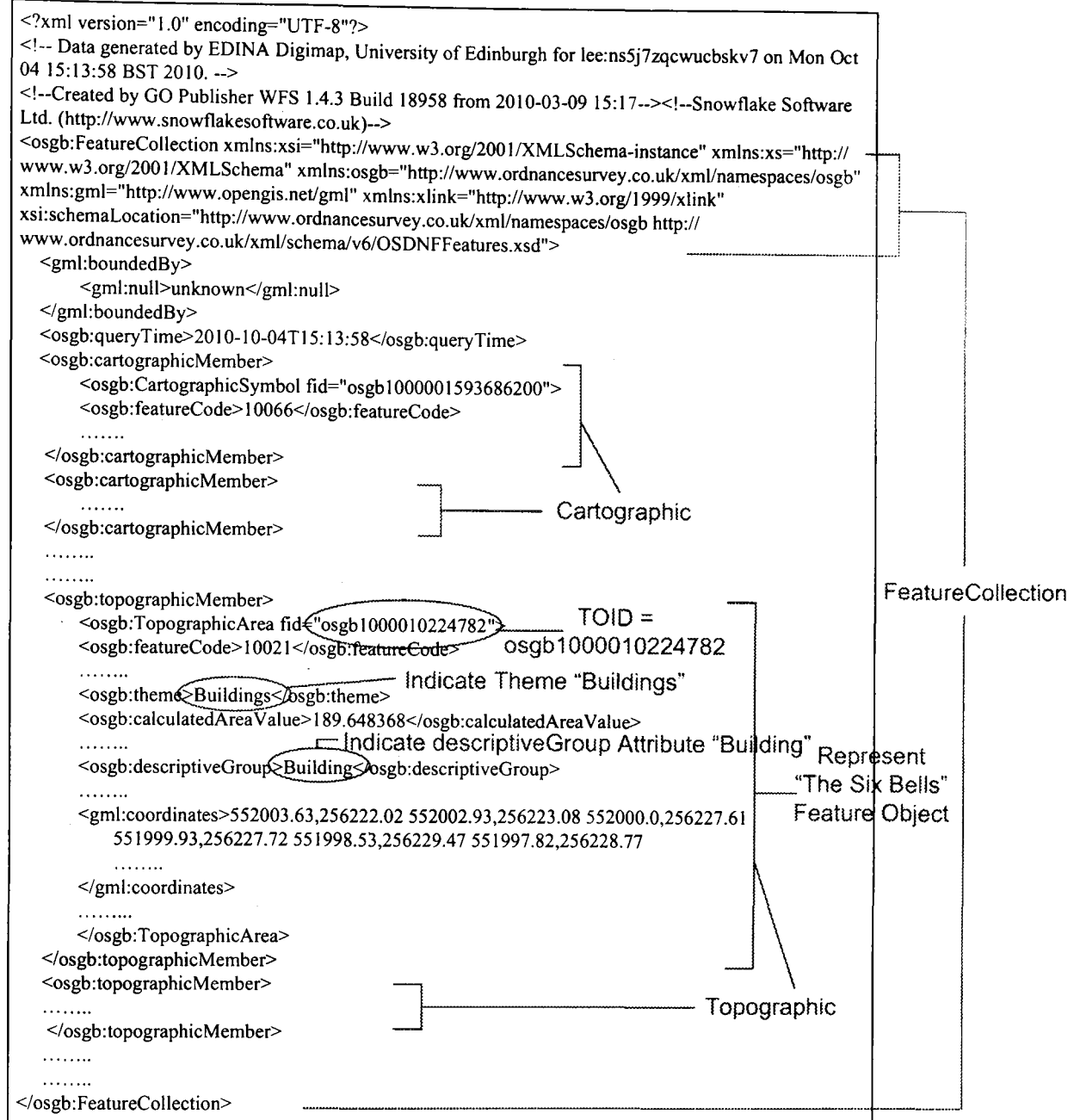
18 Define the content and placement of text when rendering OS MasterMap graphically.

19 Represent topographic information and inferred topographic area boundaries such as polygon closing links.

20 Represent the boundaries of administrative areas.

21 Represent topographic information.

Table 3.1 Excerpt of GML data output of the map in Figure 3.6



The OS MasterMap topography layer provides a considerable number of details and classification in location context data to deal with the large scale area of Great Britain map while the sample map has small area and a significant number of features are not involved in the sample map. To prove the concept of using PORML framework only, a limited number of features are entered into Geographic Location Database that can illustrate the impact of the application e.g. risk assessment. For example: the theme *buildings* with descriptiveGroup²² *building* used for ‘petrol station’, ‘public house’; the theme *land* with descriptiveGroup *general surface*²³ used for ‘car park’; and the theme *roads, tracks and paths* with descriptiveGroup *road or track* used for ‘narrow road or street’, derived from GML data are considered for possible impact. An appropriate method is needed to capture topographic area feature objects for query in the application such as representation of

²² Attribute with descriptive information about the feature.

²³ Features representing, describing or limiting areas of land not covered by buildings or structures

feature objects using primitive geometries. Certain researches use the simplest primitive geometry to model the GIS objects such as a point to represent a topographic feature object (Francis, Thambidurai et al. 2006; Wadembere and Ogao 2010) for handling objects in applications. The methods to model the representation of GIS object is generally complicated and beyonds our scope. However, in our case a topographic area feature object is represented by a point easting/northing coordinate (E, N) using manual approximation of appropriate point in the polygon of topographic area feature object e.g. approximate point that look like the centre of the polygon etc. The points representing the topographic area feature objects are added in the Geographic Location Database. Other feature properties could also be added in the Geographic Location Database such as place name, place type to provide the meaning of feature objects.

The Geographic Location Database is constructed using the feature properties to describe and represent the feature objects used as the location context data as follows.

- **ID** represents new assigned id of the topographic area feature object
- **PN** or place name represents the business name of buildings or places
- **PT** or place type represents the type of buildings or places linked to concepts or classes regarding buildings or places in domain ontology
- **E** represents easting in easting/northing coordinate in metre unit
- **N** represents northing in easting/northing coordinate in metre unit
- **descriptiveGroup** represents a GML property derived from descriptiveGroup attribute of the feature in OS MasterMap
- **Theme** represents theme derived from the theme in OS MasterMap

Some examples of Geographic Location Database are shown in Table 3.2.

Table 3.2 Examples of location context data inserted in Geographic Location Database

ID	PN	PT	Position (E, N)		descriptive Group	Theme
			E	N		
007	The SixBells	Public House	551,994	256,228	Building	Buildings
008	The SixBells Car Park	Car Park	551,982	256,222	General Surface	Land
019	Garage	Garage Service	552,021	256,256	Building	Buildings
023	Antics Technologies, Edmund House	House	552,033	256,289	Building	Buildings
025	High Street	Narrow Road or Street	551,999	256,238	Road or Track	Roads, Tracks and Paths

3.6.2. Querying location context data

The feature objects (buildings and places) surrounding the incident place on the sample map are considered as the contextual information that might have an impact on a risk assessment activity. The mobile device location, the centre of PORML Working Area, is assumed in a location on the sample map as shown in Figure 3.7.

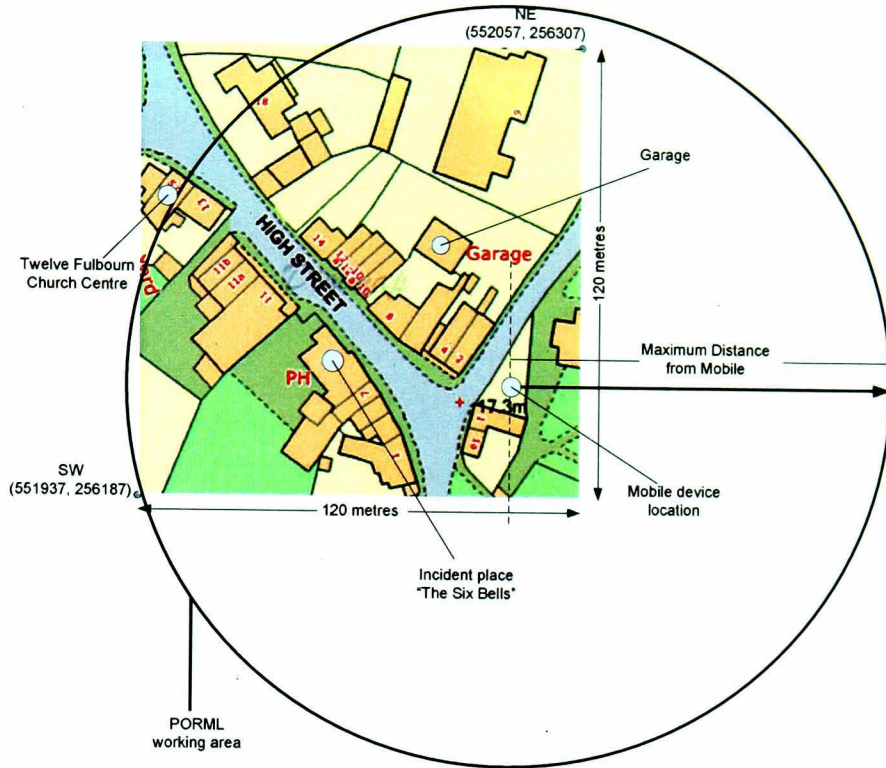


Figure 3.7 Using PORML Working Area to find and choose the incident place position

Since the incident place location is located very close to the centre of the sample map, the PORML Working Area is set by radius of the circular area 'Maximum Distance from Mobile', for example, to 100 metres to ensure that it covers the incident place location. Each feature object inside the PORML Working Area will be taken into account for finding the incident place location by distance calculation of two easting/northing coordinates between the mobile device location and the feature objects using a simple formula:

$$D^2 = (E1 - E2)^2 + (N1 - N2)^2 \quad \text{----- (1)}$$

$$D \leq \text{Maximum Distance from Mobile} \quad \text{----- (2)}$$

D = distance parameter between mobile device and feature object.

E1, E2 = easting of easting/northing coordinate of mobile device location and feature object location;

N1, N2 = northing of easting/northing coordinate of mobile device location and feature object location;

Maximum Distance from Mobile = the maximum distance between mobile object and feature object for considering involvement.

The distance of two objects can be calculated using the distance formula (1) and (2) related to mobile device location in order to find the incident place location in the PORML Working Area. After the PORML knows the incident place location and its name, the Location Context Data Query component will set the incident place location as the centre of the Interest Area as shown in Figure 3.8.



Figure 3.8 Using Interest Area to specify the boundaries which buildings and places are involved for location context data collection

The Interest Area is set by radius of the circular area 'Maximum Distance from Incident', for example, to 30 metres to cover the considered feature objects. Each feature object inside the Interest Area will be taken into account for considering the location context data from the feature object that might impact the user activity of the incident, for example, risk assessment activity using a simple formula:

$$d^2 = (e1 - e2)^2 + (n1 - n2)^2 \quad \text{----- (3)}$$

$$d \leq \text{Maximum Distance from Incident} \quad \text{----- (4)}$$

d = distance parameter between incident place and feature object;

e1, e2 = easting of easting/northing coordinate of incident place location and feature object location;

n1, n2 = northing of easting/northing coordinate of incident place location and feature object location;

Maximum Distance from Incident = the maximum distance between incident place and feature object for considering involvement.

The distance between two feature objects is calculated using distance formula (3) and (4) related to the incident place location to find the feature objects inside the Interest Area. To query the location context data corresponding to incident type for the incident place location in the Interest Area boundary, rule-based selection is used in the Location Context Data Query component and the following parameters are involved in the query:

$$LCDI = Query(incident\ type, PT, e, n, descriptiveGroup, theme) \text{ ---- (5)}$$

LCDI = extracted location context data for specified incident place that might impact the user activity of incident e.g. evacuation area using Car Park in theme “Land”, hazardous materials from Petrol Station, traffic condition from Narrow Road or Street etc.;

Incident type = type of incident, for example, chimney fire, building fire;

PT, E or e, N or n, descriptionGroup and theme = described details above in previous section.

For example, we assume a case in chimney fire and use the examples of location context data inserted in Geographic Location Database shown in Table 3.2 that correspond to the feature objects on the map with specifying Interest Area shown in Figure 3.8. The ‘SixBells pub (ID = 007)’ is assumed as an incident place and the results of distance calculation between feature objects and the incident place (≤ 30 metres) using formula (3) are found that only ‘The SixBells Car Park (ID = 008)’ and ‘High Street (ID = 025)’, except the incident place, are inside the Interest Area. Therefore, the LCDI of ‘The SixBells Car Park’ and ‘High Street’ are extracted and generated using formula (5) as ‘Car Park (Land)’ and ‘Narrow Road’ respectively, whereas the others are blank or empty string. These examples are shown in Table 3.3.

Table 3.3 Examples of location context data (LCDI) that might impact the user activity of incident extracted from Geographic Location Database

ID	PN	PT	Distance from incident place in metre unit calculated from formula (3)	descriptive Group	Theme	LCDI from formula (5)
007	The SixBells	Public House	0.0	Building	Buildings	Blank
008	The SixBells Car Park	Car Park	13.42	General Surface	Land	Car Park (Land)
019	Garage	Garage_Service	38.9	Building	Buildings	Blank
023	Antics Technologies, Edmund House	House	72.4	Building	Buildings	Blank
025	High Street	Narrow Road or Street	11.18	Road or Track	Roads, Tracks and Paths	Narrow Road

Certain of the context data may not be inserted into the Geographic Location Database such as weather conditions – wind, sunny, visibility, and other specific context related to the type of incident e.g. crowded of people surroundings etc. These context data are provided by interaction with the user. The use of these context data and location context data stated in Table 3.3 are shown in Table 4.10 in Chapter 4, and Figure 6.12 in Chapter 6.

3.7. Discussion

The PORML framework is designed to promote reflective learning in fire risk assessment to support the training in FRS. On the one hand, the framework provides certain benefits of training in FRS practice. The reflective learning of the framework does not impact on any fighting fire during firefighters operation and the crew commander or incident commander can recognise easily from recent incident in order to **provide accurate information of activities or actions to reflect their activities or actions** (Schon 1983) during his/her dialogue interaction after the fighting fire incident is complete. The client of the PORML framework does not use any specific client application depending upon hardware or operating system. That means it can be **flexible to use different mobile devices including the future versions of mobile device development providing the Internet web browser**. The incident commander can interact with the PORML server via network services using Internet web browser provided by those devices. Using the text-based dialogue interface rather than graphic-based dialogue interface to access the PORML server will help us to perform the dialogue interaction faster and reduce the frustration of low bandwidth network services.

The information of user profiles in the User Record Database used by User Authentication and User Profile Collection component can be **extended in the future for personalisation to particular user** including the past experience of crew commander and crew member. The possible feature of Location Context Data Query component can be developed to collect the incident place location using graphic map on the mobile device in case the GPS receiver is not available to detect the position of mobile device. Using the graphic map can also help us employ the PORML server with the computer laptop or desktop easily to review the risk assessment activity at the fire station or other places rather than the PORML Working Area. The user activity can be **extended in the future for the past experience involvement** by recording the User Current Activity as the user past activity (experience) for the next use to compare with the next user activity. **The log file of user dialogue interaction can be used to remember a user's reflective learning and review and be referenced for debrief or incident review report to higher management.**

On the other hand, certain drawbacks appear on the concept and design of the PORML framework. The use of PORML will **depend upon the availability of network connection and Internet service provider**. The Location Context Data Query component of the framework uses National Grid easting/northing coordinates as the example for implementing the prototype to describe and represent topographic feature objects on the map so as to calculate the distance between two feature objects in units of metre but the framework **does not state the standard of GPS coordinate**

(Ordnance Survey 2008) provided by GPS receiver. If the GPS receiver detecting the position provides longitude, latitude and ellipsoid height coordinates (WGS84, OSGB36 TRF) and does not provide National Grid easting/northing coordinates, the PORML server **must be able to convert the former coordinate system to the latter coordinate system** (see conversion in (Ordnance Survey 2008)). Otherwise this type of GPS receiver can not be used in the PORML server.

The framework **can not provide explicitly the details of location context data query component when it is applied to automatic GML data collection** interacting with maps service providers or geo-spatial vendors. It has to be different from the semi-automatic GML data collection used for implementation in our PORML prototype. Although GML is a widely used for encoding standard geographic information for interoperability, it is a framework and **the vendors might implement GML data output in different ways**. It has also a considerable number of versions that have certain difference. **The design of the PORML framework might have to refer to the version support.**

3.8. Summary

The architecture of PORML framework was introduced in this chapter. The five main components of the framework were outlined containing Web-Based Interface component, User Authentication and User Profile Collection component, Location Context Data Query component, Dialogue Manager and Planner component, and Log File Viewer component. The overview of PORML framework and its main components were presented to describe their connection and how they work. A case study of fire risk assessment is introduced for the application of PORML. The Geographic Location Database derived from GML data how it is created and is explained. The Location Context Data Query component was described regarding the use of Geographic Location Database to query location context data related to the incident. The concept of querying the location context data is explained using point geometry to represent the feature objects.

Chapter 4

Ontological Model of Risk Assessment Activity

4.1. Introduction

The previous chapter described the architecture of the PORML framework and its components in the PORML server, as well as their interaction with the remote client via a web browser. Details of the contextual information used in PORML framework, focusing on the location context data and the use of semantic data of maps (GML data), was described in Chapter 3, Section 3.6. It was shown how a sample image map (see Figure 3.6 in Chapter 3) would be linked to semantic data (see Table 3.1 in Chapter 3) about feature properties of location or location context data in Geographic Location Database (see Table 3.2 in Chapter 3). As shown in Chapter 3, the contextual information in PORML has to be further enriched with knowledge about the risk assessment activity users are engaged in.

The aim of this chapter is to present an ontological model of risk assessment (RA) activity, providing the domain model in the PORML framework. A description of the methodology followed to create an RA domain ontology is provided in Section 4.2. The requirements specifications of our first step in the methodology will be presented in Section 4.3, following the conceptualisation step to show how to use Activity Theory to create the conceptual model of an RA domain ontology in Section 4.4. The coding step to present how to build a logical model (in OWL) of the RA domain ontology is given in Section 4.5. Section 4.6 will describe the user current activity model used in PORML, while the ontological model of RA activity will be discussed in Section 4.7. The RA domain ontology and the user current activity model are crucial parts of the PORML framework and provide the knowledge blocks for the intelligent game-based dialogue (Dialogue Manager and Planner) component described in chapter 5.

4.2. Ontological Creation Methodology

4.2.1. Ontological models

In computer science and information science, the definition of an ontology was proposed originally by (Gruber 1993): “*an ontology is an explicit specification of conceptualization,*” which is “*the objects, concepts, and other entities that are presumed to exist in some area of interest and the relationships that hold among*

them.” The ontology benefits from the definition of concepts and relationships that are in terms of definitions of representational vocabulary e.g. classes, relations, functions and other objects. The representational vocabulary is used to represent knowledge and these definitions provide meaning for vocabulary and formal constraints on its coherent use.

Much existing work in risk assessment provides risk assessment ontology and methodology focusing on different types of risks or different areas of concern. For instance, the CORAS (Braber, Dimitrakos et al. 2003) project, AORDD (Siv Hilde and Geri 2005) project, RacWeb or Risk Assessment for Customs in Western Balkans (Dimakopoulos and Kassis 2008) project. The CORAS project uses a combination of Unified Modelling Language (UML) and Unified Process (UP) to support a model-based risk assessment (Gran, Fredriksen et al. 2004) on security critical systems. The CORAS model-based risk assessment methodology incorporates a risk documentation framework, a number of integrated risk assessment techniques and a risk management process (Braber, Dimitrakos et al. 2003). The CORAS ontology in risk assessment contains classes relating to security, such as assets, security requirements, threat, risk, vulnerability etc. and their relationships. The CORAS risk assessment methodology and its ontology are used and validated in the area of telemedicine and e-commerce through several trials. The AORDD project uses UML and is based on the integrated system development and risk management process of CORAS, providing support for specifying and implementing security risk treatments as aspects. The AORDD risk assessment ontology represents a general description of the situation for security critical systems and is applied in the areas such as the e-commerce system. The RacWeb project supported by the European Commission uses an existing methodology called METHONTOLOGY (Fernandez-Lopez, Gomez-Perez et al. 1997) to develop its RacWeb risk assessment ontology. The RacWeb ontology is a domain specific ontology in the area of customs risk assessment.

The ontologies are used to model data at the semantic level and are used for knowledge sharing, enabling interoperability among disparate systems etc. The purpose of developing an ontology in our work is: (1) to use the RA domain ontology as the knowledge for intelligent dialogue agent extraction; (2) to enable reuse of RA domain knowledge for extension in the future. Our ontology is also domain specific in the area of Fire and Rescue Services (FRS) and has certain constraints that will be stated in the next section. The risk assessment methodologies above are not applicable.

4.2.2. Relevant methodologies

The creation of an ontological model requires the adoption of an appropriate ontology authoring methodology. This section will describe the methodology followed for building the domain ontology employed in the PORML framework. To find and adapt the appropriate methodology used in our work, the specific constraints of our domain ontology development have to be considered as follows:

- The availability of domain experts (firefighters) is limited. Their views are important but they are not available, and they don't have any knowledge of engineering or ontology engineering (OE) skills;
- General procedures of RA explained in guides/manuals we have accessed are the standard point of view and the web contents are specific cases. In practice, the general procedure is applied in different ways so we need a generic model and a way to capture current activities;
- Since the activity is complex and not clear about the dimensions, the broad scope has to be narrowed down;
- The author is not a domain expert and is unfamiliar with the domain;
- The author lacks experience in OE, and needs a more intuitive and efficient way to define the knowledge construction;
- The iterative design is needed because of author's unfamiliarity with the domain and inexperience in OE.

Several existing methodologies and methods for building an ontology can be relevant to our ontology development process. We will review these methodologies here and will identify the important aspects and steps to be followed for the creation of the RA domain ontology in PORML.

METHONTOLOGY (Fernandez-Lopez, Gomez-Perez et al. 1997) is an ontological methodology based on the IEEE 1074-1995 standard describing software development processes (IEEE 1996). METHONTOLOGY enables the construction of ontologies including identification of ontology development, the life cycle based on evolving prototypes and the techniques for each activity (Fernandez-Lopez 1999). A number of large scale ontologies have been developed following this methodology e.g. chemical ontology (Fernandez-Lopez, Gomez-Perez et al. 1999), environmental pollutant ontologies (Gomez-Perez and Rojas-Amaya 1999), reference-ontology (Arpirez, Gomez-Perez et al. 1998) and a restructured version of the (KA)² ontology (Blazquez, Fernandez-Lopez et al. 1998). METHONTOLOGY is used in large ontology development with involvement of domain experts and knowledge engineers for long time periods. In our case, a small scale domain ontology will be

built so the strictness of activities and tasks in this methodology does not seem applicable. This methodology identifies a set of activities which are carried out when building ontologies. Three categories of activities are advised to perform: (1) project management activities including planning, control and quality assurance (2) development-oriented activities including specification, conceptualization, formalization, implementation and maintenance (3) support activities including knowledge acquisition, evaluation, integration, documentation and configuration management. However, it is useful adapting the stage of knowledge acquisition from this methodology to the first step of our methodology (see Section 4.2.3) including (Fernandez-Lopez, Gomez-Perez et al. 1999): (1) informal interviews with domain experts to consider coarse grained knowledge (2) study the main concepts given in documents, books, manuals, or other sources as the domain expert to learn as much as possible about the domain expertise (3) start looking of more general knowledge and gradually move down to particular details. The knowledge glossary construction also seems to be applicable.

Gruninger and Fox's methodology is based on experience in developing the ontology in the TOVE (Toronto Virtual Enterprise) project (Fox 1992). The developed ontologies using this methodology, e.g. scheduling ontology and enterprise design ontology, employ first order logic for constituting their integrated model (set of ontologies to support enterprise modelling). This methodology consists of six proposed steps: (1) capture of motivating scenarios (2) formulation of informal competency questions (3) specification of the terminology of the ontology within a formal language (4) formulation of formal competency questions using the terminology of the ontology (5) specification of axioms and definitions for the terms in the ontology within the formal language (6) establishing conditions for characterizing the completeness of the ontology. The methodology emphasises the importance of the competency questions during the whole development process (Fernandez-Lopez 1999; Corda 2007). This methodology does not provide sufficient details of the recommended techniques and activities. For instance, no detailed description of techniques for formulating the competency questions is involved (Fernandez-Lopez 1999). However, Gruninger and Fox's methodology uses the motivating scenario to define the scope corresponding to the first step of our methodology.

Uschold and King's methodology is based on experience in developing an ontology for enterprise modelling process (Uschold and King 1995), namely Enterprise Ontology (including terms and definitions relevant to business enterprise). This methodology consists of four steps: (1) identifying purpose (2) building the ontology (3) evaluation (4) documentation. This methodology does not

provide sufficient details of the recommended techniques and activities. Indeed, the key concepts and relationships in the domain under study are identified during acquisition but no details are given about how this could be performed and the guidelines are vague (Fernandez-Lopez 1999). Furthermore, the developer switches from knowledge acquisition into ontology implementation without performing any kind of ontology modelling activities (Fernandez-Lopez and Gomez-Perez 2002). However, Uschold and Kind's methodology suggests using the potential users to define the scope corresponding to the first step of our methodology, identifying the main concepts corresponding to the second step of our methodology.

Ordnance Survey's methodology provides two main aspects in ontological development, namely the conceptual aspect and the computational or logical aspect (Hart, Dolbear et al. 2007). The methodology assigns a set of tasks and guidelines for building a conceptual domain ontology (domain ontology defined in terms of conceptual aspects specified and used by the domain expert) with examples from Ordnance Survey's Hydrology Ontology (Kovacs, Dolbear et al. 2006). This conceptual ontology is an organised way of representing domain knowledge and it is written in structured English sentences or controlled natural language. The logical ontology represents the domain knowledge in a suitable formal language intended for machine use. The conceptual ontology is translated into a logical ontology by an ontology engineer. There are five steps: (1) identifying the purpose, scope and other requirements of the ontology (2) gathering source knowledge and documents (3) capturing ontology content in a knowledge glossary (4) writing the glossary content in structured English sentences (5) evaluating and validating the ontology and documentation, which domain experts need to follow to complete the conceptual domain ontology. In our case, we contacted and interviewed the domain experts or potential users to define the scope only at the first step of our methodology, because strong involvement of domain experts throughout does not seem applicable. The knowledge glossary construction with identification of core concepts²⁴ and secondary concepts²⁵ seem to be beneficial to our work.

4.2.3. Methodology followed in this project

The appropriate methodology should be employed in our project and the chosen tasks and methods from the existing methodologies must correspond with the specific constraints of our domain ontology development. The domain experts were involved only at the beginning of development to examine coarse grained knowledge, using interviews and questionnaires, due to the limited availability of

²⁴ Concepts that are within the scope of the domain.

²⁵ Concepts that are not within the scope of the domain but are required are included and identified in the ontology

domain experts. The motivating scenario was employed using the general procedures of RA explained in a manual, interviews and questionnaires from firefighters (domain experts) and web content with specific cases, in order to identify the purpose and scope. The Activity Theory was applied to define and construct the dimensions of RA activity and to help the author narrow down the scope to identify concepts and relationships. Since the author was not a domain expert, was unfamiliar with the domain and had little experience in OE, the intuitive ontology authoring development tools should be considered to facilitate building of the domain ontology model (described in Section 4.2.4). Iterative design using these tools was necessary. Our methodology can be outlined as follows:

1. Identifying the requirements specifications (Section 4.3);
 - Identifying the purpose of RA domain ontology;
 - Identifying the scope of RA domain ontology (using scenarios, interviews, questionnaires, and possible RA activities);
 - Gathering knowledge sources (manuals, documents, reports, questionnaires, existing ontologies, online information);
2. Creating conceptual model (Section 4.4);
 - Identifying the concepts (core, secondary) and relationships;
 - Building a conceptual glossary;
3. Coding logical model (Section 4.5);
 - Converting knowledge in the glossary into structured English sentences;
 - Building a logical model;
4. Validating the ontology.

Only steps 1 – 3 of the methodology will be presented in this chapter. With regard to the last step, part of the ontology validation will be presented at the end of the discussion section. The remaining validation will be performed via the dialogue interaction with a dialogue agent using formative evaluation in Chapter 7.

4.2.4. Ontology authoring tools used

To model the RA domain ontology, the tools used for developing an ontology following the methodology in PORML should be considered appropriately. From our specific constraints addressed above, the intuitive ontology authoring tools using controlled natural language (CNL) will be considered for use in PORML. The CNL contributes to OE by helping us to easily understand the ontology whilst supporting

all the OWL-DL language features (Hart, Johnson et al. 2007) and to enter knowledge constructs in an intuitive way (Dimitrova, Denaux et al. 2008). In the semantic web, Attempto Controlled English (ACE) (Kaljurand and Fuchs 2006), Ordnance Survey Rabbit (Hart, Johnson et al. 2007), and Sydney OWL Syntax (SOS) (Cregan, Schwitter et al. 2007) are all CNLs that can be employed to create OWL ontology language (Schwitter, Kaljurand et al. 2008).

ACE View (Kaljurand 2008) is an ontology editing tool based on ACE. It provides a CNL interface but it still requires knowledge engineering expertise to be employed effectively. ROO (Rabbit to OWL Ontology) is an intuitive ontology authoring tool using Rabbit to create structured English sentences (Denaux, Dimitrova et al. 2009) and guide an ontology developer who has little or no knowledge engineering experience to build an OWL ontology language (Dimitrova, Denaux et al. 2008). ROO is a Protégé 4 (Horridge, Drummond et al. 2009) plugin that can assist domain experts in building conceptual ontologies.

In our case, we were not aware of any tools supporting the Sydney OWL Syntax. ROO and Protégé modelling ontologies in OWL syntax were taken into account. Protégé 4 was not used as our main editor because it required experience in ontology engineering to enter Manchester syntax. ROO was mainly employed to develop our RA domain ontology corresponding to our constraints in ontology engineering and it was complemented by the Protégé 4 editor in some cases. For example, the concept of ‘Blow Back’ could not be entered using ROO (version 1.0.1) but Protégé 4 could accept it (see discussion in Section 4.7). Examples of Rabbit sentences written in ROO editor in RA domain ontology are illustrated in Table 4.1.

Table 4.1 An example of Rabbit sentence written by ROO editor

Description	Rabbit Sentence Example	Description	Rabbit Sentence Example
Concept Declaration	Public House is a concept. Place is a concept. Crew is a concept. Crew Member is a concept. Crew Commander is a concept. Chimney Fire is a concept. Fighting Fire is a concept. Car Park is a concept.	Qualified Cardinality Restriction	Every Crew <i>has member</i> exactly 1 Crew Commander .
Subjunction	Every Public House <i>is a kind of</i> Place . Every Chimney Fire <i>is a kind of</i> Fighting Fire .	Modality	A Public House usually <i>has part</i> a Car Park .
Existential Quantifier	Every Public House <i>has building</i> Building . Every Incident Commander <i>is role of</i> a Crew Member .	Instance Declaration	Hazardous Substance-Instance is a Hazardous Substance . Snow-Instance is a Snow . Chimney Fire Control Measure-ac-Instance is a Chimney Fire Control Measure-ac .
Minimal Cardinality Restriction	Every Crew <i>has member</i> at least 2 Crew Members .	Relationship Declaration	<i>has building</i> is a relationship. <i>is role of</i> is a relationship. <i>has member</i> is a relationship.

4.3. Requirements Specifications

The purpose of this step is to identify the main requirements for the RA domain ontology in PORML, to ensure that the ontology creation is focused.

4.3.1. Identifying purpose

Before creating an ontology, one should specify its purpose, namely why the ontology must be built and what the intended usage is. In our case, we want to describe the risk assessment activity in fire and rescue services, which can provide a knowledge model for planning a dialogue with the user to review how he/she has performed the current risk assessment activity. Hence, we specify that:

The purpose of RA ontology in PORML is to describe the main classes related to the fire risk assessment activity, and to link them to classes describing key topographic objects of buildings and places that are related to fire risk assessment. The intended use of the ontology is to provide the domain knowledge for planning a dialogue with a user to review the fire risk assessment activity he/she has performed.

4.3.2. Identifying scope

The scope is defined to specify which area of knowledge will be addressed by the ontology. We must set a precise and concise scope to create a good ontology (Kovacs, Dolbear et al. 2006) that can guide us to define the core concepts (the concepts within the scope of domain), the secondary concepts (the concepts not within the scope of domain that must still be included and identified in the ontology) and the concepts that are not relevant to (and will not be included in) the ontology.

We conducted an interview with a domain expert (project manager for South England from Fire Control, UK) and got feedback from firefighters' questionnaires to examine coarse grained knowledge about the domain. The possible activities from three common risk assessment activities, namely home, road traffic accident and chimney fire risk assessments, were considered. The advantages and disadvantages of these RA based on discussion with the domain expert are shown in Table 4.2.

The main advantages of home risk assessment are ease of modelling and simple to follow instruction guidelines. The main disadvantages are that its simplicity makes it unsuitable for illustrating the benefits from mobile support and that it was not clear what learning was required. The learning or training activity in FRS was a crucial activity for our selection in the project, so the home risk assessment seemed least interesting regarding the learning activity. The advantages of road traffic accident include its suitability for describing the activity and for

creating the knowledge with different activity models. However, the main disadvantages of road traffic accident are its excessive complexity and highly dynamic nature that make it impossible to capture all aspects and the fact that active collaboration with external services e.g. police, ambulance may be required. The road traffic accident therefore seems unsuitable for starting the design with the complex activity. The chimney fire looked more unusual and interesting than home inspection, was fairly simple and covered all aspects of the PORML framework. It resembles fire extinguishing activity and shares similarities with road traffic accidents but is much simpler. The main disadvantage of chimney fire is that the impact might not be very high and the details of the map might be insufficient. However, the chimney fire scenario could be created using guidelines from fire activity in the Practical Firemanship Manual (Great Britain Fire Department 1971; Great Britain Fire Department 1981) and more information about maps could be added.

Therefore, the chimney fire was selected to define the RA domain ontology and implement the prototype. A scenario could then be built with reference to generic risk assessment manual (HM Stationary Office 1998), incident command manual (HM Stationary Office 2002), practical firemanship manuals (Great Britain Fire Department 1971; Great Britain Fire Department 1981) and real incident record at Cambridgeshire FRS (see Appendix A-1) (Cambridgeshire FRS 2008), in order to define the scope of RA domain ontology and to assign the area of knowledge the ontology would cover the scenario in Table 4.3.

The scope defines for building RA domain ontology is as follows:

Chimney fire risk assessment activity of operational (or generic) risk assessment activity in Fire and Rescue Services (FRS) and related buildings and places, related risk assessment concepts corresponding to generic activity concepts e.g. tools, people, role, community etc.

The chimney fire risk assessment scenario information in Table 4.3 was used to define the scope, for instance: (1) **chimney fire risk assessment activity** was derived from ‘the chimney accident’; (2) **related buildings and places** was derived from ‘the building at the Six Bells public house’; (3) **related risk assessment concepts corresponding to generic activity concepts** was derived from ‘crew commander and his colleagues arrived at the Six Bells public house’, ‘low wind’, ‘good visibility’, ‘offensive mode’, ‘cordoned off’, ‘used roof ladder’.

The generic scenario of use of reflective on-the-job training for work practice is shown in Appendix A-2.

Table 4.2 Advantages and disadvantages of three commons of RA

Risk Assessment	Advantages	Disadvantages
Home risk assessment	<ol style="list-style-type: none"> 1. It is static situation, therefore, it will be easier to model; 2. There is a standard report form which can be followed with the instruction guideline e.g. fire & safety risk assessment; 3. There is a fire risk assessment form how to record the risk assessment (either from firefighters or another person); 4. It looks routine and should be done regularly but the impact of missing something out can be huge; 5. It can start from prevention and move to extinguish fire. 	<ol style="list-style-type: none"> 1. It is not clear what learning is required; 2. It may not be appropriate for experienced firefighters and may be beneficial for people from companies who are responsible for fire safety; 3. It may be too simple to illustrate benefits from mobile support.
Road traffic accident (RTA)	<ol style="list-style-type: none"> 1. There are many scenarios described in the literature, so it is possible to get a general idea what is happening; 2. It can be imagined what the activity is and what can be involved; 3. The generic risk assessment (GRA) can be used as the basis for describing the activity and can be used for creating the knowledge; 4. The different activity models can be used depending on location. 	<ol style="list-style-type: none"> 1. It is too complex; 2. A simple scenario can be created but we don't know how close it will be to a realistic case. It will be beneficial to talk to firefighters to see if they can advise on simple scenarios closed to realistic; 3. There is dynamic development, might use, sources depending on the situation, we may not be able to capture all aspects. This can bring an interesting challenge how to deal with incomplete knowledge sources; 4. Diverse sources of information, may require knowledge structure, whose integration will be a challenge.
Chimney fire	<ol style="list-style-type: none"> 1. The top level of the activity is the same as RTA and others; 2. It looks like fire extinguishing activity and has similarity with RTA, however, chimney fire is much simpler because it is in rural area; 3. There are not many additional tactics, as in a RTA; 4. There are similarity with home inspection; 5. It can start from prevention and extend to extinguish fire; 6. It looks more unusual and interesting than home inspection; 7. There are different aspects, some coming from the buildings, others from the surroundings, so we can add location and make it more interesting; 8. There seems to be clear need for training even for existing firefighters, as well as for inexperienced firefighters. 	<ol style="list-style-type: none"> 1. It may be too specific, not much information about activity which makes the knowledge creation more different, and related only certain areas; 2. The details we have the map may be insufficient, we may need to add more information; 3. The impact may not be very high because there are not many people indangered; 4. It may be possible to guess what an activity may include following the description in poster and GRA but this still needs validation.

Table 4.3 A scenario derived from adapting real incident record at Cambridgeshire to define the scope of RA domain ontology

The fire occurred from the chimney accident near the foyer of the building at the Six Bells public house on the 29 High Street, Fulbourn, Cambridge, Cambridgeshire, CB21 5DH. An employee in charge tried to extinguish the fire but it spread to others parts in the building. The customers and staffs were evacuated from the building. At the same time, a receptionist called 999 to FRS. And then, a few minutes two crews (one became a crew commander or an incident commander for this case) from Cambridgeshire FRS (Fire and Rescue Services) and a turntable ladder from Cambridgeshire were called to the incident, a chimney fire. The fire starts at 6:00 p.m., the weather condition is sunny, low wind, good visibility, the traffic is normal traffic, customers and staffs have about 40 persons, no drunk of people, no hazardous material for place surrounding in 30 metres radius.

The crew commander (and become an incident commander), Paul, and his colleague arrived at Six Bells public house at 6:25 p.m. They spent a few minutes to perform some initial actions:

- Obtained information from fire control station during driving vehicle before arrived at incident site – the chimney at Six Bells pub has never occurred any fire accident and it is not quite old one;
- Using the hose reel and applied a small amount of water into the grate of chimney;
- Checked which flue on fire.
- Considered attack from the grate as first firefighting option.

Paul assessed the risk (first situation) from his experiences and knowledge for another few minutes to perform the fire actions. He assessed that all hazards were low risk. Then, he decided to take actions by sending his colleague to extinguish fire in the chimney rod on the roof using a hose reel, thermal imaging camera (T.I.C.), eye protection, mirror and a roof ladder, and he went inside the building on the ground floor to extinguish fire in the grate and the other fire inside the building. Crew commander made decision in offensive mode. Fifteen minutes later, all fires were able to be extinguished at 6:45 pm. No more risk assessment activity for next situation was required.

The following factors affected the risk assessment decisions:

Environment conditions	<ul style="list-style-type: none"> • Normal traffic; Weather tends to the good conditions
Training	<ul style="list-style-type: none"> • Training of gaining access to and working on the roof activity • Training of working in roof space and cutting away activity • Training of applying extinguishing media activity
Activity	<ul style="list-style-type: none"> • Cordoned off • Safe system of work in accessing to and working on the roof for attack from above • Safe system of work in extinguishing media
Tools	<ul style="list-style-type: none"> • Used roof ladder; Used hearth kit; Used thermal imaging camera (TIC); • Used eye protection and mirror; Used work positioning and fall arrest systems

4.3.3. Gathering knowledge sources

In this step the knowledge sources (interviews and questionnaires) described in Section 4.3.2 were clarified and analysed to gather relevant information for knowledge and to look for more information from other sources related to the purpose and scope of our domain. The knowledge sources of RA in our domain were collected from all sources shown in Figure 4.1 and listed details in the Table 4.4.



Figure 4.1 Gathering list of fire risk assessment sources

The information in Table 4.4 shows that manuals were the primary sources of collected RA knowledge. The generic risk assessment (GRA) manual in particular provided general standard operating procedure information in FRS operations. The incident command manual, dynamic management of risk, and manual of firemanship were also relevant RA sources to describe the incident commander task at the incident, the dynamic risk assessment process, and scenario examples in firefighting practice respectively.

The documents for standard operating procedures and risk assessment guidance collected from different FRSs and other organisations served as guidelines for operating procedure in practice. These documents contain a small amount of different information to the GRA manual, for instance, lists of hazard/risk activities, details of hazard/risk description, persons at risk and risk codes, details of initial actions lists etc.; however, general standard operating procedures in GRA were mainly employed, complemented by these documents. Additionally, certain information about hazard/risk tables from these documents and the analytical risk assessment form reports from West Yorkshire FRS were beneficial to guide the use of hazard/risk tables and the use of examples in analytical risk assessment form reports in order to calculate the risks which did not appear in the manuals.

The existing ontologies, Ordnance Survey's buildings and places (Ordnance Survey 2010b), e-Response LFB (e-Response 2010a), and e-Response building pathology (e-Response 2010b), were studied in order to reuse the related concepts, e.g. fire station, car park, church, crew manager, ladder, shop etc. The ontologies of these concepts were not imported directly to the RA domain ontology because only a few concepts were used and their meaning (concept terms) might be changed and tailored to our RA domain. Certain concepts, e.g. firefighter, ladder, were not defined in these ontologies, so other sources (e.g. FRS manuals, reference – English dictionary, WordNet and Wikipedia) were needed to define the meanings of these concepts. The buildings and places concepts in our domain ontology needed to be linked to places in the location context data described in Chapter 3, Section 3.6.

Table 4.4 List of knowledge sources and collected data

Type of Sources	List of Sources	Collected Data
Manuals	Operational (or Generic) Risk Assessment – GRA (HM Stationary Office 1998)	Main source of collected RA knowledge to define concepts: activities, actions, operations, hazards/risks etc.
	Fire Service Operations: Incident Command (HM Stationary Office 2002)	Information about incident commander tasks: tactical mode (offensive, defensive, transitional), system of work, etc.; relevant RA terms in glossary e.g. crew commander, risk assessment, safety etc.
	Dynamic Management of Risk at Operational Incidents (HM Stationary Office 2000)	Information about dynamic risk assessment (DRA) process used to build the sequence of activities in RA scenario; relevant RA terms in glossary e.g. risk, hazard, harm, dynamic risk assessment etc.
	Manual of firemanship: a survey of the science of fire-fighting, book11, practical firemanship 1 (Great Britain Fire Department 1981), Manual of firemanship: a survey of the science of fire-fighting, Part 6a, practical firemanship 1 (Great Britain Fire Department 1971).	The views of practical fire scenario especially in chimney fire activity
References	Dictionary: Oxford Dictionary, Longman Dictionary of Contemporary English, WordNet	Defined terms that can not be found in the FRS manuals and documents e.g. chimney, firefighter, ladder, roof etc.
Documents	Standard Operating Procedure. 4Part1A – Command Support Pack, from Cambridgeshire FRS	Information about safe system of work, review forms e.g. analytical risk assessment form etc.
	Operational Performance Review Record – OP25	Clarification about health and safety orders: levels of review, guide to review processes
	Standard Operating Procedures – for Fires in Chimneys, for Fires in Buildings, for Fighting Fires in Rural Area, for Asbestos - from Humberside FRS	Compare operating procedures with GRA (a little different information from GRA) and analyse them to adapt the appropriate activities in details
	Risk assessment guidance in health and safety services, University of Leeds (Health and Safety Services)	Risk assessment process used to compare with the GRA and DRA to get the view of scenario in FRS
Reports	West Yorkshire FRS Authority - risk assessment form (non incident ground)	The examples of analytical risk assessment used to help us for calculation about risk by assuming the weight of control measures e.g. hazardous substance has severity, 7, likelihood, 6, and risk score (severity x likelihood) is 42 and risk rating is high risk etc.
Existing Ontology	Ordnance Survey Buildings and Place Ontology: BuildingAndPlaces.owl (Ordnance Survey 2010b)	Adopt some buildings and places concepts: building, place, fire station, car park, church etc.
	e-Response London Fire Brigade (LFB) Ontology: e-response_LFB.owl (e-Response 2010a)	Few concepts can be used but no descriptions e.g. ladder, firefighter, crew manager (many concepts and their descriptions are specific to LFB and out of scope)
	e-Response Building Pathology Ontology: e-response_buildings.owl (e-Response 2010b)	Few concepts can be used e.g. building, church, shop
Interview	Interview with project manager for South England from Fire Control UK (Head of Fire Control for South England)	Coarse grained risk assessment information in FRS; Suggestion of the three possible risk assessment cases for doing the thesis: home risk assessment, road traffic accident, chimney fire
Questionnaire	Questionnaire for firefighters to build scenario	General and chimney fire information in practice used to build RA scenario
Online Information	FRS website: Cambridgeshire FRS, Humberside FRS, West Yorkshire FRS	Explore real incident records used to build RA scenario; get operating procedure documents and compare to GRA
	Wikipedia	Defined terms that can not be found in the FRS manuals, documents, and sometime in the references e.g. hose, car park etc.

An informal interview with a project manager for South England (from Fire Control, UK) was used to define the scope. The project manager provided coarse grained information in FRS, suggested the three most common RA activities in FRS practice and discussed the advantages and disadvantages of these common RA activities. The discussion helped us to choose which activities could be employed for our implementation. The questionnaire for firefighters was used to collect general information about fighting fires and, in particular, chimney fire operations, from experience firefighters. FRS websites, e.g. Cambridgeshire FRS²⁶, Humberside FRS²⁷, West Yorkshire FRS²⁸ and other online information provided further documents and information to support information in the FRS manuals and to interpret certain terms which did not appear in the manuals and documents of FRS.

After collecting data from knowledge sources, two knowledge glossary tables were constructed: one for recording knowledge glossary concepts and another for recording the knowledge glossary relationships between the concepts adapted from the knowledge glossary tables in METHONTOLOGY (Blazquez, Fernandez-Lopez et al. 1998) and Ordnance Survey methodology (Kovacs, Dolbear et al. 2006) as shown in Table 4.5. The knowledge glossary concepts table consists of concept, core/secondary concept, synonym of concept, natural language description, and source of the concept. The relationships table consists of relationship, source concept and target concept. All knowledge sources were analysed and extracting the relevant concepts and relationships and their meaning with in the scope of the domain before populating the knowledge glossary into these tables as described in the next Section.

Table 4.5 Constructing the knowledge glossary table

Concept	Core/Secondary	Synonym	Natural Language Description	Source

(a) Concepts

Relationship	Source Concept	Target Concept

(b) Relationships

²⁶ <http://www.cambsfire.gov.uk/>

²⁷ <http://www.humbersidefire.gov.uk/>

²⁸ <http://www.westyorksfire.gov.uk/>

4.4. Conceptualisation

4.4.1. Use of Activity Theory to identify concepts and relationships

To model the RA activity, appropriate tools should be employed to help understand and identify the context in the RA activity in order to clarify the dimensions of activity and narrow down the scope. Context can be any information from the situation of an entity (a person, place, or object) which is relevant to the user and application (Dey 2001). Some existing work uses Activity Theory to model the context for capturing a knowledge level view of contextual knowledge that should be incorporated into an intelligent system (Kofod-Petersen and Cassens 2006), supporting context aware application (Li, Hong et al. 2004) and features of the world regarding an activity theoretical model (Kaenampornpan and O'Neill 2004).

In our case, context captures the RA activity the user has been involved in. Consequently, to derive a model of context we follow the Activity Theory, the theoretical foundations of which were described by (Vygotsky 1978) and (Leont'ev 1978). As stated in Chapter 2, Vygotsky introduced the first generation model of AT linking a subject, an object, and tools. The hierarchical structure of an activity has been divided into three levels: activity level, action level, and operation level. Engestrom (Engestrom, Miettinen et al. 1999) developed an extension model of an AT system considering social context, and adding rules, community and role (division of labour).

Our RA activity scenario was considered deliberately with the standard operating procedures in order to construct the context in the activity model. The initial activity or initial actions before assessing the risk for initial preparation or assessment preparation would be separated from the risk assessment activity in order to identify more detail about relevant components in the initial actions stage (e.g. equipment and appliances used as control measures). As a result, two separate activity stages for activity model construction were identified, activity stage 1 - initial activity (or initial actions) and activity stage 2 - risk assessment activity, as shown in Figure 4.2.

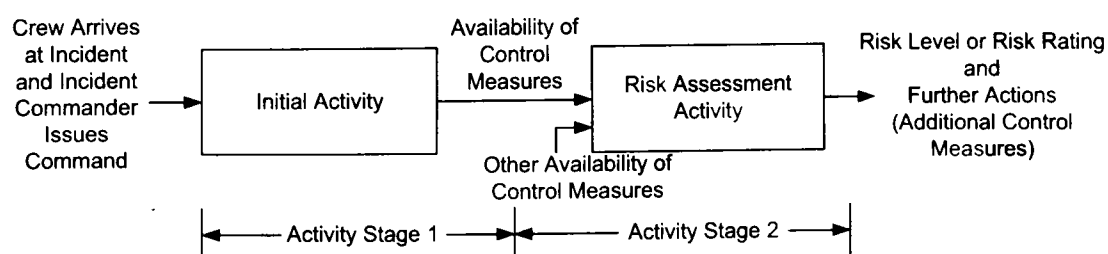


Figure 4.2 Two separate activity stages for activity model construction

However, the initial activity is actually the beginning part of the whole risk assessment process in FRS and involved only first situation. The initial activity model construction is described later in this section following construction of the risk assessment activity model. We will scope only these two activities of risk assessment process that does not include the stage of incident developed.

The initial activity model and RA activity model were defined and written in the extension model of AT system in order to identify the key context aspects at a general level. To plan the interaction with the user, we need an elaborated model of the specific initial activity and RA activity, including actions and operations using the hierarchical structure of the activity. Generally, risk assessment in practice is dynamic, meaning that the situation can change or develop at any time. As a result, the firefighter may re-assess the situation approximately every 20 minutes (information from interview with project manager for South England from fire control, UK). This process is referred to as **dynamic risk assessment (DRA)**²⁹. Figure 4.2 shows a general diagram of the risk management and the parts at the **incident ground**³⁰ contain DRA, **tactical mode**³¹, and **analytical risk assessment**. The analytical risk assessment is used for re-assessment or review at the incident ground to formalised assessment of hazards, who or what is at risk from those hazards, the likelihood³² and severity³³ of risk, assessment of existing control measures³⁴ with additional control measures, and confirmation that the DRA and tactical mode was correct. It can also be employed to feed relevant information from the incident ground, via the incident debrief, back into the risk assessment process at the systematic level (HM Stationary Office 2002).

²⁹ The continuous assessment of risk in the rapidly changing circumstances of an operational incident, in order to implement the control measures necessary to ensure an acceptable level of safety. (Fire Service Manual Volume 2 – Incident Command)

³⁰ The area in which fire service operations are taking place. This may, or may not involve a fire. (Fire Service Training Manual)

³¹ A procedure is to assist the incident commander to manage an incident effectively without compromising the health and safety of personnel. There are three tactical modes: offensive mode, defensive mode, and transitional mode. (Fire Service Manual Volume 2 – Incident Command)

³² The degree to which something can reasonably be expected to happen. (Longman Dictionary of Contemporary English)

³³ The degree of something undesirable e.g. pain, weather etc. (WordNet)

³⁴ The control measures are the intervention techniques to reduce risk. This could include the use of personnel protective equipment, breathing apparatus, specialised equipment and safety officer(s) etc. (Dynamic Management of Risk at Operational Incidents)

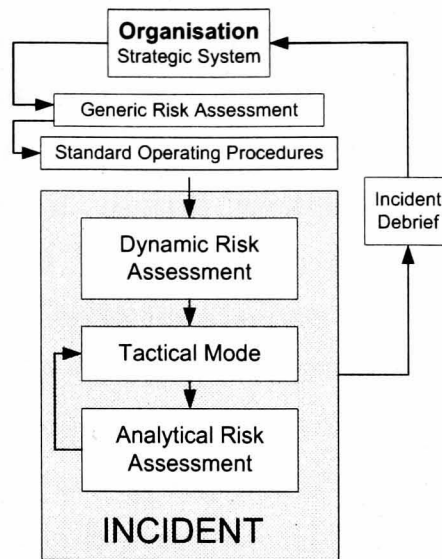


Figure 4.3 General diagram of risk management (HM Stationary Office 2002)

In our case, for both the initial activity and RA activity, the risk management was only considered at incident ground because we focused on the operations at the incident. Only the first RA situation for assessing the risk in DRA and the first tactical mode (offensive, defensive, or transitional mode) were taken into account for our scope of the PORML prototype following the scenario in Table 4.3. The notion of formal review, using analytical risk assessment at the incident ground in order to identify who or what was at risk and confirm the DRA and tactical mode was correct, was adapted to assess the risk in our first RA situation.

Initial activity model construction

Initial activity model using AT system

Let us consider an initial activity, normally called initial actions, in chimney fire that has the goal availability of control measures as shown in activity stage 1 of Figure 4.2. In general, a **crew**³⁵ (as *subjects*) containing crew members³⁶ and sometimes including **officers**, e.g. safety officer, water officer etc. depending upon the size of the incident, arrive at the incident and provide or arrange the **equipment and appliances**, as *tools*, to do something normally called initial actions (or initial activity). A crew member who is a **crew commander or crew manager**³⁷ in his *role* and acts as another *role*, **incident commander**³⁸, in the situation at the incident. The incident commander starts ordering (**at beginning**, as *rule*) his crew to perform

³⁵ a crew comprises a class of people who work at a common activity, generally in a structured or hierarchical organisation. (Wikipedia). In this case, a crew is a group of firefighters.

³⁶ Firefighters or a firemen who are members of a crew.

³⁷ An officer or firefighter tasked with supervising specific tasks or meeting specific objectives utilising one or more firefighters. (Fire Service Manual Volume 2 – Incident Command)

³⁸ The officer having overall responsibility for dictating tactics and resource management. Overall responsibility for a fire remains with the senior fire brigade officer present under the Fire Service Act Section 30(3), but subject to this a more junior officer may retain the role of Incident Commander. (Fire Service Manual Volume 2 – Incident Command)

initial preparation, as *object*, before assessing the risk. This initial preparation uses equipment and appliances and consider **people nearby, place or other environments** (as *community*) to perform the initial preparation. The *outcome* of the preparation is **availability of control measures**. Only certain initial actions (activity) will be transformed into availability of control measures. The incident commander uses these control measures to measure the risk level in RA activity. The initial activity model using the AT system is shown in Figure 4.4. The Figure shows the abstract or general level of entities but does not show the details or members of each entity, using the notion of ‘loosely specified ontology’ stated in Chapter 2, Section 2.6.3. The relationship between two entities are general relationships and might not be the same as the relationship between their members.

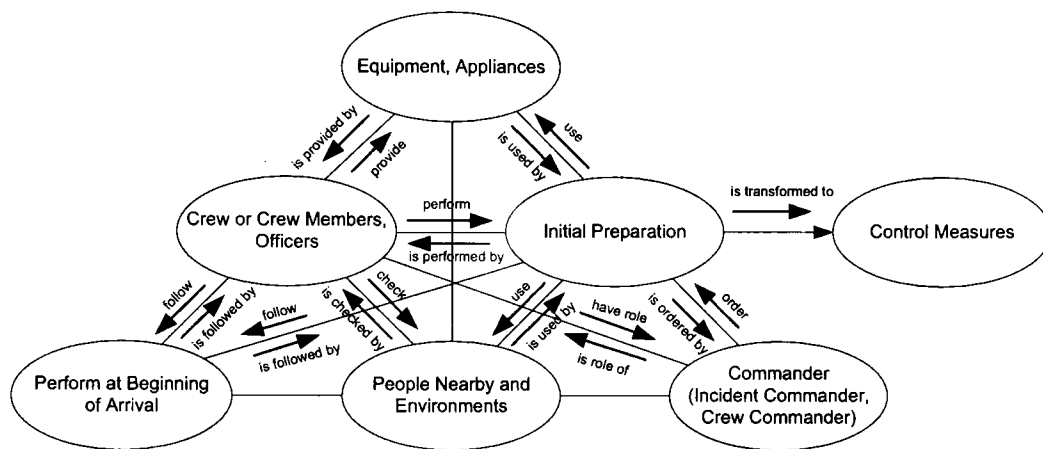


Figure 4.4 Applying AT system for initial activity model

Hierarchical structure of initial activity model

The hierarchical structure of the initial activity model in chimney fire was analysed and identified. It contains three levels: activity, action and operation level. The model contains only one initial activity. An excerpt of diagram is shown in Figure 4.5. The relationship between the activity level and action level is defined as ‘is initial activity of’ and the relationship between action level and operation level is defined as ‘is initial action of’.

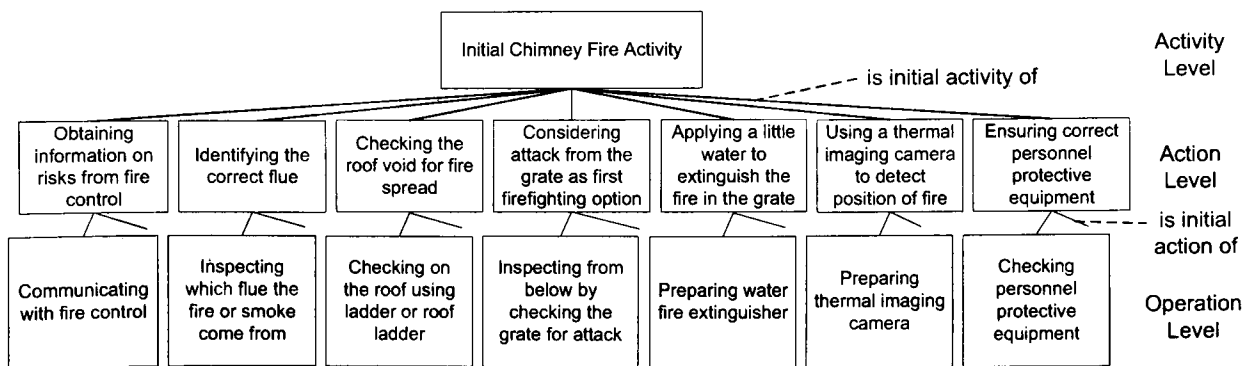


Figure 4.5 An excerpt of diagram of applying the hierarchical structure of AT to the initial activity model for chimney fire; it is assumed that the order of actions and operations are left to right

RA activity model construction

RA activity model construction using AT system

Let us consider an RA situation in an incident that has the goal, assessment result and further actions, as shown in activity stage 2 of Figure 4.2. In the incident ground, a **crew member** who assesses the risk is a *subject*. His *role* is a **crew commander or crew manager** and acts as the **incident commander** at the incident. The crew member will examine **availability of control measures** (from outcome of initial actions and from other control measures e.g. training experiences in FRS, safe system of work etc.) used as *tools* to assess the level of hazards/risks (high risk, medium risk or low risk). The level of hazards/risks is in the form of **severity x likelihood (risk assessment rule)** used as a *rule* to measure risk level or risk rating. Control measures are employed to reduce the risk to an acceptable level by reducing the likelihood while the severity remains the same. Other crew members in the **crew, people nearby, weather conditions and place** in the environment of the incident act as a *community* that might impact on the standard hazards/risks assessment. They can also be represented in the form of likelihood level that might make the risk level increase. The **hazards/risks assessment** of RA activity are *objects*, and the *outcome* is the **assessment result** (high risk, medium risk or low risk) and **any further actions** (additional control measures) that could be used. The RA activity model using AT system is shown in Figure 4.6. The Figure shows the abstract or general level of entities but does not show the details or members of each entity, using the notion of ‘loosely specified ontology’ stated in Chapter 2, Section 2.6.3. The relationship between two entities is a general relationship that might not be the same as the relationship between their members.

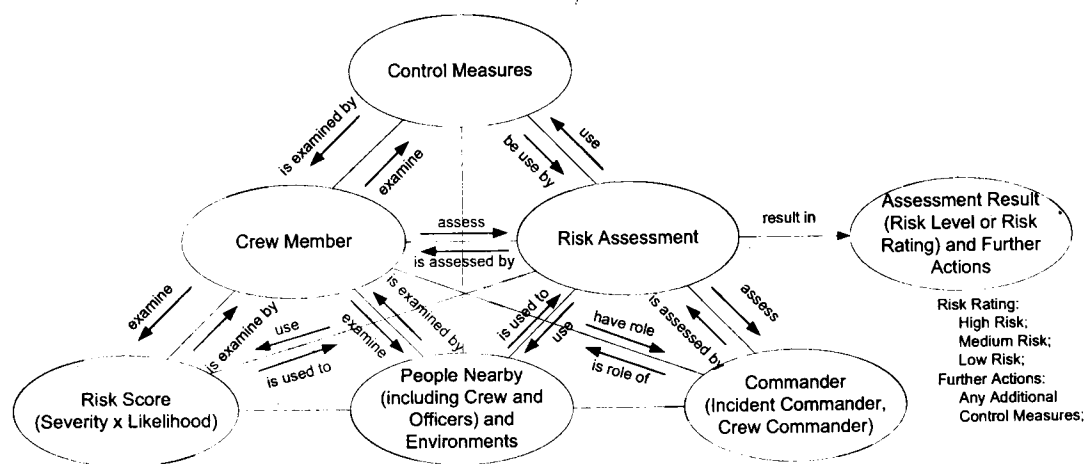


Figure 4.6 Applying AT system to RA activity model

The severity and likelihood level, the weight of risk rating, the level of hazards/risks, the control measures used to reduce likelihood level of hazards/risks and the impacts of communities (people nearby and environments) to likelihood level of hazards/risks in chimney fire RA activity are shown in Table 4.6, 4.7, 4.8,

4.9 and 4.10 respectively. These tables were used to analyse the risks and calculate the risk level or risk rating in our work, adapted from the review or re-assessment process at the incident ground in the firefighting practice called analytical risk assessment. Tables 4.6 and 4.7 were adapted from the West Yorkshire fire service's fire ground risk assessment process shown in Appendix 1 of Incident Command (HM Stationary Office 2002), Standard Operating Procedures – Cambridgeshire FRS, Humberside FRS, and risk assessment guidance in (Health and Safety Services). Tables 4.8 and 4.9 were analysed from GRA (HM Stationary Office 1998) but all figures in these table were assumed by analysing the examples of risk assessment form reports (non incident ground) of other fire and rescue incidents e.g. high rise building fire, road traffic collisions, from West Yorkshire FRS Authority. Table 4.10 was assigned by the author for impacts of other contexts (people nearby and environments) to the risk assessment.

Table 4.6 Severity and likelihood level

Level	Severity (S)	Likelihood (L)
1	No injury	Will not occur
2	Slight (first aid only)	Probably will not occur
3	Minor injury (up to 3 days absence)	Very unlikely
4	Moderate injury (3 – 15 days absence)	Unlikely
5	More moderate injury (16 days – 1 month's absence)	Medium
6	Serious injury (over 1 month's absence)	Likely
7	Serious injury (permanent disablement)	Very likely
8	Death	Probably will occur
9	Multiple deaths	Will occur

Table 4.7 Weight of risk rating, and risk score

Risk Score	Weight or Range of Risk Score	Risk Level or Risk Rating
Severity x Likelihood (S x L)	< 15	Low Risk
	>= 15, < 40	Medium Risk
	>= 40	High Risk

Table 4.8 Level of hazards/risks

Risk Assessment Activity in Chimney Fire	Hazards/ Risks	Severity Level	Likelihood Level (without Control Measures and Community Impacts)	Risk Score (SxL)	Risk Rating: Low (<15); Medium (>=15, <40); High (>=40)
Gaining access to and working on roof	Falling Masonry	7	6	42	High Risk
	Roof Conditions	5	5	25	Medium Risk
Working in roof space and cutting away	Hazardous Substances	6	5	30	Medium Risk
Applying extinguishing media	Fire Spread	5	5	25	Medium Risk
	Blow Back	5	4	20	Medium Risk

Table 4.9 The control measures used to reduce likelihood level of hazards/risks

Control Measures	Relate to Hazards/Risks	Reduce Likelihood
Cordon off an unsafe area	Falling Masonry/Roof Conditions	-0.5
Use safe systems of work for gaining access to and working on roof	Falling Masonry/Roof Conditions	-1.0
Complete training of hazard or risk in gaining access to and working on roof	Falling Masonry/Roof Conditions	-0.5
Use aerial appliances	Falling Masonry/Roof Conditions	-1.0
Use roof ladders	Falling Masonry/Roof Conditions	-0.5
Use work positioning and fall arrest systems	Falling Masonry/Roof Conditions	-0.5
Complete training of hazard or risk for pitch and flat roof	Falling Masonry/Roof Conditions	-0.5
Use hearth kit	Hazardous Substances	-1.0
Use safe systems of work for asbestos and MMMF material	Hazardous Substances	-1.0
Use breathing apparatus and decontamination procedures	Hazardous Substances	-1.0
Complete training of hazard or risk for working in roof space and cutting away	Hazardous Substances	-0.5
Complete training of hazard or risk for applying extinguishing media	Fire Spread/Blow Back	-0.5
Use safe systems of work for applying extinguishing media	Fire Spread/Blow Back	-1.0
Use thermal imaging camera	Fire Spread/Blow Back	-0.5
Use eye protection and mirror	Fire Spread/Blow Back	-0.5
Use full fire kit with helmet	Fire Spread/Blow Back	-0.5

Table 4.10 The context from community (people nearby and environments) and the impacts on likelihood level of hazards/risks

Community Impacts	Relate to Hazards/Risks	Impact	Increase/Reduce Likelihood
Off-Peak Time	All Hazards/Risks	No	+0.0
Peak Time with Low Traffic or Wide Road	All Hazards/Risks	No	+0.0
Peak Time with High Traffic or Congested Traffic Road or Narrow Road/Street	All Hazards/Risks	Yes	+0.2
Sunny or Rain	All Hazards/Risks	No	+0.0
Freeze or Snow	All Hazards/Risks	Yes	+0.2
Low Wind	All Hazards/Risks	No	+0.0
High Wind	All Hazards/Risks	Yes	+0.2
Bad Visibility	All Hazards/Risks	Yes	+0.2
Good Visibility	All Hazards/Risks	No	+0.0
Crowd of People	All Hazards/Risks	Yes	+0.2
Drunk People	All Hazards/Risks	Yes	+0.2
Hazardous Substance Nearby	All Hazards/Risks	Yes	+0.2
Car Park (Land) with No Crowd	All Hazards/Risks	No	-0.0
Car Park (Land) with Crowd	All Hazards/Risks	Yes	-0.2

Hierarchical structure of RA activity model

The hierarchical structure of the RA activity model was analysed and identified. It contained three levels: activity, action and operation level. The RA activity model for chimney fire contains three kinds of RA activities, but will be different for other fire fighting RA activities or other GRA categories (e.g. rescues, generic hazards etc.) of GRA. An excerpt of the diagram is shown in Figure 4.7. The relationship between activity level and action level was defined as ‘is risk assessment activity of’ and the relationship between action level and operation level was defined as ‘is risk assessment action of’.

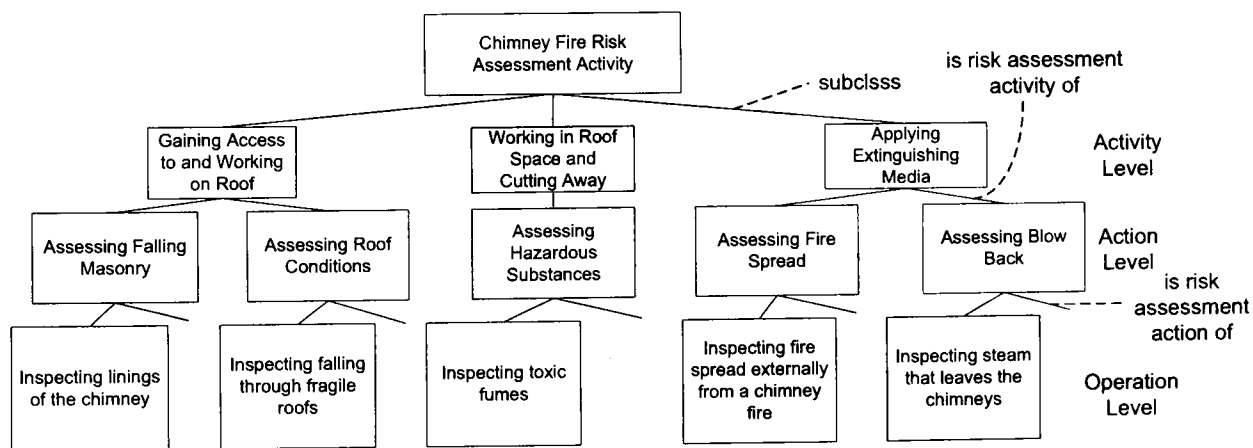


Figure 4.7 An excerpt of diagram of applying the hierarchical structure of AT to the RA activity model of chimney fire: it is assumed that the order of activities, actions and operations are left to right

4.4.2. Building conceptual knowledge glossary

The concepts and relationships can be derived from the entities in the initial activity model in Figure 4.4 and RA activity model in Figure 4.6. Main or core concepts of initial activity model were identified with entities such as *subject* - **crew, crew member, safety officer**; *tools* - **thermal imaging camera, eye protection, turn table ladder**; *object* - **initial preparation**; *rule* - **perform at beginning (not use)**; *community* - **incident place, car park, public house**; *role* - **incident commander, crew commander**; *outcome* - **control measures (availability)**. Core concepts of the RA activity model were identified with entities such as *subject* - **crew member**; *tools* - **control measures**; *object* - **hazards, risks, risk assessment**; *rule* - **risk score, severity, likelihood**; *community* - **crew, incident place, car park, public house, weather conditions**; *role* - **incident commander, crew commander**; *outcome* - **risk rating, high risk, medium risk, low risk**. Table 4.11 and 4.12 show examples of core concepts derived from the initial activity model and RA activity model using AT system and examples of relationships between the core concepts respectively.

Table 4.11 Examples of knowledge glossary of concepts derived from initial activity model and RA activity model using AT system

Concept	Core/Secondary	Synonym	Natural Language Description	Source
Chimney Fire	Core	-	The combustion of residue deposits referred to as creosote, on the inner surfaces of chimney tiles, flue liners, stove pipes, etc.	Wikipedia
Risk Assessment	Core	-	The process of analysing the level of risk, considering those in danger and evaluating whether hazards are adequately controlled, taking into account any existing control measures.	Dynamic Management of Risk at Operational Incidents
Chimney Fire Risk Assessment	Core	-	A kind of risk assessment of fighting fire (there are eleven kinds of fighting fire: building fire, high rise building fire, chimney fire, rural area fire, farm fire, PPV fire, refuse fire, public entertainment venue fire, secure accommodation fire, petro chemical installation fire, involving pipeline fire)	A Guide to Operational Risk Assessment
Commander	Core	-	An officer who is in charge of a group of fire crew or particular fire activity.	Adapted from Longman Dictionary of Contemporary English
Control Measure	Core	-	An intervention technique to reduce risk. This could include the use of PPE, BA, specialised equipment and safety officer(s) etc.	Dynamic Management of Risk at Operational Incidents
Crew	Core	-	A crew comprises a body or a class of people who work at a common fire activity, generally in a structured or hierarchical organisation.	Wikipedia
Crew Commander	Core	Crew Manager	An officer or firefighter tasked with supervising specific tasks or meeting specific objectives utilising one or more firefighters.	Fire Service Manual Volume 2 (Incident Command)
Crew Member	Core	-	A member of a crew.	-
Fighting Fire	Core	-	A category of generic or operational risk assessment (there are five categories: responding to emergencies, carrying out rescues, fighting fires, incidents involving transport, generic hazards)	A Guide to Operational Risk Assessment
Fire Appliance	Core	-	Any fire service operational vehicle.	Manual of Firemanship – Ladders and Appliances
Fire Equipment	Core	-	Any fire service operational equipment	-
Fire Officer	Core	-	A senior ranking firefighter or fire safety inspector in the UK	Wikipedia
Hazard	Core	-	Something with the potential to cause harm. This could be anything from a slippery domestic kitchen floor to a radiation leak from a nuclear reactor.	Dynamic Management of Risk at Operational Incidents
High Risk	Core	-	The rating or level of risk is high	-
Incident Commander	Core	-	The officer having overall responsibility for dictating tactics and resource management. Overall responsibility for a fire remains with the senior fire brigade officer present under the Fire Service Act Section 30(3), but subject to this a more junior officer may retain the role of Incident Commander.	Fire Service Manual Volume 2 (Incident Command)
Initial Preparation	Core	-	A preparation when firefighters arrive at the incident before assessing the risk	-
Likelihood	Core	-	The degree to which something can reasonably be expected to happen.	Longman Dictionary of Contemporary English
Low Risk	Core	-	The rating or level of risk is low	-
Medium Risk	Core	-	The rating or level of risk is medium	-
Public House	Core	-	The formal name for a pub in Britain which is a drinking establishment licensed to serve alcoholic drinks for consumption on or off the premises in countries and regions of British influence.	Wikipedia
Risk	Core	-	A measure of the likelihood that the harm from a particular hazard will occur, taking into account the possible severity of the harm.	Dynamic Management of Risk at Operational Incidents
Risk Rating	Core	Risk Level	The level of assessed risk measured in high, medium and low risk	-
Severity	Core	-	The degree of something undesirable e.g. pain, weather etc.	WordNet

Table 4.12 Examples of relationships derived from initial activity model and RA activity model using AT system

Relationship	Source Concept	Target Concept
is role of	Incident Commander	Crew Member
has role	Crew Member	Incident Commander
use control measure	Risk Assessment Activity	Control Measure
assess risk	Incident Commander	Risk Assessment
is a kind of	Chimney Fire	Fighting Fire
is role of	Incident Commander	Crew Member
has member	Crew	Crew Member
is member of	Incident Commander	Crew Commander

The concepts of initial activity model and RA activity model were defined in a hierarchical way corresponding to Figure 4.5 and Figure 4.7. The concepts of control measure group (e.g. chimney fire control measure-aa, chimney fire control measure-ab etc.) were defined corresponding to RA activities (e.g. chimney fire risk assessment activity-a) as shown in Table 4.13. The examples of knowledge glossary concepts and relationships derived from the initial activity model are shown in Table 4.14 and Table 4.15 respectively. The examples of knowledge glossary concepts and relationships derived from the RA activity model are shown in Table 4.16 and Table 4.17 respectively. The knowledge glossary concepts of control measures for chimney fire are shown in Table 4.18. The examples of knowledge glossary relationships between RA activities and control measures are defined as shown in Table 4.19. The knowledge glossary relationships between RA actions and hazards are defined as shown in Table 4.20.

Table 4.13 Examples of defined concepts for activities, actions, operations, and control measures

Level	Concepts
Initial Activity	Initial Activity, Initial Chimney Fire Activity
Initial Action	Initial Action, Initial Chimney Fire Action, Initial Chimney Fire Action-a, Initial Chimney Fire Action-b
Initial Operation	Initial Operation, Initial Chimney Fire Operation, Initial Chimney Fire Operation-aa, Initial Chimney Fire Operation-ab, Initial Chimney Fire Operation-ba, Initial Chimney Fire Operation-bb
Risk Assessment Activity	Risk Assessment Activity, Chimney Fire Risk Assessment Activity, Chimney Fire Risk Assessment Activity-a, Chimney Fire Risk Assessment Activity-b, Chimney Fire Risk Assessment Activity-c
Risk Assessment Action	Risk Assessment Action, Chimney Fire Risk Assessment Action, Chimney Fire Risk Assessment Action-aa, Chimney Fire Risk Assessment Action-ab, Chimney Fire Risk Assessment Action-ba
Risk Assessment Operation	Chimney Fire Risk Assessment Operation, Chimney Fire Risk Assessment Operation-aaa, Chimney Fire Risk Assessment Operation-aab, Chimney Fire Risk Assessment Operation-aba, Chimney Fire Risk Assessment Operation-abb
Control Measure	Control Measure, Chimney Fire Control Measure, Chimney Fire Control Measure-aa, Chimney Fire Control Measure-ab, Chimney Fire Control Measure-ba, Chimney Fire Control Measure-bb

Table 4.14 Examples of knowledge glossary concepts derived from initial activity model using hierarchical structure of AT in Figure 4.5

Concept	Core/Secondary	Synonym	Natural Language Description	Source
Initial Chimney Fire Action-a	Core	-	Obtaining information on risks from fire control	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-b	Core	-	Identifying the correct flue	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-c	Core	-	Checking the roof void for fire spread	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-d	Core	-	Considering attack from the grate as first firefighting option	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-e	Core	-	Applying a little water to extinguish the fire in the grate	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-f	Core	-	Using a thermal imaging camera to detect position of fire	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Action-g	Core	-	Ensuring correct personnel protective equipment	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-aa	Core	-	Communicating with fire control	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-ba	Core	-	Inspecting which flue the fire or smoke come from	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-ca	Core	-	Checking on the roof using ladder or roof ladder	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-da	Core	-	Inspecting from below by checking the grate for attack	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-ea	Core	-	Preparing water fire extinguisher	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-fa	Core	-	Preparing thermal imaging camera	Initial Activity Model of Operational Risk Assessment
Initial Chimney Fire Operation-ga	Core	-	Checking personnel protective equipment	Initial Activity Model of Operational Risk Assessment

Table 4.15 Examples of knowledge glossary relationships derived from initial activity model using hierarchical structure of AT in Figure 4.5

Relationship	Source Concept	Target Concept
is initial activity of	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-a (obtaining information on risks from fire control)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-b (identifying the correct flue)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-c (checking the roof void for fire spread)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-d (considering attack from the grate as first firefighting option)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-e (applying a little water to extinguish the fire in the grate)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-f (using a thermal imaging camera to detect position of fire)
	Initial Chimney Fire Activity (initial activity for chimney fire)	Initial Chimney Fire Action-g (ensuring correct personnel protective equipment)
is initial action of	Initial Chimney Fire Action-a (obtaining information on risks from fire control)	Initial Chimney Fire Operation-aa (communicating with fire control)
	Initial Chimney Fire Action-b (identifying the correct flue)	Initial Chimney Fire Operation-ba (inspecting which flue the fire or smoke come from)
	Initial Chimney Fire Action-c (checking the roof void for fire spread)	Initial Chimney Fire Operation-ca (checking on the roof using ladder or roof ladder)
	Initial Chimney Fire Action-d (considering attack from the grate as first firefighting option)	Initial Chimney Fire Operation-da (inspecting from below by checking the grate for attack)
	Initial Chimney Fire Action-e (applying a little water to extinguish the fire in the grate)	Initial Chimney Fire Operation-ea (preparing water fire extinguisher)
	Initial Chimney Fire Action-f (using a thermal imaging camera to detect position of fire)	Initial Chimney Fire Operation-fa (preparing thermal imaging camera)
	Initial Chimney Fire Action-g (ensuring correct personnel protective equipment)	Initial Chimney Fire Operation-ga (checking personnel protective equipment)

Table 4.16 Examples of knowledge glossary concepts derived from RA activity model using hierarchical structure of AT in Figure 4.7

Concept	Core/Secondary	Synonym	Natural Language Description	Source
Chimney Fire Risk Assessment Activity-a	Core	-	Gaining access to and working on roof	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Activity-b	Core	-	Working in roof space and cutting away	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Activity-c	Core	-	Applying extinguishing media	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Action-aa	Core	-	Assessing falling masonry	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Action-ab	Core	-	Assessing roof condition	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Action-ba	Core	-	Assessing hazardous substance	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Action-ca	Core	-	Assessing fire spread	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Action-cb	Core	-	Assessing blow back	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Operation-aaa	Core	-	Inspecting linings of the chimney	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Operation-aba	Core	-	Inspecting falling through fragile roofs	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Operation-baa	Core	-	Inspecting toxic fumes	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Operation-caa	Core	-	Inspecting fire spread externally from a chimney fire	RA Activity Model of Operational Risk Assessment
Chimney Fire Risk Assessment Operation-cba	Core	-	Inspecting steam that leaves the chimneys	RA Activity Model of Operational Risk Assessment

Table 4.17 Examples of knowledge glossary relationships derived from RA activity model using hierarchical structure of AT in Figure 4.7

Relationship	Source Concept	Target Concept
is a kind of (is subclass of)	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Risk Assessment Activity (risk assessment activity for chimney fire)
	Chimney Fire Risk Assessment Activity-b (working in roof space and cutting away)	Chimney Fire Risk Assessment Activity (risk assessment activity for chimney fire)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Risk Assessment Activity (risk assessment activity for chimney fire)
is risk assessment activity of	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Risk Assessment Action-aa (assessing falling masonry)
	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Risk Assessment Action-ab (assessing roof conditions)
	Chimney Fire Risk Assessment Activity-b (working in roof space and cutting away)	Chimney Fire Risk Assessment Action-ba (assessing hazardous substances)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Risk Assessment Action-ca (assessing fire spread)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Risk Assessment Action-cb (assessing blow back)
is risk assessment action of	Chimney Fire Risk Assessment Action-aa (assessing falling masonry)	Chimney Fire Risk Assessment Operation-aaa (inspecting linings of the chimney)
	Chimney Fire Risk Assessment Action-ab (assessing roof conditions)	Chimney Fire Risk Assessment Operation-aba (inspecting falling through fragile roofs)
	Chimney Fire Risk Assessment Action-ba (assessing hazardous substances)	Chimney Fire Risk Assessment Operation-baa (inspecting toxic fumes)
	Chimney Fire Risk Assessment Action-ca (assessing fire spread)	Chimney Fire Risk Assessment Operation-caa (inspecting fire spread externally from a chimney fire)
	Chimney Fire Risk Assessment Action-cb (assessing blow back)	Chimney Fire Risk Assessment Operation-cba (inspecting steam that leaves the chimneys)

Table 4.18 The knowledge glossary concepts of control measures for chimney fire

Concept	Core/ Secondary	Synonym	Natural Language Description	Source
Chimney Fire Control Measure-aa	Core	-	Cordon off an unsafe area	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ab	Core	-	Use safe systems of work for gaining access to and working on roof	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ac	Core	-	Complete training of hazard or risk in gaining access to and working on roof	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ad	Core	-	Use aerial appliances	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ae	Core	-	Use roof ladders	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-af	Core	-	Use work positioning and fall arrest systems	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ag	Core	-	Complete training of hazard or risk for pitch and flat roof	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ba	Core	-	Use hearth kit	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-bb	Core	-	Use safe systems of work for asbestos and MMMF material	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-bc	Core	-	Use breathing apparatus and contamination procedures	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-bd	Core	-	Complete training of hazard or risk for working in roof space and cutting away	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ca	Core	-	Complete training of hazard or risk for applying extinguishing media	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-cb	Core	-	Use safe systems of work for applying extinguishing media	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-cc	Core	-	Use thermal imaging camera	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-cd	Core	-	Use eye protection and mirror	A Guide to Operational Risk Assessment
Chimney Fire Control Measure-ce	Core	-	Use full fire kit with helmet	A Guide to Operational Risk Assessment

Table 4.19 Examples of knowledge glossary relationships between RA activities and control measures

Relationship	Source Concept	Target Concept
use control measure	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Control Measure-aa (cordon off an unsafe area)
	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Control Measure-ab (use safe systems of work for gaining access to and working on roof)
	Chimney Fire Risk Assessment Activity-a (gaining access to and working on roof)	Chimney Fire Control Measure-ac (complete training of hazard or risk in gaining access to and working on roof)
	Chimney Fire Risk Assessment Activity-b (working in roof space and cutting away)	Chimney Fire Control Measure-ba (use hearth kit)
	Chimney Fire Risk Assessment Activity-b (working in roof space and cutting away)	Chimney Fire Control Measure-bb (use safe systems of work for asbestos and MMMF material)
	Chimney Fire Risk Assessment Activity-b (working in roof space and cutting away)	Chimney Fire Control Measure-bc (use breathing apparatus and contamination procedures)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Control Measure-ca (complete training of hazard or risk for applying extinguishing media)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Control Measure-cb (use safe systems of work for applying extinguishing media)
	Chimney Fire Risk Assessment Activity-c (applying extinguishing media)	Chimney Fire Control Measure-cc (use thermal imaging camera)

Table 4.20 The knowledge glossary relationships between RA actions and hazards

Relationship	Source Concept	Target Concept
assess risk	Chimney Fire Risk Assessment Action-aa (assessing falling masonry)	Falling Masonry
	Chimney Fire Risk Assessment Action-ab (assessing roof condition)	Roof Condition
	Chimney Fire Risk Assessment Action-ba (assessing hazardous substance)	Hazardous Substance
	Chimney Fire Risk Assessment Action-ca (assessing fire spread)	Fire Spread
	Chimney Fire Risk Assessment Action-cb (assessing blow back)	Blow Back

All core concepts and relationships derived from initial activity model and RA activity model in Section 4.4.1, defining meaning in natural language and assigning other descriptive information, would be populated into the knowledge glossary concept table and relationship table. The secondary concepts were also identified and populated into the knowledge glossary concepts table. The secondary concepts are not central to the domain but are required to fully describe the core concepts to satisfy the purpose of the RA domain ontology (Kovacs, Dolbear et al. 2006). If the concepts had synonyms, they could be filled in the table. The concept terms or meaning of concepts would be entered in the natural language description column. The list of knowledge glossary of risk assessment concepts is shown in Appendix B (not include list of risk assessment activities, actions and operations, and list of control measures).

4.5. Coding

4.5.1. Converting to structured English sentences

The knowledge glossary concepts and relationships of the initial activity model and RA activity model from Table 4.11, 4.12, 4.14, 4.15, 4.16, 4.17, 4.18, 4.19 and 4.20 are converted into structured English sentences using Rabbit language (Dolbear, Hart et al. 2007; Hart, Johnson et al. 2007). The structured English sentences are constructed using a specific structure: a subject concept, a relationship, and an object concept; and modifiers that are employed to convey the meaning of each sentence precisely (Kovacs, Dolbear et al. 2006). Table 4.21 shows examples of structured English sentences using Rabbit for describing concepts and relationships (Denaux, Dimitrova et al. 2009).

Table 4.21 Examples of structured English sentences using Rabbit for describing concepts and relationships

Model	Rabbit Sentence
Initial Activity Model and RA Activity Model (use AT system)	Every Crew <i>has member</i> at least 2 Crew Members.
	Every Crew <i>has member</i> exactly 1 Crew Commander.
	Every Incident Commander <i>is role of</i> a Crew Member.
	Every Initial Preparation <i>use tool</i> a Fire Equipment.
	Every Initial Preparation <i>use tool</i> a Fire Appliance.
	Every Initial Activity <i>use tool</i> a Fire Equipment.
	Every Initial Activity <i>use tool</i> a Fire Appliance.
	Every Thermal Imaging Camera <i>is a kind of</i> a Fire Equipment.
	Every Personal Protective Equipment <i>is a kind of</i> a Fire Equipment.
	Every Initial Chimney Fire Action-f <i>use tool</i> Thermal Imaging Camera.
	Every Initial Chimney Fire Action-g <i>use tool</i> Personal Protective Equipment.
	Every Risk Assessment <i>use control measure</i> a Control Measure.
	Every Risk Assessment Activity <i>use control measure</i> a Control Measure.
	Every Chimney Fire Risk Assessment Activity <i>use control measure</i> a Chimney Fire Control Measure.
	Every Chimney Fire Risk Assessment Activity-a <i>use control measure</i> a Chimney Fire Control Measure-aa.
	Every Chimney Fire Risk Assessment Activity-a <i>use control measure</i> a Chimney Fire Control Measure-ab.
	Every Chimney Fire Risk Assessment Activity-b <i>use control measure</i> a Chimney Fire Control Measure-ba.
	Every Chimney Fire Risk Assessment Action-aa <i>assess risk</i> a Falling Masonry.
Every Chimney Fire Risk Assessment Action-ab <i>assess risk</i> a Roof Condition.	
Every Chimney Fire Risk Assessment Action-ba <i>assess risk</i> a Hazardous Substance.	
Initial Activity Model (use hierarchical structure of AT)	Every Initial Activity <i>is initial activity of</i> an Initial Action.
	Every Initial Action <i>is initial action of</i> an Initial Operation.
	Every Initial Chimney Fire Activity <i>is initial activity of</i> an Initial Chimney Fire Action.
	Every Initial Chimney Fire Activity-a <i>is initial activity of</i> an Initial Chimney Fire Action-a.
	Every Initial Chimney Fire Activity-a <i>is initial activity of</i> an Initial Chimney Fire Action-b.
	Every Initial Chimney Fire Activity-a <i>is initial activity of</i> an Initial Chimney Fire Action-f.
	Every Initial Chimney Fire Activity-a <i>is initial activity of</i> an Initial Chimney Fire Action-g.
	Every Initial Chimney Fire Action <i>is initial action of</i> an Initial Chimney Fire Operation.
	Every Initial Chimney Fire Action-a <i>is initial action of</i> an Initial Chimney Fire Operation-aa.
	Every Initial Chimney Fire Action-a <i>is initial action of</i> an Initial Chimney Fire Operation-ab.
	Every Initial Chimney Fire Action-b <i>is initial action of</i> an Initial Chimney Fire Operation-ba.
	Every Initial Chimney Fire Action-f <i>is initial action of</i> an Initial Chimney Fire Operation-fa.
	Every Initial Chimney Fire Action-g <i>is initial action of</i> an Initial Chimney Fire Operation-ga.
RA Activity Model (use hierarchical structure of AT)	Every Chimney Fire Risk Assessment <i>is a kind of</i> a Fighting Fire Risk Assessment.
	Every Chimney Fire Risk Assessment Activity <i>is a kind of</i> a Fighting Fire Risk Assessment Activity.
	Every Risk Assessment Activity <i>is risk assessment activity of</i> a Risk Assessment Action.
	Every Risk Assessment Action <i>is risk assessment action of</i> a Risk Assessment Operation.
	Every Chimney Fire Risk Assessment Activity <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Action.
	Every Chimney Fire Risk Assessment Action <i>is risk assessment action of</i> a Chimney Fire Risk Assessment Operation.
	Every Chimney Fire Risk Assessment Activity-a <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Action-aa.
	Every Chimney Fire Risk Assessment Activity-a <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Action-ab.
	Every Chimney Fire Risk Assessment Activity-b <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Action-ba.
	Every Chimney Fire Risk Assessment Action-aa <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Operation-aaa.
	Every Chimney Fire Risk Assessment Activity-ba <i>is risk assessment activity of</i> a Chimney Fire Risk Assessment Action-baa.

4.5.2. Building a logical model

The OWL ontology language was chosen to encode our logical model of the RA domain ontology using ROO and Protégé for authoring the model as stated in Section 4.2.4. The RA domain ontology was written with Rabbit sentences using ROO. The logical model in the RA domain ontology was represented as the OWL language model which could be built from authoring tools, ROO and Protégé. The concepts and relationships populated into the knowledge glossary concepts table and relationships table were encoded in OWL as classes or subclasses and as properties respectively. Firstly, we used ROO to create classes and properties by entering the Rabbit sentence as examples in Table 4.21 using ROO editor. For example, a sentence was entered in the ROO like this:

Every **incident commander** *is role of* a **crew member**.

ROO would then check whether classes ‘**incident commander**’, ‘**crew member**’ and property ‘*is role of*’ were present or created. If they were not present, ROO would prompt the user to create those classes or property first and then the sentence would be accepted and converted to a logical model in OWL format. Examples in Table 4.22 corresponding to selected examples in Table 4.21 compare the Rabbit sentences created using ROO to the creation results of logical model in OWL Manchester syntax.

Table 4.22 Examples of Rabbit sentences created using ROO and the results in Manchester syntax

Rabbit Sentence	Manchester Syntax
Every Crew <i>has member</i> at least 2 Crew Members .	Class: Crew SubClassOf: <i>haveMember</i> min 2 CrewMember
Every Crew <i>has member</i> exactly 1 Crew Commander .	Class: Crew SubClassOf: <i>haveMember</i> exactly 1 CrewCommander
Every Incident Commander <i>is role of</i> a Crew Member .	Class: IncidentCommander SubClassOf: <i>beRoleOf</i> some CrewMember
Every Initial Preparation <i>use tool</i> a Fire Equipment .	Class: InitialPreparation SubClassOf: <i>useTool</i> some FireEquipment
Every Thermal Imaging Camera <i>is a kind of</i> a Fire Equipment .	Class: ThermalImagingCamera SubClassOf: FireEquipment
Every Initial Chimney Fire Action-f <i>use tool</i> a Thermal Imaging Camera .	Class: InitialChimneyFireAction-f SubClassOf: <i>useTool</i> some ThermalImagingCamera
Every Chimney Fire Risk Assessment Activity-a <i>use control measure</i> a Chimney Fire Control Measure-aa .	Class: ChimneyFireRiskAssessmentActivity-a SubClassOf: <i>useControlMeasure</i> some ChimneyFireControlMeasure-aa
Every Initial Chimney Fire Activity-a <i>is initial activity of</i> an Initial Chimney Fire Action-a .	Class: InitialChimneyFireActivity-a SubClassOf: <i>beInitialActivityOf</i> some InitialChimneyFireAction-a
Every Chimney Fire Risk Assessment Activity-a <i>is risk assessment activity</i> a Chimney Fire Risk Assessment Action-aa .	Class: ChimneyFireRiskAssessmentActivity-a SubClassOf: <i>beRiskAssessmentActivity</i> some ChimneyFireRiskAssessmentAction-aa

Classes

The concepts in the initial activity model and RA activity model are represented as classes of RA domain ontology. Each class in the logical model has the same namespace reference called IRI (Internationalized Resource Identifier) which is created at the beginning. For example, we created the namespace as: <http://www.semanticweb.org/ontologies/2551/9/GRA.owl#> using ROO or Protégé and used it during initial development. Examples of classes and subclasses in our logical model are shown in Figure 4.8.

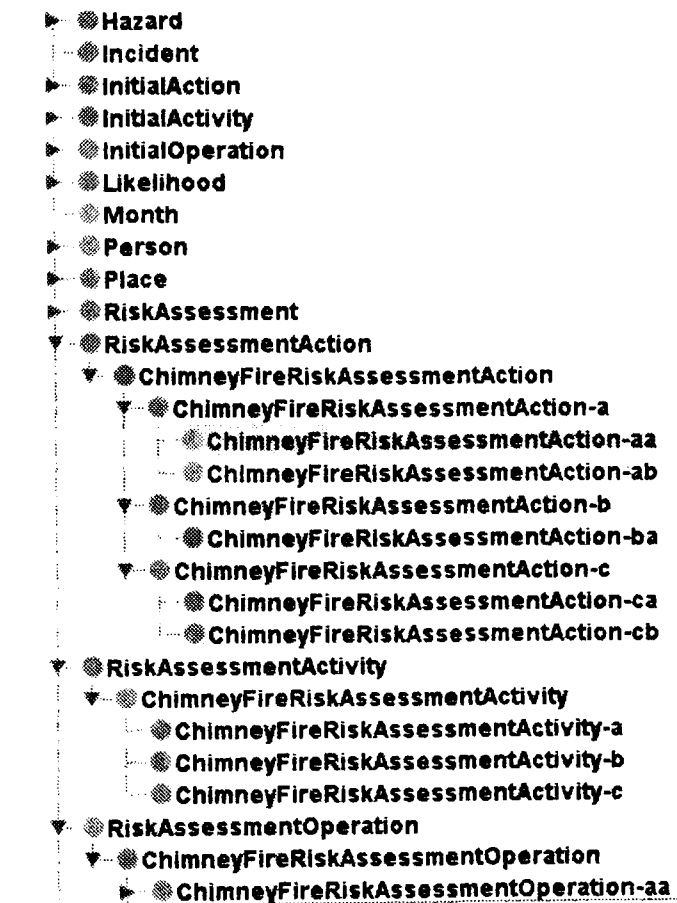


Figure 4.8 Examples of classes and subclasses in RA logical model

Properties

The relationships in the initial activity model and RA activity model are represented as properties of the RA domain ontology. There are two main types of properties: object properties and datatype properties. Object properties are relationships between instances or individuals (or between classes) while datatype properties link an instance or individual to an XML Schema Datatype value or an rdf literal (Horridge, Drummond et al. 2009). Examples of object properties in a logical model corresponding to examples in Table 4.22 are shown in Table 4.23. The datatype properties will be discussed in the next section.

Table 4.23 Examples of object properties in RA logical model in RA domain ontology corresponding to examples in Table 4.22

Object property	Manchester Syntax
has member	Class: Crew SubClassOf: <i>haveMember</i> min 2 CrewMember
	Class: Crew SubClassOf: <i>haveMember</i> exactly 1 CrewCommander
is role of	Class: IncidentCommander SubClassOf: <i>beRoleOf</i> some CrewMember
use tool	Class: InitialPreparation SubClassOf: <i>useTool</i> some FireEquipment
	Class: InitialChimneyFireAction-f SubClassOf: <i>useTool</i> some ThermalImagingCamera
is a kind of	Class: ThermalImagingCamera SubClassOf: FireEquipment
use control measure	Class: ChimneyFireRiskAssessmentActivity-a SubClassOf: <i>useControlMeasure</i> some ChimneyFireControlMeasure-aa
is initial activity of	Class: InitialChimneyFireActivity-a SubClassOf: <i>beInitialActivityOf</i> some CrewMember
is risk assessment activity of	Class: ChimneyFireRiskAssessmentActivity-a SubClassOf: <i>beRiskAssessmentActivityOf</i> some ChimneyFireRiskAssessmentAction-aa

Individuals

The risk level or risk rating has to be calculated to assess the risks (high, medium, low). The relations of the severity (S) and likelihood (L) level, weight of risk rating and level of hazards/risks in chimney fire, as shown in Table 4.6, 4.7 and 4.8 respectively must use datatype values to calculate the risks. The individuals for hazards/risks were created and assigned the datatype values using datatype properties in order to provide the severity level and likelihood level in RA domain ontology as shown in Table 4.24 corresponding to Table 4.8 for hazards/risks in chimney fire. The levels of these hazards/risks are employed for the baseline of hazard/risk levels without using any tools or control measures to reduce the risks.

The control measures employed to reduce the likelihood of hazards/risks and the contexts from people nearby and environments might increase the likelihood of hazards/risks as stated in the RA activity model constructed in Section 4.4.1. It is necessary to define their individuals and datatype values as context parameters in order to use them for risk level calculation in a particular situation. The individuals of chimney fire control measures are shown in Table 4.25 corresponding to Table 4.9. The individuals of context from communities are shown in Table 4.26 corresponding to Table 4.10.

Table 4.24 Datatype properties of individuals of hazards/risks for chimney fire

Datatype property	Instance or Individual	Value	Manchester Syntax
has severity	Falling Masonry-Instance	7.0	Individual: Falling Masonry-Instance <i>has severity "7.0"^^decimal</i>
	Roof Condition-Instance	5.0	Individual: Roof Condition-Instance <i>has severity "5.0"^^decimal</i>
	Hazardous Substance-Instance	6.0	Individual: Hazardous Substance-Instance <i>has severity "6.0"^^decimal</i>
	Fire Spread-Instance	5.0	Individual: Fire Spread-Instance <i>has severity "5.0"^^decimal</i>
	Blow Back-Instance	5.0	Individual: Blow Back-Instance <i>has severity "5.0"^^decimal</i>
has likelihood	Falling Masonry-Instance	6.0	Individual: Falling Masonry-Instance <i>has likelihood "6.0"^^decimal</i>
	Roof Condition-Instance	5.0	Individual: Roof Condition-Instance <i>has likelihood "5.0"^^decimal</i>
	Hazardous Substance-Instance	5.0	Individual: Hazardous Substance-Instance <i>has likelihood "5.0"^^decimal</i>
	Fire Spread-Instance	5.0	Individual: Fire Spread-Instance <i>has likelihood "5.0"^^decimal</i>
	Blow Back-Instance	4.0	Individual: Blow Back-Instance <i>has likelihood "4.0"^^decimal</i>

Table 4.25 Datatype properties of individuals of chimney fire control measures

Datatype property	Instance or Individual	Value	Manchester Syntax
has likelihood (for control measures)	Chimney Fire Control Measure-aa-Instance (Cordon off an unsafe area)	-0.5	Individual: Chimney Fire Control Measure-aa-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ab-Instance (Use safe systems of work for gaining access to and working on roof)	-1.0	Individual: Chimney Fire Control Measure-ab-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-ac-Instance (Complete training of hazard or risk in gaining access to and working on roof)	-0.5	Individual: Chimney Fire Control Measure-ac-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ad-Instance (Use aerial appliances)	-1.0	Individual: Chimney Fire Control Measure-ad-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-ae-Instance (Use roof ladders)	-0.5	Individual: Chimney Fire Control Measure-ae-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-af-Instance (Use work positioning and fall arrest systems)	-0.5	Individual: Chimney Fire Control Measure-af-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ag-Instance (Complete training of hazard or risk for pitch and flat roof)	-0.5	Individual: Chimney Fire Control Measure-ag-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ba-Instance (Use hearth kit)	-1.0	Individual: Chimney Fire Control Measure-ba-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-bb-Instance (Use safe systems of work for asbestos and MMMF material)	-1.0	Individual: Chimney Fire Control Measure-bb-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-bc-Instance (Use breathing apparatus and contamination procedures)	-1.0	Individual: Chimney Fire Control Measure-bc-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-bd-Instance (Complete training of hazard or risk for working in roof space and cutting away)	-0.5	Individual: Chimney Fire Control Measure-bd-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ca-Instance (Complete training of hazard or risk for applying extinguishing media)	-0.5	Individual: Chimney Fire Control Measure-ca-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-cb-Instance (Use safe systems of work for applying extinguishing media)	-1.0	Individual: Chimney Fire Control Measure-cb-Instance <i>has likelihood "-1.0"^^decimal</i>
	Chimney Fire Control Measure-cc-Instance (Use thermal imaging camera)	-0.5	Individual: Chimney Fire Control Measure-cc-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-cd-Instance (Use of eye protection and mirror)	-0.5	Individual: Chimney Fire Control Measure-cd-Instance <i>has likelihood "-0.5"^^decimal</i>
	Chimney Fire Control Measure-ce-Instance (Use of full fire kit with helmet)	-0.5	Individual: Chimney Fire Control Measure-ce-Instance <i>has likelihood "-0.5"^^decimal</i>

Table 4.26 Datatype properties of context parameters from community impacts

Datatype Property	Instance or Individual	Datatype Value	Manchester Syntax
has likelihood	Off-Peak Time-Instance	+0.0	Individual: Off-Peak Time-Instance <i>has likelihood "0.0"^^decimal</i>
	Peak Time-Instance (with High Traffic or Congested Traffic Road or Narrow Road/Street)	+0.2	Individual: Peak Time-Instance <i>has likelihood "0.2"^^decimal</i>
	Sunny-Instance	+0.0	Individual: Sunny-Instance <i>has likelihood "0.0"^^decimal</i>
	Rain-Instance	+0.0	Individual: Rain-Instance <i>has likelihood "0.0"^^decimal</i>
	Freeze-Instance	+0.2	Individual: Freeze-Instance <i>has likelihood "0.2"^^decimal</i>
	Snow-Instance	+0.2	Individual: Snow-Instance <i>has likelihood "0.2"^^decimal</i>
	Low Wind-Instance	+0.0	Individual: Low Wind-Instance <i>has likelihood "0.0"^^decimal</i>
	High Wind-Instance	+0.2	Individual: High Wind-Instance <i>has likelihood "0.2"^^decimal</i>
	Bad Visibility-Instance	+0.2	Individual: Bad Visibility-Instance <i>has likelihood "0.2"^^decimal</i>
	Good Visibility-Instance	+0.0	Individual: Good Visibility-Instance <i>has likelihood "0.0"^^decimal</i>
	Crowd of People-Instance	+0.2	Individual: Crowd of People-Instance <i>has likelihood "0.2"^^decimal</i>
	Drunk People-Instance	+0.2	Individual: Drunk People-Instance <i>has likelihood "0.2"^^decimal</i>
	Hazardous Substance Nearby-Instance	+0.2	Individual: Hazardous Substance Nearby-Instance <i>has likelihood "0.2"^^decimal</i>
	Car Park-Instance (with Crowd)	-0.2	Individual: Car Park-Instance <i>has likelihood "-0.2"^^decimal</i>

The RA domain ontology contains 315 classes, 37 object properties, 2 datatype properties and 32 individuals. It is hosted at <http://www.comp.leeds.ac.uk/scswe/ontology/GRA.owl> and the ontology IRI can be found at <http://www.comp.leeds.ac.uk/scswe/ontology/GRA.owl#>.

4.6. User Current Activity Model

A User Current Activity (UCA) model will be generated during the dialogue interaction process. When the dialogue agent is started, the RA domain ontology will first be loaded into memory as an ontology template of UCA. Each UCA model is specified in OWL and resembles an ontology specification. It is presented as an instantiation of an initial activity and RA activity model defined in the RA domain ontology. At the beginning, the special class 'Status', and its special instances 'Yes' and 'No' are inserted into the UCA in order to indicate the 'yes' or 'no' answers of users to dialogue questions during dialogue interaction. The answer 'yes' means user did or had experience of that activity or action, while the answer 'no' means the user did not do or had no experience of that activity or action. The UCA is updated by inserting the instances of classes and their properties after the user answers the dialogue questions so as to record the experiences of user activity in the UCA. When the dialogue interaction ends, the latest updated UCA in memory will be saved to a

file in the user directory. The file is named as ‘user’ plus ‘_uca’, for example, ‘paul/paul_uca’, ‘wichai/wichai_uca’. Examples of relationships between instances in the RA domain ontology and inserted instances in UCA for experiences of situation 1 and 2 with incident ID no.1 (the same incident but different situations) are shown in Table 4.26. For the risk calculation, the instances inserted in UCA are not assigned datatype values. They will instead use the datatype values from the instances of the same classes in the RA domain ontology. For instance, in Table 4.26 an instance ‘Chimney Fire Control Measure-aa-Instance’ of a class **Chimney Fire Control Measure-aa** is assigned datatype value ‘-0.5’ in the RA domain ontology. When the user answers the experience ‘Yes’ of this control measure for situation 1, the dialogue agent will create an instance ‘Chimney Fire Control Measure-aa-S1-Inc1’ of class **Chimney Fire Control Measure-aa** and insert it in UCA. The datatype value ‘-0.5’ is involved in risk calculation for risk reduction (the likelihood level of the falling masonry hazard and roof condition hazard are reduced by 0.5). Examples of instances (e.g. Initial Chimney Fire Action-a-Inc1) for recording user activities and their relationship (haveStatus) with instance ‘Yes’ or ‘No’ inserted by the dialogue agent are shown in Table 4.27.

Table 4.26 Examples of relationships between instances in RA domain ontology and inserted instances in UCA for experiences of situation 1 and 2 with the incident ID no.1

Instance in RA ontology	Instance Inserted in UCA for Situation 1 Incident ID no. 1	Instance Inserted in UCA for Situation 2 Incident ID no. 1
Chimney Fire Control Measure-aa-Instance (Cordon off an unsafe area)	Chimney Fire Control Measure-aa-S1-Inc1	Chimney Fire Control Measure-aa-S2-Inc1
Chimney Fire Control Measure-ab-Instance (Use safe systems of work for gaining access to and working on roof)	Chimney Fire Control Measure-ab-S1-Inc1	Chimney Fire Control Measure-ab-S2-Inc1
Chimney Fire Control Measure-ac-Instance (Complete training of hazard or risk in gaining access to and working on roof)	Chimney Fire Control Measure-ac-S1-Inc1	Chimney Fire Control Measure-ac-S2-Inc1
Chimney Fire Control Measure-ad-Instance (Use aerial appliances)	Chimney Fire Control Measure-ad-S1-Inc1	Chimney Fire Control Measure-ad-S2-Inc1
Off-Peak Time-Instance	Off-Peak Time-S1-Inc1	Off-Peak Time-S2-Inc1
Peak Time-Instance	Peak Time-S1-Inc1	Peak Time-S2-Inc1
Sunny-Instance	Sunny-S1-Inc1	Sunny-S2-Inc1
Bad Visibility-Instance	Bad Visibility-S1-Inc1	Bad Visibility-S2-Inc1
Falling Masonry-Instance	Falling Masonry-S1-Inc1	Falling Masonry-S2-Inc1
Hazardous Substance-Instance	Hazardous Substance-S1-Inc1	Hazardous Substance-S2-Inc1

Table 4.27 Examples of instances for user activities and their properties inserted by dialogue agent to UCA

Object Property	Manchester Syntax
has status	Individual: InitialChimneyFireAction-a-S1-Inc1 <i>haveStatus Yes</i>
	Individual: InitialChimneyFireAction-c-S1-Inc1 <i>haveStatus No</i>
	Individual: ChimneyFireRiskAssessmentAction-aa-S1-Inc1 <i>haveStatus No</i>
	Individual: ChimneyFireRiskAssessmentAction-ca-S1-Inc1 <i>haveStatus Yes</i>

The class ‘Initial Chimney Fire Action-a’ has the instance ‘Initial Chimney Fire Action-a-S1-Inc1’, and class ‘Status’ has the instance ‘Yes’. The instance ‘Initial Chimney Fire Action-a-S1-Inc1’ relates to the instance ‘Yes’ with object property ‘has status’. This indicates that the user has an experience in ‘Initial Chimney Fire Action-a-S1-Inc1’. In contrast, the instance ‘Chimney Fire Risk Assessment Action-aa-S1-Inc1’ relates to the instance ‘No’ with object property ‘has status’. This indicates that the user has no experience in ‘Chimney Fire Risk Assessment Action-aa-S1-Inc1’. The suffix ‘Inc1’ is the incident ID e.g. Inc1, Inc2, and so on. Each incident has a unique ID that is assigned at the beginning of the dialogue interaction. The suffix ‘S1’ is the situation ID e.g. S1, S2, ... etc. The first situation will be assigned the situation ID ‘S1’, the next situation ‘S2’ and so on. In this work, we consider only the first situation for our PORML prototype.

The UCA will be used by the dialogue agent to keep track the user activity. The dialogue agent will query the UCA model to find the next move of dialogue. Querying the model and dialogue agent will be addressed on the next Chapter.

4.7. Discussion

Many existing projects in risk assessment provide the risk assessment development methodologies, for instance, CORAS (Braber, Dimitrakos et al. 2003), AORDD (Siv Hilde and Geri 2005) and RacWeb (Dimakopoulos and Kassis 2008), focusing on different types of risks or different areas of concern. They seem not to be applicable to our risk assessment ontology development in FRS RA because they were developed for other specific purposes and areas of concern. For example, RA in security critical systems applied to the areas of telemedicine and e-commerce, RA in customs etc. Our RA domain ontology is specific to the area of FRS so we have certain specific constraints on ontology development that must be considered, such as the limited availability of domain experts is limited, the fact that the author is not a domain expert and is not familiar with the domain, the fact that the author lacks experience in ontology engineering etc. To find and adapt the appropriate methodology approach used in our work, the relevant existing ontology

methodologies reviewed in Section 4.2.2 were adapted and tailored to the specific constraints of our domain ontology development methodology. For example, the stage of knowledge acquisition in METHONTOLOGY was adapted to the first step of our methodology, the motivating scenario in Gruninger and Fox's methodology was adapted to define the scope corresponding to the first step of our methodology, the knowledge glossary construction with identifying core concepts and secondary concepts in Ordnance Survey methodology was adapted to the second step of our methodology etc.

On the one hand, our methodological approach has certain strengths in ontology development to be considered. Firstly, the knowledge sources obtained from the scenario-based method and other knowledge sources collection method in our methodology can be an alternative way for specific domain development which has very limited availability of domain experts involved. Secondly, the author who creates a domain ontology but is not familiar with the domain, or has little or no experience in ontology engineering can benefit from this approach. Thirdly, our approach can be applied and extended to other FRS RA activities e.g. building fire, rescue from high etc. by extending the scope and identifying which concepts and relationships are involved. It might be possible to adapt this to other activities e.g. police patrol, ambulance etc. using Activity Theory to consider the contextual information involved and identify the concepts and relationships related to those activities.

On the other hand, our methodological approach has certain disadvantages which should be considered. Firstly, the collection of data from knowledge sources without strong involvement of domain experts, combined with the author's unfamiliarity with the domain can result in unreliable information. Indeed, risk calculation used analytical risk assessment from gathered knowledge sources, but while the collected sources provided information about the process and method to analyse the risk by calculation, they did not state where the figures used for calculating the risk rating, e.g. the severity and likelihood in falling masonry hazard/risk, came from and how. The author assumed the figures for 'severity=7' and 'likelihood=6' in this hazard/risk by comparison with the few available report examples in other fire RAs accessed online. The data collection process might be faster and these figures might be more accurate if the experienced crew commanders or higher level commanders (domain experts) were involved closely. Secondly, the iterative design of RA domain ontology was needed to evolve the classes and properties during development process when elaborating the details and testing with the dialogue agent. Thirdly, in fact the generation of the ontology including evolution and extension could be considered and assessed for development process

in terms of creation cost and development time. If the costs are high and it is time-consuming development, the methodological approach may be impractical. So, supplementary techniques could be needed to reduce costs and development time for evolution and extension of ontology such as adding and updating concepts and relationships using dialogue agent with capability to employ natural language processing, providing special dialogue game mechanism to add new concepts or update existing concepts and relationships into the RA ontology (with a validation process). Fourthly, another point is our creation of a knowledge glossary table. General or limited relationships were built e.g. 'is a kind of', 'has member', 'is member of' etc. More expressive relationships were not considered in our design e.g. transitive, symmetric, disjoint, functional relationship etc. These relationships might be relevant in some domains or large ontologies and they can be represented in OWL as properties for expressiveness.

The Activity Theory can be used to help us develop a conceptual model of the RA activity to identify the concepts and relationships in order to build RA domain ontology. The AT is suitable for providing the main structure of the context and constructing the context dimensions of RA activity model at the abstract level. It can help to capture contextual knowledge and create the entities in an activity model that can be incorporated into the intelligent system. It also provides a hierarchical structure of the activity that can discriminate the conscious and unconscious attention using three different levels: activity, action, and operation. This hierarchical structure is very useful to identify the levels of attention of activity and can help to define contents in the structure using the level discrimination.

However, when we elaborate into the details of the contexts, the AT model is not sufficient to provide the details of the entities in context, both in the AT system and in the hierarchical structure of AT. The details of entities have to be analysed from the gathered knowledge sources and populated into the AT system and its hierarchical structure, for example, the entity 'tools' in initial activity model using AT system was defined as 'equipment and appliances' at abstract level (see Figure 4.5) and the details of this entity can be: 'eye protection', 'mirror', 'fall arrest system', 'full fire kit' and others. The AT model also does not tell us about the relationships between the entities and between different levels of hierarchical structure. In our RA activity model, the relationships were analysed and not used as one to one relationship e.g. the entity 'subject' in an RA activity model using the AT system was defined as 'crew member' (this entity has only one member), and the entity 'role' was defined as 'commander' at the abstract level. The details of this entity can be: 'incident commander' or 'crew commander'. The relationships between 'crew member' and 'incident commander', and between 'crew member'

and 'crew commander' are the same, 'is role of' and 'has role'. Also, the relationship between two entities at the abstract level of AT system defined might not be the same as the relationship between the members of their detail level. These are some limitations of applying the AT to model our contexts in RA activity.

The Rabbit language and ROO authoring tool were mainly employed to build the logical model in our RA domain ontology. The primary advantage of using this tool is ease of use. Even with no experience in ontology engineering, it is fast to construct the classes and properties in logical model by writing structured English sentences in Rabbit. A useful feature of ROO provides the key phrases which make the constructs unambiguous by underlining the key phrases. ROO also has the ability to check whether the concepts (classes) and relationships (object properties) on the entered sentence are present or not. If they are not present, indicated by red underlining in, ROO would navigate the author to create that class or property before accepting the entered sentence.

However, a few problems were found while developing our RA domain ontology using Rabbit sentence and ROO authoring tool (version 1.0.1). Rabbit contains a sentence form that cannot be translated into OWL using the word 'usually' (Hart, Johnson et al. 2007) e.g. 'A Public House usually has part a Car Park'. The reason for including this word is to enable the domain expert to record frequent but not mandatory relationships. The term 'Blow Back' used to represent a hazard on our RA domain ontology can not be accepted as a concept by ROO. ROO treats the word 'Blow' as a verb, so this term can not be entered in the Rabbit sentence. Actually, the word 'Blow' in this case is a noun. Based upon discussions with the developer of ROO, certain words can not only be nouns, but also be verbs or others. The word 'Blow' in this case is translated as a verb by ROO, therefore, this is a limitation of ROO in this version.

The RA domain ontology was validated in three ways: (1) using reasoners (FaCT++ and Pellet) in Protégé 4 (2) using formative evaluation (3) commented by an ontology engineer. Firstly, the RA domain ontology was checked using Protégé 4. The RA domain ontology was classified by reasoners to compute the inferred class hierarchy in order to check for inconsistencies in the ontology and find the unsatisfiable classes or inconsistent classes. After the reasoners finished classifying, no unsatisfiable classes appeared on the inferred class hierarchy view. Secondly, the validation of the RA domain ontology will be performed via the dialogue interaction with a dialogue agent using formative evaluation explained in Chapter 7. Thirdly, the RA domain ontology was checked by an ontology engineer who had experience in ontology development and ontology authoring tool development including ROO.

After inspecting the RA domain ontology, he made the following comments, in discussion with the author:

- It is useful that the first and last sentences are exactly what people need to know about the purpose of the ontology. However, the second part of the first sentence might not be clear what the meaning of 'key map objects of buildings and places' is. After discussion, it has been changed to 'key topographic objects of buildings and places';
- The scope has one long sentence that is hard to read and understand and the author mentions several concepts that most people will not understand, so the sentence should be divided into several sentences. The author think that the original scope appearing on the Section 4.3.2 could be kept as current design for a PORML prototype. New scope will be considered deliberately and changed on the next version of the RA domain ontology;
- A considerable list of knowledge sources is provided in the RA domain ontology. It can make the impression of a well researched ontology;
- The RA domain ontology does not import any other ontologies. The author chooses to build the RA domain ontology as a single ontology. It contains 315 classes, 37 object properties, 2 datatype properties and 32 individuals. It is a medium size ontology with small DL constructs being used and its expressivity is ALCIQ(D). Due to the size of the ontology, it is difficult to discover what are the main concepts. There are several concepts at the top level and they mostly have subclasses. It is not a bad thing *per se* but it might be easier to understand the ontology if it was modularised. It is possible to modularise the RA domain ontology. However, it is not in the scope of the author's work and the tools that support for modularising ontologies in ROO and Protégé are not good enough at the moment;
- The concepts and the relationships are mostly described by natural language. The rabbit sentences related to them make the terminology easy to learn;
- Certain subclass relationships are dubious. For instance, (1) Why a 'Control Unit' is a subclass of 'Fire Vehicle'? The 'Fire Appliance' seems to be something that is a part of a 'Fire Vehicle'. (2) A 'Roof Condition' is a kind of 'Hazard'. This is not always true because some roof conditions are not hazardous. It could be renamed to 'Hazardous Roof Condition' or something similar. The author can explain as follows: (1) The control unit is used in the meaning of FRS as '*A vehicle equipped as a mobile control room for use by the officer*'. The fire appliance is used in the meaning of FRS as '*A vehicle designed to assist in fighting fire by transporting firefighters to the scene and providing*

them with access to the fire, water, or other equipment'. (2) The GRA manual implies the phase 'Roof Condition' for a hazard of FRS risk assessment. The author follows in this way;

- Most classes seem to be defined in order to have the vocabulary during the dialogue, but no inferencing is performed, for instance, 'Crowd of People' is defined as being anything that 'has Person' at least 50 'Person', but the relationship 'has Person' is not used in other places, therefore the reasoner will never conclude that something is a 'Crowd of People'. This is fine, if the author say that the purpose of the ontology is to serve as a lightweight ontology that provides the vocabulary used in risk assessment, but that the ontology is not meant to make complex inferences. Whatever inference is made is manually encoded using subsumption (subClassOf) assertions.
- The ontology IRI is <http://www.semanticweb.org/ontologies/2551/9/GRA.owl#>. However the author can not publish this ontology there, because the author do not own the semanticweb.org domain. It could be renamed to something that related to the location where the ontology are hosted. The author will rename the ontology IRI as <http://www.comp.leeds.ac.uk/scswe/ontology/GRA.owl#> or look like this IRI.

4.8. Summary

This chapter presented the ontological model of risk assessment activity, providing the RA domain model in the PORML framework. The relevant existing methodologies were considered in order to find and adapt the appropriate methodology corresponding to the specific constraints of our domain ontology development used in the PORML framework. Our methodology was outlined as follows:

- Identifying the requirements specifications – identifying purpose and scope, gathering knowledge sources;
- Creating conceptual model – identifying the concepts and relationships using the Activity Theory concept, buiding a glossary;
- Coding logical model – converting knowledge in the glossary into structured English sentences, building the logical model;
- Validating the ontology.

We conducted an interview with a fire control manager and got feedback from firefighters's questionnaires, before building a scenario in order to identify our purpose and scope. The RA knowledge sources were gathered from manuals,

references, existing ontologies, online information etc., and knowledge glossary concept and relationship tables were constructed. The main or core concepts and relationships were identified using Activity Theory system and its hierarchical structure to construct the RA activity conceptual model and define the concept terms and relationship terms. Then, we populated these terms into the knowledge glossary tables. The knowledge glossary concept and relationship terms were converted into structured English sentences using a controlled natural language. The ontology authoring tool was employed to help us enter the controlled natural language to build the logical model of the RA domain ontology in OWL format. We designed the user current activity model to keep track of the user's experiences. The model was created and maintained by the dialogue agent during dialogue interaction process to decide the move of dialogue.

The RA domain ontology created in this chapter will be employed by the dialogue game-based agent component of the PORML system described in the next chapter. The validation of this ontology was checked using the reasoners in Protégé 4, and commented by an ontology engineer with discussion. The validation will also be performed via the dialogue interaction with a dialogue agent using formative evaluation explained in Chapter 7.

Chapter 5

Dialogue Manager and Planner

5.1. Introduction

In chapter 3, the architecture of the PORML framework was presented and discussed. The five main components of the framework were introduced and the Dialogue Manager and Planner component was highlighted as the crucial component of the framework. The previous chapter described how to build a risk assessment (RA) domain ontology used to plan the dialogue contents by the Dialogue Manager and Planner component.

In this chapter, the main characteristics of the activity review and reflective learning dialogue will be presented in Section 5.2. Dialogue structure will be presented in Section 5.3. In Section 5.4 details of the dialogue games for the activity review and reflective learning dialogue will be described. Dialogue management will be presented in Section 5.5 and adapting dialogue to the user current activity model will be presented in Section 5.6.

5.2. Activity Review and Reflective Learning Dialogue – Main Characteristics

5.2.1. Activity review

FRS activity review

In FRS practice, firefighters usually undertake initial formal training and continuous personal/professional development in line with their roles and operational needs. Firefighters mainly learn experientially from their everyday activities. Activity review of an operational incident is used during an operational debrief to help firefighters learn from an operational incident. The purpose of an operational debrief is to (Kent FRS 2010) (1) validate good practice and procedure; (2) identify improvements in procedures, training and tools; (3) check safe systems of work and health and safety compliance; and (4) identify the success or failure of fire safety measures. In general, there are two levels of review (Cambridgeshire FRS 2007): (1) local review (also known as hot debrief); and (2) service review (also known as cold or structured debrief). Certain FRSs might also use different classification or names for these levels. For example, Kent FRS classifies the reviews under three debrief

stages (Kent FRS 2010): (1) informal debrief (also known as hot debrief) – occurs at the end of the incident before leaving the scene; (2) written debrief – occurs on return to the station and is used to enable learning points to be given in feed back and acted on; and (3) formal debrief (also known as cold debrief) – occurs with the command team or selected personnel from an incident to get the maximum learning from larger incidents and incidents of special interest.

The local review or hot debrief is conducted for incidents involving 1–4 pumping appliances. The hot debrief, which occurs at the incident, is an informal meeting to review a particular incident or situation. Its objective is to review an incident from an operational perspective whilst it is fresh in the minds of those involved. It is effective in identifying to local crews the benefits of using the appropriate equipment and resources (Essex County FRS 2009). For incidents involving 1–4 pumps, formal Command Support, which provides Command Support Packs, is used. These packs provide the formalised Command Support System the Incident Commander requires at small or developing incidents i.e. 1–4 pumps. Each pack contains information and forms such as an incident command board, resource record form, key decision and message record form, analytical risk assessment form and aide-memoirs for functional officer roles. However, a significant number of small and routine incidents may not require the formal support and processes it offers.

The service review or cold debrief is conducted in the following circumstances: (1) all incidents involving 5 or more pumping appliances; (2) when required by the Area Manager or Brigade Manager following unusual or special incidents; and (3) when a serious deficiency that could affect the safety of others if not reported and acted on is identified. The cold debrief is submitted to an Operational Performance Review, accompanied by a report which considers the areas (e.g. brief narrative, command and control effectiveness, use of communication, resource usage, risk assessment and planning etc.) that need support following the performance review outcomes. Where incidents develop beyond 4 pumps, the Command Support Pack should be transferred to the Command Unit. The Command Unit will be mobilised to provide logistic support to manage the incident command process.

In our case, the activity review can be easily applied to the local review or hot debrief because in small scale incidents, the overall process is handled locally. The local review may take the form of an end of shift meeting to review the day's events or a more focused debrief on a specific incident or situation. A local review of a specific incident must be carried out within 24 hours of the incident occurrence. As the service review is for large scale incidents, it is more complicated and takes much

longer. For this reason, it might not be appropriate for the activity review to be applied directly to the service review. However, the activity review can help with general risk assessment of the incident before the formal review of a large scale incident as it provides quick results.

Dialogue for activity review

Using interactive dialogue in a review can be helpful for learning and improving practice. It is beneficial to identify and explore the perspectives of learners. For example, (Durrant, Dunnill et al. 2004) examined projects in school improvement and development in which a Higher Education Institute worked in partnership with individual secondary schools to support school self-review through developing critical and authentic dialogue between people and their relationships. Corresponding to a research by (Hadfield 2003) that revealed that head teachers realised the importance of making connections between people where people could learn from one another, recognising that this process involved emotions, relationships and values to accumulate knowledge through dialogue that could help schools improve practice. In another example, (Peters, Bratt et al. 2004) used a tutorial dialogue called 'SCoT-DC tutor' in a training system for Navy damage control to conduct the after-action review and perform related tutoring. The tutorial dialogue had a repertoire of hinting tactics which were deployed in response to learners' answers to questions and identified and discussed repeated mistakes so that the learner could learn the correct actions and avoid practicing mistakes based on the tutor's feedback regarding appropriate actions in response to crises (e.g. fires, floods).

In our work, an activity review is used after a fire incident is completed in the form of RA activity/action questions which are issued in sequence to obtain the learner's response to the questions. The answers are compared to existing knowledge of general RA to provide feedback to the learner. This review can be of benefit to all FRS debriefs, especially hot debriefs, for firefighter learning and improvement.

5.2.2. Reflective questions

Reflective learning is another main objective of the interactive dialogue for learning. The literature review of reflective learning and dialogues for reflection is presented in Chapter 2. The review or debriefing sessions in the firefighter training aim to trigger the cognitive process of reflection. The questions supporting reflective learning are needed to encourage reflection on the user's activity or experience. These questions can also be developed to support a particular domain.

In our work, existing reflective questions (Race 2006; Moon 2007) are adapted to develop reflective questions for PORML which can be appropriately applied to a FRS risk assessment domain.

5.3. Dialogue Structure

This section presents the structure of dialogue planning which consists of PORML dialogue game (DG) episodes. These episodes are classified and characterised according to the operational activity which the user has performed in operational FRS practice. Figure 5.1 shows the structure of dialogue planning used in PORML. There are two main types of PORML DG episodes: Sequential DG episodes and Interruption DG episodes.

Sequential DG episodes are played as the main part of an activity review session of an incident, corresponding to the sequence of actions in an operational FRS practice. These episodes include:

- **CollectContextInformationDG** episode - determines the location of the incident and checks contextual information surrounding the incident place;
- **InitialActionsDG** episode – reviews an initial activity or initial actions of operational FRS practice;
- **InitialControlMeasuresDG** episode – inquires whether existing and available control measures were used when firefighters initially arrived at the incident place;
- **IdentifyRiskAssessmentDG** episode – identifies which sub-activities of the RA activity the user assesses in the incident;
- **SituationAssessmentDG** episode – reviews who was harmed in the hazards and reviews the results of risk assessment of that situation;
- **ModeAndSystemDG** episode – reviews the tactical mode and safe systems of work the user chose. In future development, an actions review of tactical control could be included in this episode in order to also review control operations including all possible measures taken to protect personnel, corresponding to the chosen tactical mode and safe systems of work;

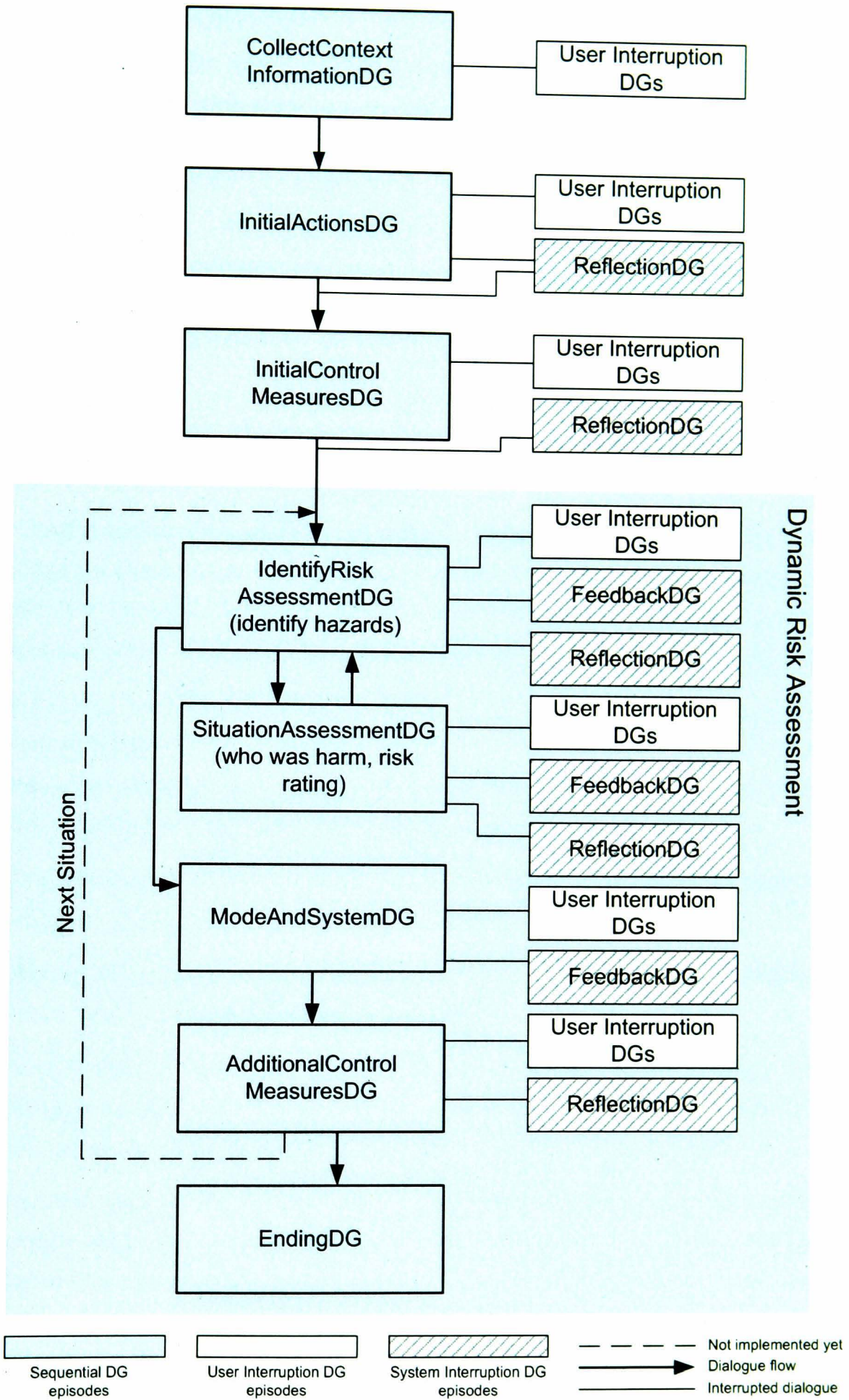


Figure 5.1 The structure of dialogue plan of PORML dialogue game episodes

- **AdditionalControlMeasuresDG** episode – suggests whether other control measures could be added to those already being used in the current situation. At the moment, in this episode, we have only developed suggestions regarding further actions the user could take to reduce the hazards/risks in the assessment of the first situation. However, in the future, this episode could be extended to support a further actions review after suggestions are given as well as an actions review as the incident develops, in order to also perform an assessment of the next situation. Such risk assessment, which involves repeated assessment in different situations of the same incident is called Dynamic Risk Assessment;
- **EndingDG** episode – generates an agent utterance to inform the user that the end of the dialogue has been reached. The dialogue agent then closes the session and the dialogue interactions are recorded.

Interruption DG episodes are used to interrupt the Sequential DG episodes for a specific purpose e.g. to explain the meaning of words (concepts), respond to the results of a selection, reflect on the actions etc. The Interruption DG episodes are divided into: User Interruption DG episodes and System Interruption DG episodes.

User Interruption DG episodes are activated by the user. Agent and user utterances are not generated in these episodes. Instead, a popup window is generated for this purpose. The messages generated in the popup window are not recorded in the User Dialogue Interaction Log Files. These episodes include:

- **ExplanationDG** episode – describes two concepts in an Explain Concept popup window. These concepts are from parts of the current agent utterance;
- **HistoryDG** episode – allows the last four lines of recent dialogue interactions to be viewed in a Dialog History popup window;
- **UserEndingDG** episode – requests to end the dialogue immediately with an Ending Confirmation popup window and then closes the session without recording any dialogue interactions in the User Dialogue Interaction Log Files.

System Interruption DG episodes are activated automatically at pre-assigned points. The agent utterances in the System Interruption DG episodes are then generated and performed by the dialogue agent. Contrary to User Interruption DG episodes, the utterances in these episodes are recorded in the User Dialogue Interaction Log Files. These episodes include:

- **FeedbackDG** episode – occurs in response to the user's answer in order to provide feedback or suggest something relating to the selected answer;
- **ReflectionDG** episode – initiates reflection on actions using reflective questions relating to previous answers or actions in order to support reflective learning.

5.4. Dialogue Games for Activity Review and Reflective Learning

Dialogue game episodes are used in interactive dialogues. The dialogue games used in PORML are reviewed in Chapter 2. They are adapted to the interactive dialogues in the PORML dialogue game episodes. These PORML dialogue game episodes correspond to their activity review and reflective learning goals.

5.4.1. Definitions of PORML dialogue games

A dialogue game represents an interaction episode regarding a particular goal. PORML dialogue game episodes are divided into two types: Sequential DG episodes and Interruption DG episodes. The Sequential DG episodes are the main episodes that contain *CollectContextInformationDG*, *InitialActionsDG*, *InitialControlMeasuresDG*, *IdentifyRiskAssessmentDG*, *SituationAssessmentDG*, *ModeAndSystemDG*, *AdditionalControlMeasuresDG*, and *EndingDG*. The Interruption DG episodes contain *ExplanationDG*, *HistoryDG*, *UserEndingDG*, *FeedbackDG* and *ReflectionDG*. The Interruption DG episodes are used to interrupt the Sequential DG episodes for a specific purpose e.g. explain the meaning of words (concepts), respond to the result of a selection or encourage reflection on actions.

5.4.2. Sequential DG episodes: activity model

The activity/action review of an incident in terms of RA activity is the key design of Sequential DG episodes. The Sequential DG episodes are played as the main part of an incident review session, corresponding to the sequence of actions in practice. The Sequential DG episodes are played in the following sequence:

CollectContextInformationDG

After user login is successful, PORML has to determine the location of the incident place and check the contextual information surrounding it. The contextual information is determined from the Geographic Location Database based on the location of the incident and the type of incident as provided by the user's input (developed in PORML prototype) or by automatic extraction from the User Record Database (not yet developed in PORML prototype) as explained in the architecture of PORML framework in Chapter 3. The *CollectContextInformationDG* episode is the first dialogue episode and is used to collect contextual information about the circumstances (or contexts) surrounding the incident place. Questions in this episode are used to ask the user about incident location (either GPS is used to get the current location of the device and select the incident place from a list of places or the incident place is selected on a map directly – not yet developed in the PORML prototype), type of incident (e.g. chimney fire, high rise building fire, rescue from

high etc.), date and time of incident, and weather conditions (type or characteristics of weather e.g. sunny, snow etc.; wind – high/low; visibility – high/low).

InitialActionsDG

The InitialActionsDG episode is used to review the initial activity of operational FRS practice which is carried out when the firefighters arrive at the incident place. This initial activity is normally called initial actions and occurs before risk assessment begins. This episode reviews the series of initial actions that correspond to the type of incident occurring. The initial actions are performed to prepare or provide appropriate environments surrounding the incident place, including equipment, actions and so on, for operational FRS activity e.g. fighting fire, assessing risk etc. Certain initial actions might be control measures for risk assessment e.g. provide the use of a thermal imaging camera, provide the use of eye protection and mirror etc. Based on the answers given during the review, if the user performs or provides initial actions in terms of control measures, the status of using these control measures will be set and informed for use in the next episode, InitialControlMeasuresDG. The finite state network (Jordan, Ringenberg et al. 2006) is adapted to our state network diagram to show the sequence of actions and response states. Figure 5.2 shows the state network diagram of InitialActionsDG episode.

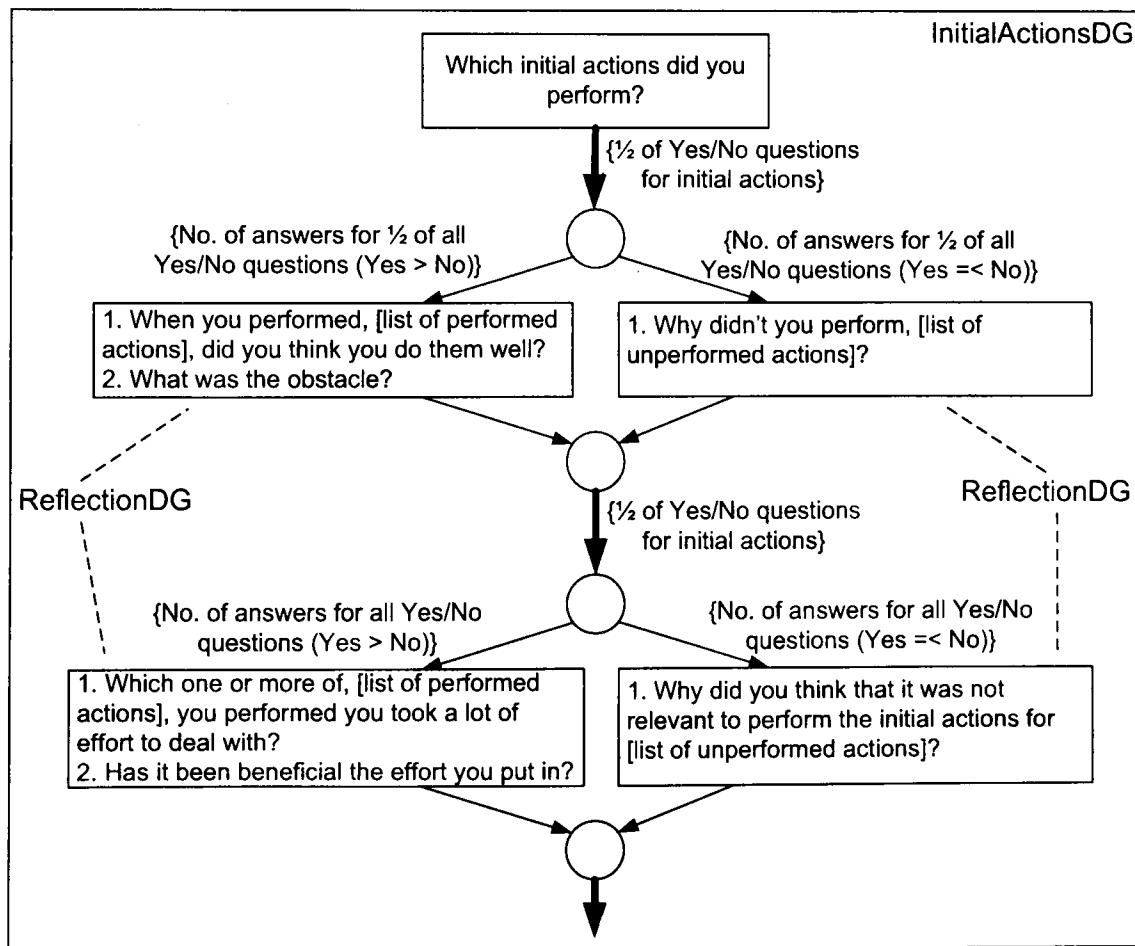


Figure 5.2 The state network diagram of InitialActionsDG episode

InitialControlMeasuresDG

The InitialControlMeasuresDG episode is used to inquire whether existing and available control measures were used when firefighters first arrived at the incident place or at the first situation of the incident. These control measures are tools in risk assessment and are used to determine the level of risk for each hazard. The issued questions about the control measures correspond to the type of incident performed. The status of using these control measures will be set for later use. The status of each control measure will be retrieved to calculate the risk level or risk rating for that situation by the SituationAssessmentDG episode. Figure 5.3 shows the state network diagram of InitialControlMeasuresDG episode.

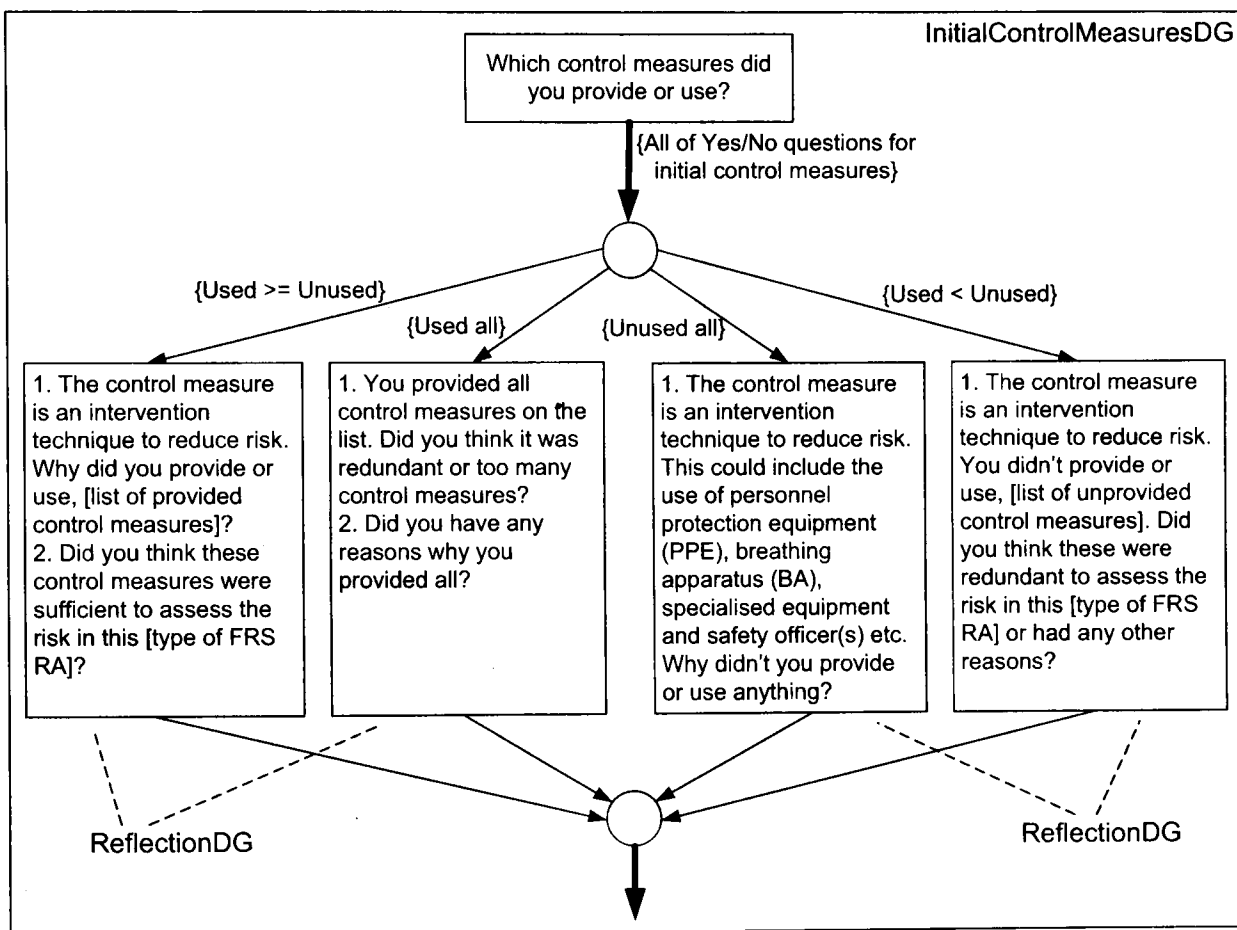


Figure 5.3 The state network diagram of InitialControlMeasuresDG episode

IdentifyRiskAssessmentDG

The IdentifyRiskAssessmentDG episode is used to identify the activities the user assessed in the incident (ie. the types of RA activity for a FRS RA that were carried out). For example, RA activity for a chimney fire is conducted for three activities (ie. these are types of RA activity for a chimney fire): (1) gaining access to and working on the roof (2) working in roof space and cutting away (3) applying extinguishing media. To identify which of these activities were assessed, the user is asked which RA activities he performed for the given type of incident. Say, for example, the user did not perform the RA activity for working in roof space and cutting away but did

for the other two activities in a chimney fire incident. The activities that the user carried out will be inquired about further for assessment by the SituationAssessmentDG episode, while the others will be skipped to get feedback and initiate reflection instead. Figure 5.4 shows the state network diagram of IdentifyRiskAssessmentDG episode.

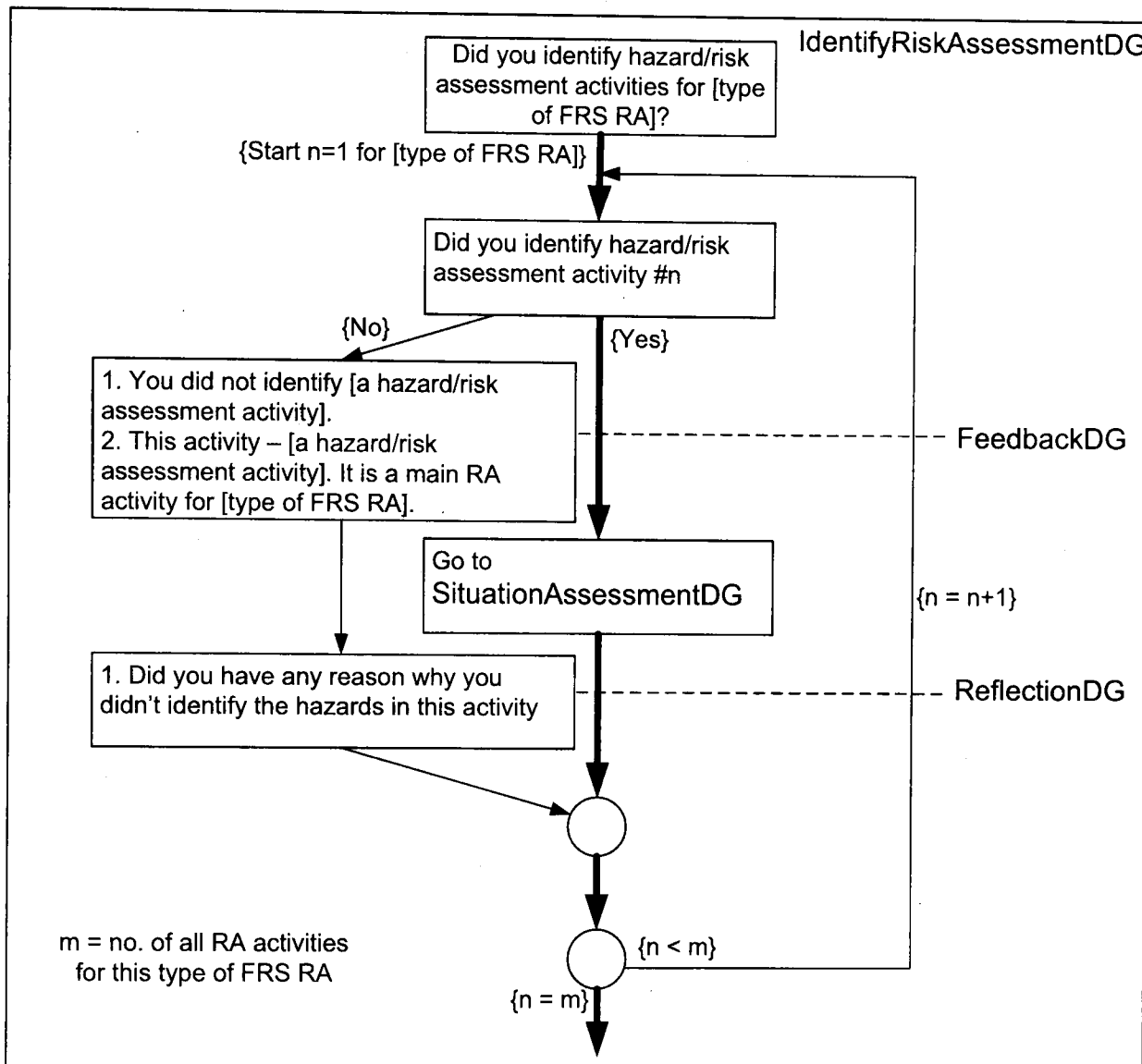


Figure 5.4 The state network diagram of IdentifyRiskAssessmentDG episode

SituationAssessmentDG

The SituationAssessmentDG episode is used to review risk assessment of a given situation in the incident. An incident may have more than one situation for risk assessment. If the user wants to assess different situations, other episodes (e.g. PerformActionsDG – the actions for adding control measures but not implemented in the PORML prototype, IdentifyRiskAssessmentDG etc.) have to be added and re-required to re-assess the risk for those situations. However, the PORML prototype only illustrates the first situation because most of the dialogue questions in the sequential episodes would be repeated in other situations. The dialogue questions in the SituationAssessmentDG episode are used to ask the user about his decisions in

the risk assessment of the given situation. To review the user's decisions in operational RA activity, his answers are compared to the decision resulting from a PORML risk rating calculation using analytical risk assessment as explained in Chapter 4. Figure 5.5 shows the state network diagram of SituationAssessmentDG episode.

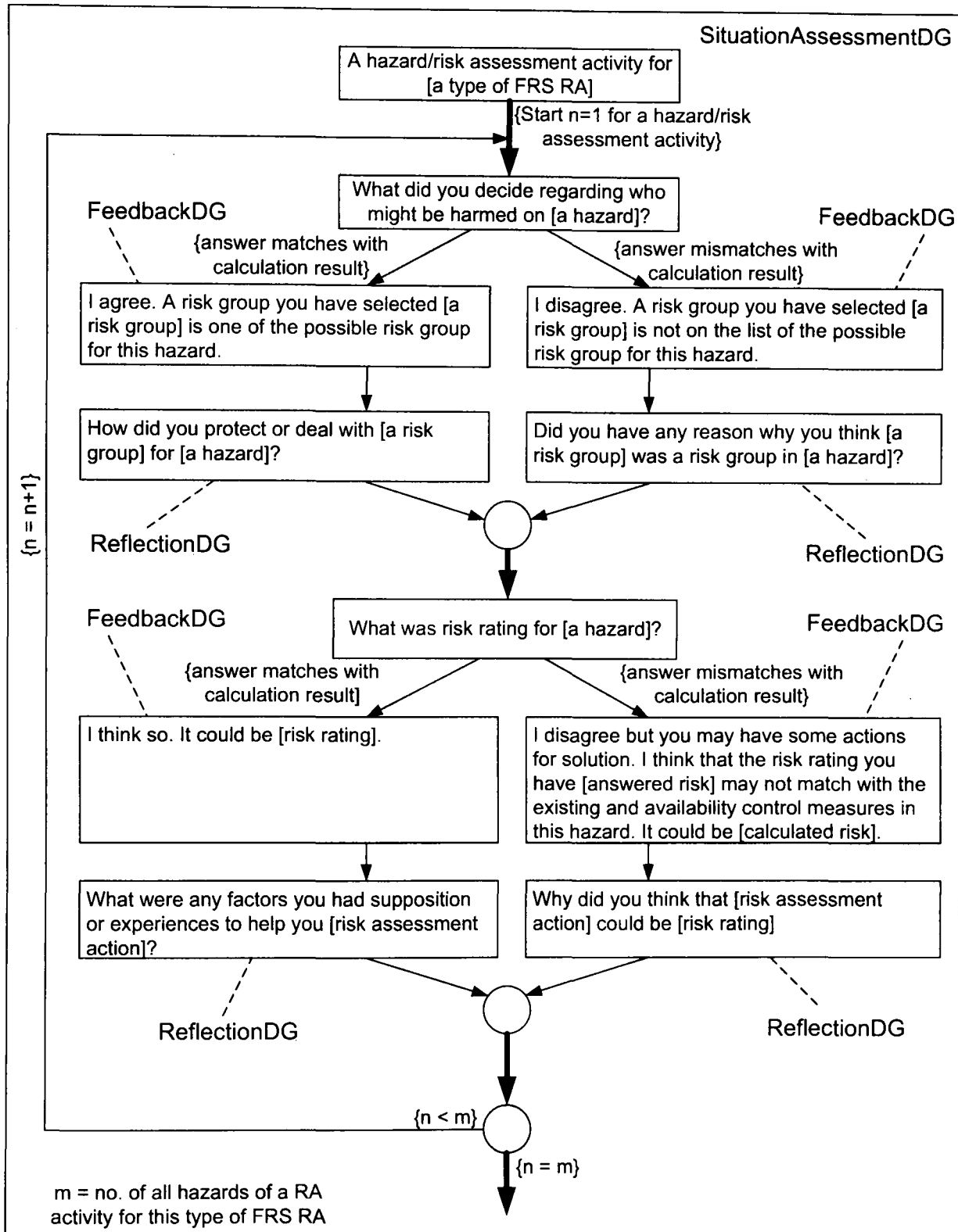


Figure 5.5 The state network diagram of SituationAssessmentDG episode

ModeAndSystemDG

The ModeAndSystemDG episode is used to review which mode and system the user has chosen to deal with a given situation. The dialogue agent asks the user about the

chosen tactical mode in this situation. There are three tactical modes: offensive mode, defensive mode and transitional mode. The offensive mode is the normal mode of operation. If the offensive mode is chosen, it means the potential benefits outweigh the identified risks and the Incident Commander will be committing fire crews into a relatively hazardous area to fight fire or rescue people whilst supported by appropriate procedure, equipment and training (HM Stationary Office 2002). Additional control measures might be required to manage the identified risks in this mode. If the defensive mode is chosen, the identified risks outweigh the potential benefits and no matter how many additional control measures are put into place, the risks are too great. Hence, the Incident Commander would fight the fire with ground monitor jets and aerial jets, and concentrate on protecting exposure risks and adjoining property without committing fire crews into the hazardous area (HM Stationary Office 2002). The transitional mode is when the offensive mode and the defensive mode are used simultaneously but in different sectors (a sector can be dealt with using either an offensive mode or a defensive mode at a time but never both modes at the same time) for a large incident. This is not available for the PORML prototype. If the transitional mode is chosen, the dialogue agent will inform the user that the PORML prototype does not support the transitional mode and the offensive mode is chosen instead.

Afterwards, questions in the ModeAndSystemDG episode are used to ask the user about the safe systems of work chosen in this situation. The questions on the safe systems of work in the PORML prototype correspond to the activity level of risk assessment. They relate to the type of incident e.g. safe systems of work for working on roof space and cutting away for attack from above in a chimney fire incident (e.g. hazardous substances - asbestos, MMMF materials etc.), safe systems of work for access to the grate for attack from below in a chimney fire incident, safe systems of work for a combination of attack from below and on the roof including allowing fire to burn out in chimney fire incident etc. The selection of the safe systems of work will affect the information provided by the AdditionalControlMeasureDG episode according to the selection made. For example, in the case of an offensive mode in a chimney fire incident, if the safe systems of work for access to the grate for attack from below are chosen, only additional control measures for the hazards (fire spread hazard, blow back hazard) in applying extinguishing media activity will be informed. Figure 5.6 shows the state network diagram of ModeAndSystemDG episode.

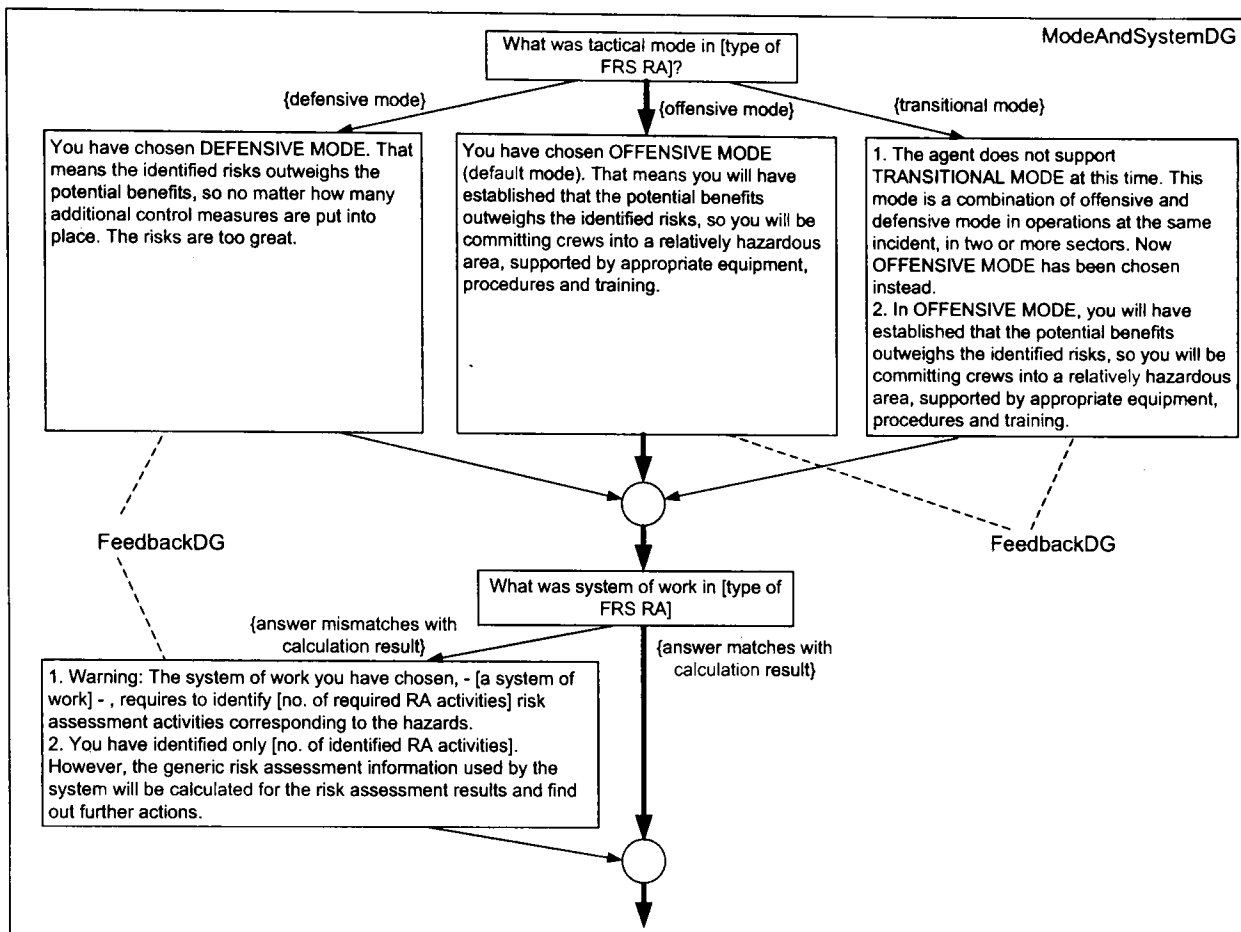


Figure 5.6 The state network diagram of ModeAndSystemDG episode

AdditionalControlMeasuresDG

The AdditionalControlMeasuresDG episode is used to suggest to the user which (unused) control measures could be added to the existing and available control measures already being used in the current situation. The reason for adding control measures is to reduce hazards/risks to an acceptable level for a given situation e.g. reduce the risk of falling masonry hazard from medium risk to low risk etc. If the offensive mode is chosen, the additional control measures for each hazard are identified and suggested by this episode. If the defensive mode is chosen in the previous episode, ModeAndSystemDG, this episode will not provide any suggestions about additional control measures for each hazard but will issue a message (agent utterance) to explain the characteristic of the defensive mode as follows:

“You have chosen DEFENSIVE MODE. That means the identified risks outweigh the potential benefits, so no matter how many additional control measures are put in place. The risks are too great.”

If the transitional mode is chosen in the previous episode, it will not be considered by this episode but the offensive mode will be chosen and considered instead (with the reason above). Figure 5.7 shows the state network diagram of the AdditionalControlMeasuresDG episode.

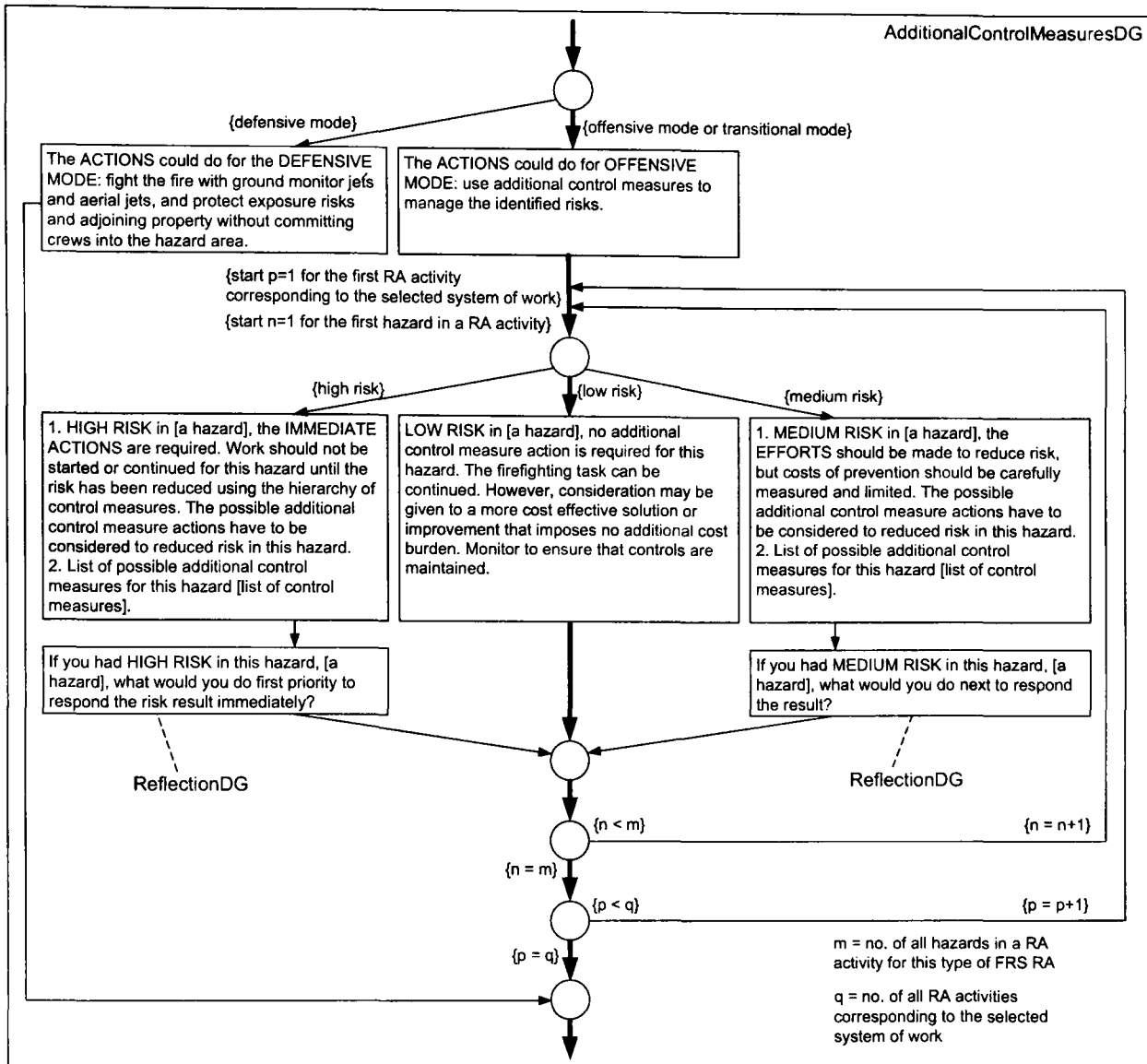


Figure 5.7 The state network diagram of AdditionalControlMeasuresDG episode *EndingDG episode*

The EndingDG episode is a simple dialogue game that generates only one agent utterance. This episode is used to inform a user that the end of the dialogue game has been reached by issuing the agent utterance ‘End Dialog’. The dialogue agent then closes the session, writes the UCA model into the user directory and records the dialogue interactions in the User Dialogue Interaction Log Files.

5.4.3. User Interruption DG episodes

User interruption during playing Sequential DG episodes can be performed. When it is activated by the user, the relevant User Interruption DG episode is generated and performed by the dialogue agent. The purpose of the User Interruption DG episodes in PORML is to clarify or do something that does not have to be issued in the main or sequential interactive dialogue e.g. explain the meaning of concepts in the current agent utterance, show dialogue history or end the dialogue session immediately.

There are three User Interruption DG episodes: the ExplanationDG episode, HistoryDG episode and UserEndingDG episode. A user can use these episodes to interrupt the Sequential DG episodes at any time during dialogue interaction. When the ExplanationDG episode and HistoryDG episode interrupt the Sequential DG episodes, they do not impact or change the sequence of agent utterances in the current Sequential DG episode. However, it is possible for the UserEndingDG episode to change the current Sequential DG episode to the end of the dialogue session, providing that the user confirms that the session should be ended. The display resulting from a User Interruption DG episode is shown as a popup window which appears over the main user interface display that would be showing a current interactive dialogue.

ExplanationDG episode

The ExplanationDG episode is used to describe the concepts in the current agent utterance. If the agent utterance constructed from a combination of its components (originator, inflexion, subject, predicate and object) contains concepts (the subject and object components of the utterance) that are actions in the RA domain ontology, the description of the actions is normally explained in terms of either their operations or their meaning. Others agent utterances might not be explained e.g. reflective questions and feedback sentences.

HistoryDG episode

The HistoryDG episode is used to view recent dialogue interaction in a popup window with the last four lines of the dialogue interaction. Sometimes the user may not be able to remember recent questions or answers that relate to the current question of an agent utterance. Furthermore, the dialogue game cannot be replayed to view or change past answers. Therefore, viewing the dialogue interaction history using the HistoryDG episode can help users make a decision about the response to a current agent utterance or question in certain situations e.g. answering the reflective questions, ending the dialogue interaction etc.

UserEndingDG episode

During the dialogue interaction of a review session, a user might need to cancel the session before completing it e.g. to restart the session because of some mistakes made, testing the dialogue etc. The UserEndingDG episode is used to force the dialogue agent to end the dialogue interaction immediately and terminate the session. In this case, the UCA model is not written into the user directory and the dialogue interactions are not recorded in the User Dialogue Interaction Log Files after terminating the session.

5.4.4. System Interruption DG episodes

Unlike a user interruption, the system interruption is activated automatically by the dialogue agent. Upon activation, the relevant System Interruption DG episode is generated and performed. The purpose of the System Interruption DG episodes in PORML is to respond to the user when the review reaches the assigned points for reflection or feedback. There are two System Interruption DG episodes: the FeedbackDG episode and the ReflectionDG episode.

FeedbackDG episode

The FeedbackDG episode is used in response to the user's answers in order to explain or suggest something relating to the answer that is selected by the user. This response might be an explanation or a suggestion relating to the answer and the agreement or disagreement of the dialogue agent with the answer chosen.

Feedback message = (type of incident, Sequential DG episode, type of inquiry, user's answer)

Feedback message = a response message to explain or suggest something relating to the user's selected answer;

Type of incident = incident type in GRA e.g. chimney fire, building fire, road traffic accident etc.;

Sequential DG episode = name of Sequential DG episode e.g. InitialActionsDG etc.;

Type of inquiry = type of question (agent utterance) issued previously e.g. yes/no question, question (what, where, who) providing a selection of answers;

User's answer = yes or no answer to the previous yes/no question, selected answer from the answer list of the previous question.

Table 5.1 shows examples of feedback messages that are assigned and determined by the combination of: the type of incident, Sequential DG episode, type of inquiry and user's answer.

Table 5.1 Examples of feedback message

Type of Incident	Sequential DG Episode	Type of Inquiry	Feedback Message Examples (depend upon user's answer)
Chimney fire	IdentifyRiskAssessmentDG	Identify risk activity	You did not identify risk assessment activity of gaining access to and working on roof for chimney fire. This activity – An operational activity in "A Guide to Operational Risk Assessment" is to consider hazards and risks for gaining access to and working on roof. It contains two significant hazards, "Falling Masonry", "Roof Conditions".
	SituationAssessmentDG	Risk group	I agree. A risk group you have selected whole time group is one of the possible risk group for this hazard. The possible risk group can be, (1) public group (2) retained group (3) volunteer group (4) whole time group.
		Risk rating	I think so. It could be medium risk.
	ModeAndSystemDG	Tactical mode	The agent does not support transitional mode at this time. This mode is a combination of offensive and defensive modes in operations at the same incident, in two or more sectors. Now, OFFENSIVE MODE has been chosen instead. (default mode)
Systems of work		Warning: The system of work you have chosen, - access to and working on roof -, requires to identify 2 risk assessment activities for hazards. You have identified only 1. However, the generic risk assessment information used by the system will be calculated for the risk assessment results and find out further actions.	

ReflectionDG episode

The ReflectionDG episode is used to ask questions that encourage reflection on actions that a user previously answered as having taken. This is to support reflective learning. The reflective questions are derived from a Reflection Template and are built by adapting the existing reflective questions from other areas e.g. learning and teaching in education (Race 2006), educational laboratory³⁹; training institute⁴⁰ etc. The dialogue agent provides a free text input box to the user after issuing a reflective question and the user can type any text in this input box to reflect on the previous actions. The reflective answers are not analysed by the dialogue agent. They are only recorded in the User Dialogue Interaction Log Files for the user to view. The reflective questions are retrieved from the Reflection Template by determining the parameters as follows:

Reflective questions = (type of incident, Sequential DG episode, reflective point, type of inquiry, user's answer)

Reflective questions = one or more questions extracted from the Reflection Template;

Type of incident = incident type in GRA e.g. chimney fire, building fire, road traffic accident etc.;

Sequential DG episode = name of the Sequential DG episode e.g. InitialActionsDG etc.;

³⁹ http://www.nationalserviceresources.org/filemanager/download/learns/self_reflect.pdf

⁴⁰ <http://www.thirteen.org/edonline/ntti/>

Reflective point = point at which the reflective question is to interrupt the Sequential DG episode e.g. middle of an episode, end of an episode, any point of the Sequential DG episode;

Type of inquiry = type of question (agent utterance) issued previously e.g. yes/no question, question (what, where, who) providing a selection of answers;

User's answer = yes or no answer to the previous yes/no question, selected answer from the answer list of the previous question.

Table 5.2 shows examples of reflective questions that are assigned depending on the combination of the: type of incident, Sequential DG episode, reflection point, type of inquiry and user's answer.

Table 5.2 Examples of reflective question used to interrupt Sequential DG episodes

Type of Incident	Sequential DG Episode	Reflection Point	Type of Inquiry	Reflective Question Examples (depend upon user's answer)
Chimney fire	InitialActionsDG	Middle, End	Yes/No questions	When you performed, (1) obtain information on risks from fire control, (2) identify the correct flue, (4) consider attack from the grate as first firefighting option, did you think you were able to do them well? What was the obstacle? If you have any alternative actions, how did you do?
	InitialControlMeasuresDG	End	Yes/No questions	The control measure is an intervention technique to reduce risk. This could include the use of personnel protection equipment (PPE), breathing apparatus (BA), specialised equipment and safety officer(s) etc. Why didn't you provide anything?
	IdentifyRiskAssessmentDG	Inside	Identify risk activity	Did you have any reason why you didn't identify the hazards in this activity?
	SituationAssessmentDG	Inside	Risk group	How did you protect or deal with non service personnel group for assessing falling masonry hazard/risk?
			Risk rating	What were any factors you had supposition or experiences to help you assessing hazardous substances for working in roof space and cutting away activity?
AdditionalControlMeasureDG	Inside	Risk result	If you had MEDIUM RISK in this hazard, assessing the roof conditions hazard/risk for gaining access to and working on roof activity, what would you do next to respond the risk result?	

5.5. Dialogue Management

We consider a dialogue management model to deal with the dialogue involved in the activity review and reflective learning. The main components of the model are:

- Dialogue (Game) Agent
- Dialogue Game Analyser
- Workspace
- Long Term Memory

Dialogue Agent

The dialogue agent is a core of Dialogue Manager and Planner component in the PORML framework and is used to manage the processing of dialogue and to plan the dialogue episodes. The dialogue agent issues an agent utterance to the user after it receives the result of an analysis of a user utterance from the dialogue game analyser and processes that result, taking into consideration, other information in the PORML workspace and long term memory.

Dialogue Game Analyser

The dialogue game analyser, which is a part of the Dialogue Manager and Planner component, receives a user utterance which is constructed or entered by a user via the Web-Based Interface component. The user utterance is analysed and the dialogue game analyser generates a result which is then forwarded to the dialogue agent.

PORML Workspace

The PORML workspace consists of all the temporary data and results of the dialogue conducted during interactions. This includes the results of querying location context data, user profile data, User Current Activity (UCA) model, dialogue interaction history, current dialogue game, incident code, situation code and so on. These data and results can be changed during dialogue interactions.

Long Term Memory

The long term memory consists of permanent data that the dialogue agent reads for initial data, including the RA Domain Ontology and User Record Database, or for reflection, including the Reflection Template. The dialogue agent does not change any data in the long term memory during dialogue interactions.

5.5.1. Utterances

The building block of each dialogue is called an **utterance**. The utterance issued by a dialogue agent is called an **agent utterance** while the utterance constructed by a user is called a **user utterance**. Both agent and user utterances produced in PORML are classified into two forms: those using OWL statements and those using non-OWL statements. Each utterance consists of three elements (Denaux 2005; Aroyo, Denaux et al. 2006) : an originator, an inflexion or intention and an OWL or non-OWL statement. The **originator** is the producer of the utterance i.e. dialogue agent or user. The **inflexion** states the dialogue purpose of the utterance. The **OWL statement** is the domain-related proposition of an utterance which is a model extracted from the RA domain ontology in terms of concepts and relationships. The **non-OWL statement** is any text including a blank, a phrase, or a clause as well as concepts, one or more sentences etc.

A significant number of inflexion types in PORML are created and defined to cover the current implementation of PORML prototype as shown in Table 5.3.

Table 5.3 The type of inflexion created and used in PORML

Type of Inflexion	Issue on Utterance	Used by
INFORM_I_DID	Yes, I did	User utterance
INFORM_I_DID_NOT	No, I did not	User utterance
INFORM_SPECIFIC_ANSWER	That was	User utterance
INFORM_AGENT_EXPLAIN	[blank]	Agent utterance
INQUIRE_USER_EXPLAIN	[No utterance]	ExplanationDG for popup window
INQUIRE_YES_NO	Did you	Agent utterance
INQUIRE_YES_NO_IDENTIFY	Did you identify	Agent utterance
INQUIRE_WHAT_WAS	What was	Agent utterance
INQUIRE_WHO_MIGHT_BE_HARMED	What did you decide regarding who might be harmed on	Agent utterance
REFLECTION_GAME	[blank]	User utterance, agent utterance
SKIP_TURN	Proceed to next question	User utterance
END_DIALOG	The dialog has been ended End Dialog	User utterance Agent utterance

In cases where an OWL statement is used, the statement consists of a RDF triple comprising a simple concept1-relationship-concept2 pattern. Concept1 and concept2 are concepts in the RA domain ontology while the relationship between the two concepts might be a direct (e.g. subclass) or indirect relationship in the RA domain ontology. An example of an OWL statement is as follows:

Concept1 - *"obtain information on risks from fire control"* [Initial Chimney Fire Action-a]

Relationship - *"in"* [SubClassOf]

Concept2 - *"initial actions for chimney fire"* [Initial Chimney Fire Action]

In cases where a non-OWL statement is used, the statement can consist of any text. The inflexion for this statement may appear on the display as a blank e.g. "" (REFLECTION_GAME), a phase e.g. *"Proceed to next question"* (SKIP_TURN) etc. Examples of non-OWL statements are as follows:

"Has it been beneficial the effort you put in?" [reflective question]

"You have already answered:- You performed use thermal imaging camera in the initial actions dialog game. That means it was provided." [feedback]

5.5.2. Analysing user utterances

At each user turn, the user constructs a user utterance and submits it to PORML. The PORML prototype provides a preset inflexion relating to its question – the current agent utterance – which enables the construction of a user utterance. For example, if

an agent utterance is a Yes/No question (inflexion – INQUIRE_YES_NO), the issued inflexions for the user utterance are the Yes answer (inflexion – INFORM_I_DID) and the No answer (inflexion - INFORM_I_DID_NOT) options for user selection. However, the ReflectionDG episode is a special case for user utterance construction. The user can type any text at all using free text input and this text is not analysed to find its meaning. The inflexion for a user utterance of the ReflectionDG episode is the same as the inflexion for its question i.e. REFLECTION_GAME.

After the user provides an answer, the submitted user utterance is examined by the dialogue game analyser. The dialogue game analyser analyses the incoming user utterance by checking the type of inflexion to identify what the characteristics of the user utterance are. The type of inflexion corresponds to the characteristics of the user utterance, as shown in Table 5.4.

Table 5.4 The characteristics of user utterance corresponding to the type of inflexion

Characteristics of User Utterance	Type of Inflexion
Is it an OWL-statement answer?	INFORM_SPECIFIC_ANSWER
Is it a yes/no answer?	INFORM_I_DID, INFORM_I_DID_NOT
Is it a request to end dialogue? (in UserEndingDG)	END_DIALOG
Is it a skip turn?	SKIP_TURN
Is it a reflective answer? (in ReflectionDG)	REFLECTION_GAME
Is it a request for explanation? (in ExplanationDG) [not require user utterance, use command button]	INQUIRE_USER_EXPLAIN

The result of the analysis, which relates to the type of inflexion and the characteristics of the utterance that are involved, will then be forwarded to the dialogue agent to determine the next move and to generate the next agent utterance.

5.5.3. Generating agent utterance

At the beginning of the first dialogue game episode, CollectContextInformationDG, the first agent utterance is issued by the dialogue agent to introduce the first Sequential DG episode. Similarly, when other Sequential DG episodes are introduced, the first agent utterance of each of these episodes is issued to introduce what these episodes are about, as per the following example of the InitialActionsDG episode:

“Agent: The following set of dialogues will ask you about the initial actions you performed for chimney fire when you arrived at the incident place, SixBells Pub.”

This is an agent utterance using the inflexion INFORM_AGENT_EXPLAIN (issued as a blank on the utterance) followed by a text message (non-OWL statement) produced in this episode which is to inform about or explain the purpose

of the episode. After issuing the first agent utterance of the first dialogue game episode, the dialogue agent will wait for a user’s response. When the user enters or constructs a user utterance, it is analysed by the dialogue game analyser.

The next step of the processing is to generate an appropriate response from the dialogue agent. The dialogue agent considers the result of the analysis by the dialogue game analyser and processes the result with the use of other information from the workspace and long term memory to issue the next agent utterance. The issued agent utterance consists of the type of inflexion that corresponds to the characteristics of the agent utterance as shown in Table 5.5

Table 5.5 The characteristics of the agent utterance corresponding to the type of inflexion

Characteristics of Agent Utterance	Type of Inflexion
General explanation	INFORM_AGENT_EXPLAIN
Feedback the user’s answer	INFORM_AGENT_EXPLAIN
“Yes/No” question	INQUIRE_YES_NO
“Yes/No” question for identifying hazards/risks	INQUIRE_YES_NO_IDENTIFY
“What” question	INQUIRE_WHAT_WAS
“Who might be harmed” question	INQUIRE_WHO_MIGHT_BE_HARMED
Reflective question (in ReflectionDG)	REFLECTION_GAME
End dialogue message (in EndingDG)	END_DIALOG

In the case of an OWL statement being used, an agent utterance is built by putting, for example, the originator – “Agent:”, inflexion (INQUIRE_YES_NO) – “Did you” with “?” and the OWL statement (an example from Section 5.5.1) together, such that the agent utterance of this OWL statement will look like this:

Agent Utterance - “Agent: Did you obtain information on risks from fire control in initial actions for chimney fire?” [Yes/No question]

In the case of a non-OWL statement being used, an agent utterance is built by putting, for example, the originator – “Agent”, inflexion (REFLECTION_GAME) – “” and the non-OWL statement (an example from Section 5.5.1) together, such that the agent utterance of this non-OWL statement will look like this:

Agent Utterance – “Agent: Has it been beneficial the effort you put in?” [reflective question]

5.6. Adapting Dialogue to User Current Activity Model

This section describes how the dialogue agent deals with the UCA model. The dialogue agent uses the UCA model to track the activity review during dialogue interactions by querying and updating the information in the UCA model e.g. create an instance, query an instance and a class etc. Querying the information in the UCA

model is considered for the use of utterance construction. Updating the UCA model is considered when the user answers the questions.

5.6.1. Querying the UCA model

The dialogue agent retrieves information that matches certain criteria from the UCA model by querying the model. The SPARQL query is normally used in PORML to find a concept or a class, an instance or an individual, or a property from the UCA model. The result of the query will be a part of an OWL or non-OWL statement construction used for building the following utterances: agent utterances and answer options for user utterance construction.

The query string for the SPARQL query format is shown in the examples and grouped normally by its purpose according to the different episodes. The query string examples consist of prefixes. Each prefix is a combination of the ‘PREFIX’ keyword, a prefix label and an IRI as shown in the bold font below.

```
String queryStr =
    "PREFIX GRA:
      <http://www.comp.leeds.ac.uk/scswe/ontology/GRA.owl#>" +
    "PREFIX dc: <http://purl.org/dc/elements/1.1/>" +
    "PREFIX owl: <http://www.w3.org/2002/07/owl#>" +
    "SELECT ?x" +
    "WHERE { GRA:"+ontology_class+" dc:description ?x }";
```

The prefixes in the query string examples are shown in Table 5.6. The prefix label ‘GRA’ is used to reference to the current location of RA domain ontology of the PORML prototype while the others are standard references. In the examples, we will use the phrase ‘prefix_declaration_for – xxx’ instead to show which prefixes have to be declared.

Table 5.6 Prefix declaration in query string examples

Prefix label	IRI
GRA	http://www.comp.leeds.ac.uk/scswe/ontology/GRA.owl#
dc	http://purl.org/dc/elements/1.1/
rdf	http://www.w3.org/1999/02/22-rdf-syntax-ns#
rdfs	http://www.w3.org/2000/01/rdf-schema#
owl	http://www.w3.org/2002/07/owl#

To query a description annotation (*x*) of the class variable (*ontology_class*), the query string of a query command is used to retrieve the description of the specified class. For example, the class ‘Initial Chimney Fire Action-a’ in RA domain ontology has its description annotation “*obtain information on risks from fire control*”. The bold italic font represents an input variable ‘*ontology_class*’ and output query ‘*x*’. The italic font represents a specified property, instance, or class in the UCA model. An example is as follows:

```
String queryStr = "prefix_declaration_for - GRA, dc" +
    "SELECT ?x" +
    "WHERE { GRA:"+ontology_class+" dc:description ?x }";
```

The other selected examples are shown according to the different episodes as follows:

InitialControlMeasuresDG

Query an instance of control measures:

To query an instance of control measures (**x**) by a class variable of control measures (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdf" +  
  "SELECT ?x" +  
  "WHERE { ?x rdf:type GRA:"+ontology_class+" .}";
```

Query an instance of control measures corresponding to the instance of class "Status":

To query an instance (**x**) – ('Yes' or 'No') of class 'Status' in the UCA model by an instance variable of control measures (*ontology_individual*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA" +  
  "SELECT ?x" +  
  "WHERE { GRA:"+ontology_individual+" GRA:haveStatus ?x .}";
```

The results of the two examples above are used to check whether the current control measures review and an initial action in the InitialActionsDG (previous episode) match. For example, if an initial action *"use a thermal imaging camera to detect position of fire"* was performed, which is detected by querying the instance of control measures in the first example and querying the instance (is 'Yes' – in this case) of class 'Status' in the second example, the issued agent utterance for the review of current control measures is *"Agent: You have already answered:- You performed use thermal imaging camera in the initial actions dialog game. That means it was provided."* Conversely, if this initial action was not performed and the result of querying the instance of class 'Status' becomes 'No', the issued agent utterance for the review of current control measures is *"Agent: You have already answered:- You did not performed use thermal imaging camera in the intial actions dialog game. That means it was not provided."*

FeedbackDG during interrupting SituationAssessmentDG

Query risk rating:

To query the suggested risk rating instance (**x**), which is calculated using analytical risk assessment, and its risk rating class (**y**) corresponding to the specified risk assessment action (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdf" +  
  "SELECT ?x ?y" +  
  "WHERE { _:R rdf:type GRA:"+ontology_class+" ." +  
  " _:R GRA:haveRisk ?x ." +  
  "?x rdf:type ?y }";
```

For example, if the *ontology_class* is the class ‘Chimney Fire Risk Assessment Action-aa’ (assessing falling masonry hazard) and the result of the risk rating calculation of this hazard was ‘Medium Risk’, the *x* will be the instance ‘Medium Risk-Instance-S1-Inc1’ and *y* will be the class ‘Medium Risk’.

Query list of possible risk groups:

To query a list of risk groups (*x*) corresponding to the specified risk assessment action (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdfs, owl" +
  "SELECT ?x" +
  "WHERE { GRA:"+ontology_class+" rdfs:subClassOf _:R ." +
  " _:R a owl:Restriction ." +
  " _:R owl:onProperty GRA:assess ." +
  " _:R owl:someValuesFrom _:P ." +
  " _:P rdfs:subClassOf _:Q ." +
  " _:Q a owl:Restriction ." +
  " _:Q owl:onProperty GRA:harmOn ." +
  " _:Q owl:someValuesFrom ?x }";
```

For example, if the *ontology_class* is the class ‘Chimney Fire Risk Assessment Action-ba’ (assessing hazardous substance), the *x* will be the classes ‘Retained Group’, ‘Volunteer Group’ and ‘Whole Time Group’.

FeedbackDG interrupting ModeAndSystemDG

Query selected safe systems of work:

To query the selected instance (*x*) and its class (*y*) of safe systems of work corresponding to the specified risk assessment activity instance (*ontology_individual*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdf" +
  "SELECT ?x ?y" +
  "WHERE { GRA:"+ontology_individual+" GRA:haveSystem ?x ." +
  " ?x rdf:type ?y }";
```

For example, if the *ontology_individual* is the instance ‘Chimney Fire Risk Assessment Activity-S1-Inc1’ of the class ‘Chimney Fire Risk Assessment Activity’ (RA activity for chimney fire) and the user selected safe systems of work for access to the grate for attack from below, the *x* will be the instance ‘Chimney Fire System of Work-d-S1-Inc1’ and the *y* will be its class ‘Chimney Fire System of Work-d’ (access to the grate for attack from below).

Query a list of hazard/risk activities for the selected safe systems of work:

To query a list of hazard/risk activities (*x*) corresponding to the selected safe systems of work (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdfs, owl" +
  "SELECT ?x" +
  "WHERE { GRA:"+ontology_class+" rdfs:subClassOf _:R ." +
  " _:R a owl:Restriction ." +
  " _:R owl:onProperty GRA:beSystemOf ." +
  " _:R owl:someValuesFrom ?x }";
```

For example, if the *ontology_class* is the class ‘Chimney Fire System of Work-b’ (working in roof space and cutting away for attack from above), the *x* will be the

classes ‘Chimney Fire Risk Assessment Activity-b’ (RA activity of working in roof space and cutting away for a chimney fire) and ‘Chimney Fire Risk Assessment Activity-c’ (RA activity of applying extinguishing media for a chimney fire).

AdditionalControlMeasuresDG

Query a list of risk ratings corresponding to the specified RA activity:

To query a list of risk ratings (*a*) of each hazard/risk action (*x*) corresponding to the specified RA activity (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdfs, rdf, owl" +
  "SELECT ?x ?a" +
  "WHERE { GRA:"+ontology_class+" rdfs:subClassOf _:R ." +
  " _:R a owl:Restriction ." +
  " _:R owl:onProperty GRA:beRiskAssessmentActivityOf ." +
  " _:R owl:someValuesFrom ?x ." +
  "?y rdf:type ?x ." +
  "?y GRA:haveRisk ?z ." +
  "?z rdf:type ?a }";
```

For example, if the *ontology_class* is the class ‘Chimney Fire Risk Assessment Activity-a’ (risk assessment activity of gaining access to and working on the roof for a chimney fire) and from the risk rating calculation the risk of falling masonry hazard was found to be ‘High Risk’ and the risk of roof condition hazard was ‘Medium Risk’, the *x* will be the classes ‘Chimney Fire Risk Assessment Action-aa’ (assessing falling masonry hazard) and ‘Chimney Fire Risk Assessment Action-ab’ (assessing roof condition hazard) while the *a* will be the classes ‘High Risk’ and ‘Medium Risk’.

Query a list of non-active control measures:

To query an instance (*y*) and its class (*x*) of a list of control measures that are not provided or used for the specified hazard/risk activity (*ontology_class*), the query string is as follows:

```
String queryStr = "prefix_declaration_for - GRA, rdfs, rdf, owl" +
  "SELECT ?x ?y" +
  "WHERE { GRA:"+ontology_class+" rdfs:subClassOf _:R ." +
  " _:R a owl:Restriction ." +
  " _:R owl:onProperty GRA:haveControlMeasure ." +
  " _:R owl:someValuesFrom _:S ." +
  "?x rdfs:subClassOf _:S ." +
  "?y rdf:type ?x ." +
  "?y GRA:haveStatus GRA:No }";
```

For example, if the *ontology_class* is the class ‘Chimney Fire Risk Assessment Activity-c’ (risk assessment activity of applying extinguishing media for a chimney fire) and the user answered the questions in the InitialControlMeasuresDG episode to say that he did not use a thermal imaging camera and full fire kit with helmet, the *x* will be the classes ‘Chimney Fire Control Measure-cc’ (use thermal imaging camera) and ‘Chimney Fire Control Measure-ce’ (use full fire kit with helmet) and the *y* will be the instances ‘Chimney Fire Control Measure-cc-S1-Incl’ and ‘Chimney Fire Control Measure-ce-S1-Incl’.

5.6.2. Updating the UCA model

At the initial stage of building the UCA model, before issuing the first agent utterance, the dialogue agent performs the following tasks:

- Create an empty model of the UCA model and then copy a RA model from the RA domain ontology to the UCA model;
- Add the incident code or incident ID instance, for example, 'Inc1' to the class 'Incident' in the UCA model;
- Add the situation code or situation ID instance 'S1' for the first situation to the class 'Situation' in the UCA model;
- Add a special class 'Status' to the top level of the UCA model and a relationship 'haveStatus'. There are two instances of this class, 'Yes' and 'No';
- Start the first episode.

After the first agent utterance has been issued and the user answers the question asked by the dialogue agent, the answer or user utterance is analysed. The dialogue game analyser checks the type of inflexion corresponding to the characteristics of the user utterance (see Table 5.4 in Section 5.5.2) and forwards the result to the dialogue agent. The dialogue agent then considers this result and performs as follows:

- If the type of inflexion is `INFORM_SPECIFIC_ANSWER` (an OWL statement answer), `INFORM_I_DID` (Yes answer), or `INFORM_I_DID_NOT` (No answer), the dialogue agent will use the user's answer to update the UCA model;
- For other types of inflexion i.e. `END_DIALOG`, `SKIP_TURN`, `REFLECTION_GAME`, `INQUIRE_USER_EXPLAIN`, the dialogue agent will not do anything to the UCA model.

In the case of inflexion type `INFORM_I_DID` or `INFORM_I_DID_NOT`, the dialogue agent performs the following tasks to update the UCA model:

- Build two instances in the model where one is an instance from a class (a concept1 in the concept1-relationship-concept2 pattern of an OWL statement) of the question (agent utterance) by adding a suffix, for example '-S1-Inc1', to the class. As an example:

Class: "*Initial Chimney Fire Action-a*" (obtain information on risks from fire control)

Instance: "*Initial Chimney Fire Action-a-S1-Inc1*"

It is noted that all questions with Yes/No answers are agent utterances that consist of an OWL statement. The other is an instance 'Yes' or 'No' of class 'Status':

- Build a relationship 'haveStatus' between two instances. As an example in Manchester syntax:

Individual: **InitialChimneyFireAction-a-S1-Incl**

haveStatus **Yes**

- If the questions with Yes/No answers are in the IdentifyRiskAssessmentDG episode and the answer is "Yes", two instances and a relationship 'beIdentify' are built to look like the following example in Manchester syntax:

Individual: **ChimneyFireRiskAssessmentActivity-b-S1-Incl**

beIdentifyBy **Hazard-S1-Incl**

If the answer is 'No', the dialogue agent will not do anything to the UCA model.

In the case of the inflexion `INFORM_SPECIFIC_ANSWER`, the dialogue agent performs the following tasks to update the UCA model:

- Check what type of Sequential DG episodes it is in;
- Check what the inflexion type of the question is – `INQUIRE_WHAT_WAS` or `INQUIRE_WHO_MIGHT_BE_HARMED`;
- If the type of Sequential DG episode is `ModeAndSystemDG`, check the group of the answer options;
- For example, if it is in the `SituationAssessmentDG` episode and the inflexion type of the question is `INQUIRE_WHO_MIGHT_BE_HARMED`, two instances and a relationship 'haveRiskGroup' are built to look like the following example in Manchester syntax:

Individual: **ChimneyFireRiskAssessmentAction-ba-S1-Incl**

haveRiskGroup **PublicGroup-S1-Incl**

- For example, if it is in `ModeAndSystemDG` episode and the inflexion type of question is `INQUIRE_WHAT_WAS` and the group of answer options is 'tactical mode', two instances and a relationship 'haveMode' are built to look like the following example in Manchester syntax:

Individual: **ChimneyFireRiskAssessmentActivity-S1-Incl**

haveMode **DefensiveMode-S1-Incl**

5.7. Summary

This chapter presented the model of dialogue game-based interaction used to manage and plan the dialogue. We outlined the main characteristics of the dialogue, activity review and reflective learning, which are our main goals for using this model. The dialogue structure of dialogue planning was presented. It consists of PORML dialogue game (DG) episodes. These episodes are classified and characterised according to the operational FRS RA activity which the user has performed. We also presented the two main types of PORML DG episodes: Sequential DG episodes and Interruption DG episodes. The Sequential DG episodes are played as the main part of an incident review session that corresponds to the sequence of actions in FRS practice while the Interruption DG episodes are used to interrupt the Sequential DG episodes for specific purposes e.g. to respond to the results of a user selection and reflect on the actions etc.

Dialogue management was outlined to describe the main components used to manage dialogue interactions i.e. the dialogue agent, dialogue game analyser, PORML workspace and long term memory. The building block of each dialogue, which is called an utterance, was described in terms of how it is built and was shown to consist of two types: agent utterances and user utterances. Both the agent utterance and the user utterance are produced in the process of dialogue management. They are mechanisms for interactions. The user utterance is analysed by the dialogue game analyser and the results of this analysis are forwarded to the dialogue agent. The dialogue agent then uses these results and other information from the PORML workspace and long term memory to generate the agent utterance.

Adapting dialogue to the User Current Activity (UCA) model was described to show how the model is used to produce dialogues or utterances. Querying and updating the UCA model is used to track the activity review during dialogue interactions. The SPARQL query is normally used to find a concept or a class, an instance or an individual, or a property from the UCA model. Certain examples of a query string in PORML DG episodes were given. Updating the UCA model is considered when the user answers the questions.

Chapter 6

PORML Prototype

6.1. Introduction

In Chapter 3, the PORML framework was discussed and we proposed the architecture of POMRL which consisted of five main components: Web-Based Interface, User Authentication and User Profile Collection, Location Context Data Query, Dialogue Manager and Planner, and Log File Viewer. Chapter 4 explained how to build a RA domain ontology which is a crucial knowledge source for PORML dialogue content in dialogue planning. Its application in PORML could be demonstrated to show how the core component of the PORML framework, the Dialogue Manager and Planner component - presented in Chapter 5, used the RA domain ontology and other information in the framework to manage and plan the dialogue.

This chapter will present the implementation of the PORML framework in the form of a PORML prototype to show the usability and applicability of the PORML framework for users. The PORML framework is implemented by applying the Fire and Rescue Services (FRS) risk assessment (RA) domain. The chimney fire RA, a type of RA in this domain, was chosen (see Chapter 4) for the PORML prototype. The technical specifications involved will be discussed in Section 6.2 and the description of the PORML user interface will be presented in Section 6.3. Finally, certain dialogue interaction examples of PORML will be shown and described in Section 6.4.

6.2. Technical Specifications for the PORML prototype

This section aims to describe the technical specifications required for implementing the PORML prototype. We will present the technical specifications required in terms of hardware, software and utility tools used to implement and develop the prototype. An overview of the architecture of the PORML prototype corresponding to the architecture of the PORML framework (see Figure 3.3 in Chapter 3, Section 3.3) is shown in Figure 6.1. The hardware specifications of the PORML prototype are described in Section 6.1.1, the software specifications are described in Section 6.1.2, and the utility tools and libraries are described in Section 6.1.3.

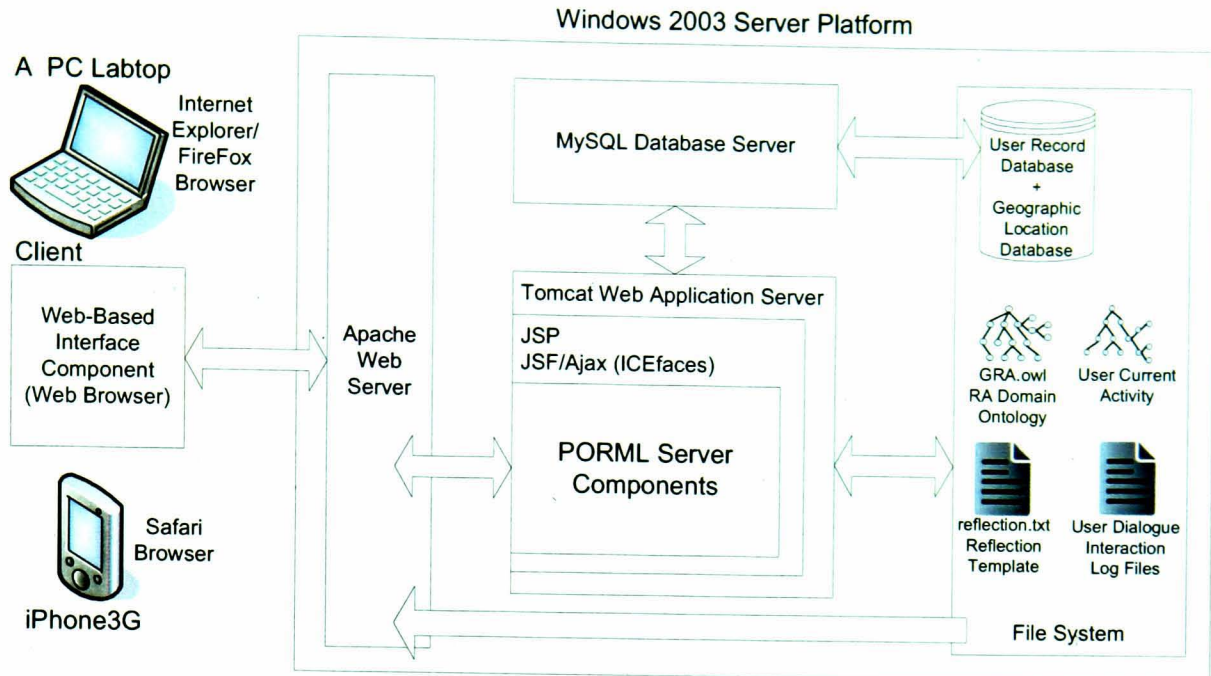


Figure 6.1 Architecture of the PORML prototype

6.2.1. Hardware specifications

The PORML prototype is developed using a PC laptop and a smart-phone. Both the laptop and the smart-phone are used as PORML clients. During development, the PORML prototype also uses the PC laptop as a temporary PORML server to test that the developing prototype works. After the first prototype is completed and ready for evaluation (see Chapter 7), the prototype is installed on a PC server platform. The hardware specifications are as follows:

- PC server platform – CPU Pentium or equivalent that can run Windows Server 2003, minimum 2 GB memory, minimum 160 GB hard disk;
- PC laptop client platform – CPU Pentium or equivalent that can run Windows XP/Vista, minimum 1 GB memory, minimum 80 GB hard disk;
- Smart-phone with touch screen – using iPhone3G, 8 GB storage.

All the necessary software to be installed on the PC server hosting the PORML prototype is operated via and available on the Internet. A user can use the PORML client, whether on a laptop or an iPhone3G with web browser, to interact with the PORML server online via the Internet. The necessary software, utility tools and libraries are also installed on the PC laptop to develop and test the PORML prototype. A smart-phone with a touch screen feature is convenient to use for dialogue interaction and seems to help the user interact with the dialogue agent faster than a non-touch screen phone. The prototype uses an iPhone3G with the operating system iOS v.3 or v.4 that has touch screen and GPS receiving features. However, the GPS feature is not utilised or implemented by this prototype. Instead, the

location of the smart-phone or laptop is assumed to be near the incident place, a SixBells public house in Cambridgeshire, as per the chimney fire scenario described in Chapter 4. It is noted that other smart-phones, with or without a touch screen feature, can be used with the PORML prototype as long as their mobile web browser supports JSF/Ajax-technology which is used for the dialogue interaction e.g. some smart-phone models of Blackberry, Nokia etc.

6.2.2. Software specifications

Software for a PC server platform is installed for the PORML prototype. For the use of this thesis, the PC server is located in Bangkok, Thailand (<http://202.44.9.119/porml>)⁴¹. The software that is necessary for hosting the PORML prototype on the PC server platform includes:

- Windows server platform – using Windows Server 2003;
- Web server – using Apache;
- Web application server – using Tomcat;
- Database server – using MySQL database server and MySQL ODBC connector.

A small number of record samples of the User Record Database and Geographic Location Database (see Chapter 3, Section 3.3; and Table 3.2 in Section 3.6.1) are created in the MySQL database server.

The software for the laptop includes:

- Windows platform – using Windows XP or Vista for the client and for the temporary server during PORML prototype development;
- Internet web browser – most browsers can support the PORML prototype e.g. Internet Explorer, FireFox, Google Chrome, Safari etc.;

The software for the smart-phone client includes:

- Mobile operating system – most mobile operating systems can support the PORML prototype e.g. iOS, Symbian, BlackBerry OS etc. The PORML prototype is mostly tested on the iPhone3G that uses iOS;
- Mobile web browser – any browsers that support JSF/Ajax technology can be used with the prototype e.g. Apple Safari, Blackberry Bold, Opera Mobile etc. The prototype normally uses the Safari browser provided by iPhone3G and this browser supports JSF/Ajax technology.

⁴¹ Hosting on this URL is only available online for a limited time.

6.2.3. Utility tools and libraries for PORML implementation

The utility software and libraries for PORML implementation that are installed on the laptop for PORML prototype development include:

- Protégé⁴² 4 ontology authoring tool;
- ROO⁴³ ontology authoring tool;
- Application development tool, namely NetBeans IDE⁴⁴, with Java Development Kit (JDK)⁴⁵;
- JSP, JSF/Ajax using ICEfaces⁴⁶ library;
- Jena⁴⁷ API library.

ROO and Protégé 4 are used to produce a RA domain ontology for the prototype, namely GRA.owl, which provides dialogue content in terms of concepts and relationships to the dialogue agent. These ontology authoring tools were addressed in Chapter 4, Section 4.2.4. The Reflection Template, namely reflection.txt, is created using a general text editor and an example of its content is shown in Figure 6.2. The content (reflective questions) in the Reflection Template used for the ReflectionDG episode is ordered according to the sequence of the Sequential DG episodes (see Chapter 5, Figure 5.1) in the same type of incident. The reflective questions are extracted from the text file reflection.txt. It is noted that the FeedbackDG can be implemented in the same way as the ReflectionDG episode. However, in the PORML prototype all feedback messages are embedded inside the FeedbackDG episode and each feedback message is extracted using a rule-based method in the FeedbackDG episode.

The PORML prototype is a Java desktop application developed under the NetBeans framework with JDK and uses the ICEfaces library for the user interface. The ICEfaces library provides a rich web presentation environment for Java Server Faces (JSF) applications which enhances the standard JSF framework and lifecycle with Ajax-based interactive features. The dialogue interaction page is implemented as a single-page user interface by Ajax-based interactive features using the ICEfaces library, while the other pages (e.g. login page and welcome page) are implemented using Java Server Page (JSP). The PORML user interface will be described in the next section.

⁴² See at URL <http://protege.stanford.edu/>

⁴³ See at URL <http://sourceforge.net/projects/confluence/>

⁴⁴ See at URL <http://www.netbeans.org>

⁴⁵ See at URL <http://www.oracle.com/technetwork/java/javase/downloads/index.html>

⁴⁶ See at URL <http://www.icefaces.org/>

⁴⁷ See at URL <http://jena.sourceforge.net/>

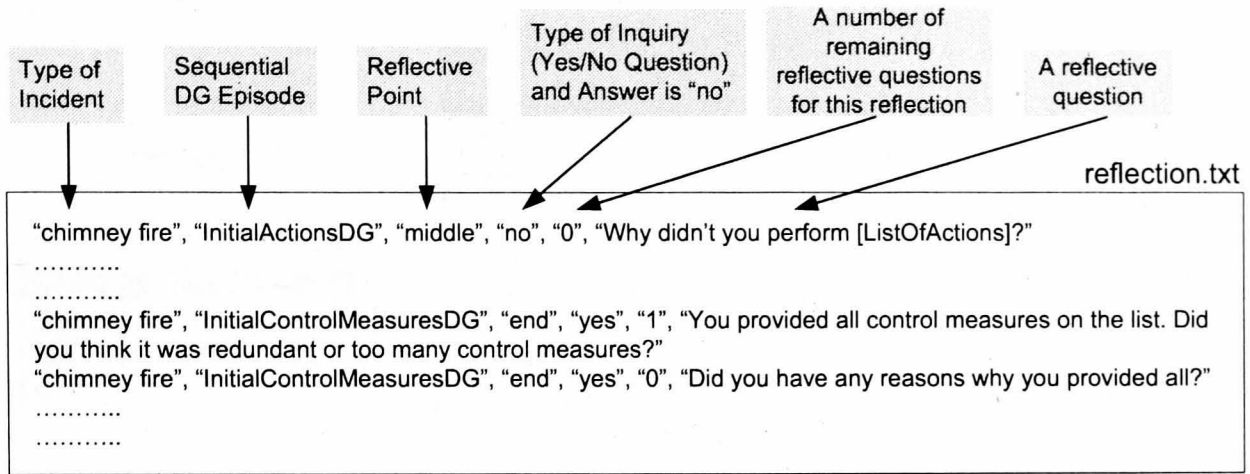


Figure 6.2 An example of the content in the Reflection Template, reflection.txt

Jena is a Java framework for building semantic web applications. The Jena API library is included in the development of the PORML prototype to provide the programmatic environments for RDF, RDFS, OWL and SPARQL including a rule-based inference engine. The content in the GRA.owl domain ontology and User Current Activity (UCA) model are queried via the Jena API used by the dialogue agent of the PORML prototype (see Chapter 5, Section 5.6).

6.3. PORML User Interface

This section aims to present the user interface of the PORML prototype which is a main component of the PORML framework known as the Web-Based Interface component (see Chapter 3, Section 3.4). This PORML user interface is designed to work in a web browser in order to support a machine independent for user interface, especially for development on mobile technology. The PORML prototype uses a text-based user interface that can be supported on both a laptop and a smart-phone. The design of the PORML user interface makes it simple for a user to communicate with the dialogue agent.

The first page of the PORML prototype is the user authentication page, shown in Figure 6.3 as seen on a laptop and a smart-phone using iPhone3G. The page size and font size are adjusted automatically to fit the laptop or the smart-phone screen. The input/output interface of the user authentication page is linked to the User Authentication and User Profile Collection component in the PORML server (see Chapter 3, Section 3.4).

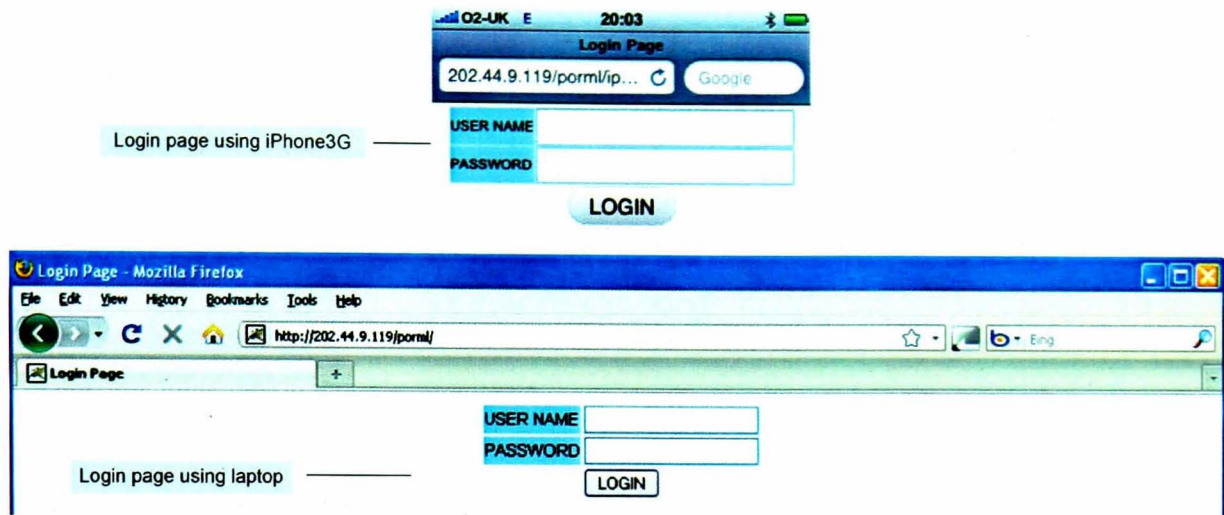


Figure 6.3 User authentication page on an iPhone3G and a Laptop

After gaining access to the PORML server via the User Authentication and User Profile Collection component, the PORML prototype issues the second page. This is the context information page (also the welcome page) relating to the chimney fire scenario described in Chapter 4, and is shown in Figure 6.4. In the case of the PORML prototype, context information relating to the chimney fire scenario is obtained by imposing fixed values of context parameters instead of using the CollectContextInformationDG episode to collect these values via dialogue interaction. The original PORML prototype is designed for evaluation by firefighters at the fire station (see Chapter 7, Section 7.4) because such an evaluation is rarely performed at the incident site and tends to be impossible to carry out at the actual incident. Therefore, the CollectContextInformationDG episode is skipped by imposing fixed values of context parameters and the next episode in the PORML prototype, the InitialActionsDG episode, will become the first dialogue game.

Based on the chimney fire scenario, these context parameters consist of the incident place – ‘SixBells Pub’, type of FRS RA – ‘chimney fire’, date and time of incident – ‘30 June 2009 18:00 – 18:45’, weather conditions – ‘sunny, low wind, good visibility’, and other contexts related to the specific type of FRS RA – ‘the incident place is not crowded (less than 50 persons), no drunk people and no crucial hazardous material in the Interest Area (30 metres surrounding the incident place excluding the incident itself)’ (see Figure 3.8 in Chapter 3, Section 3.6.2).

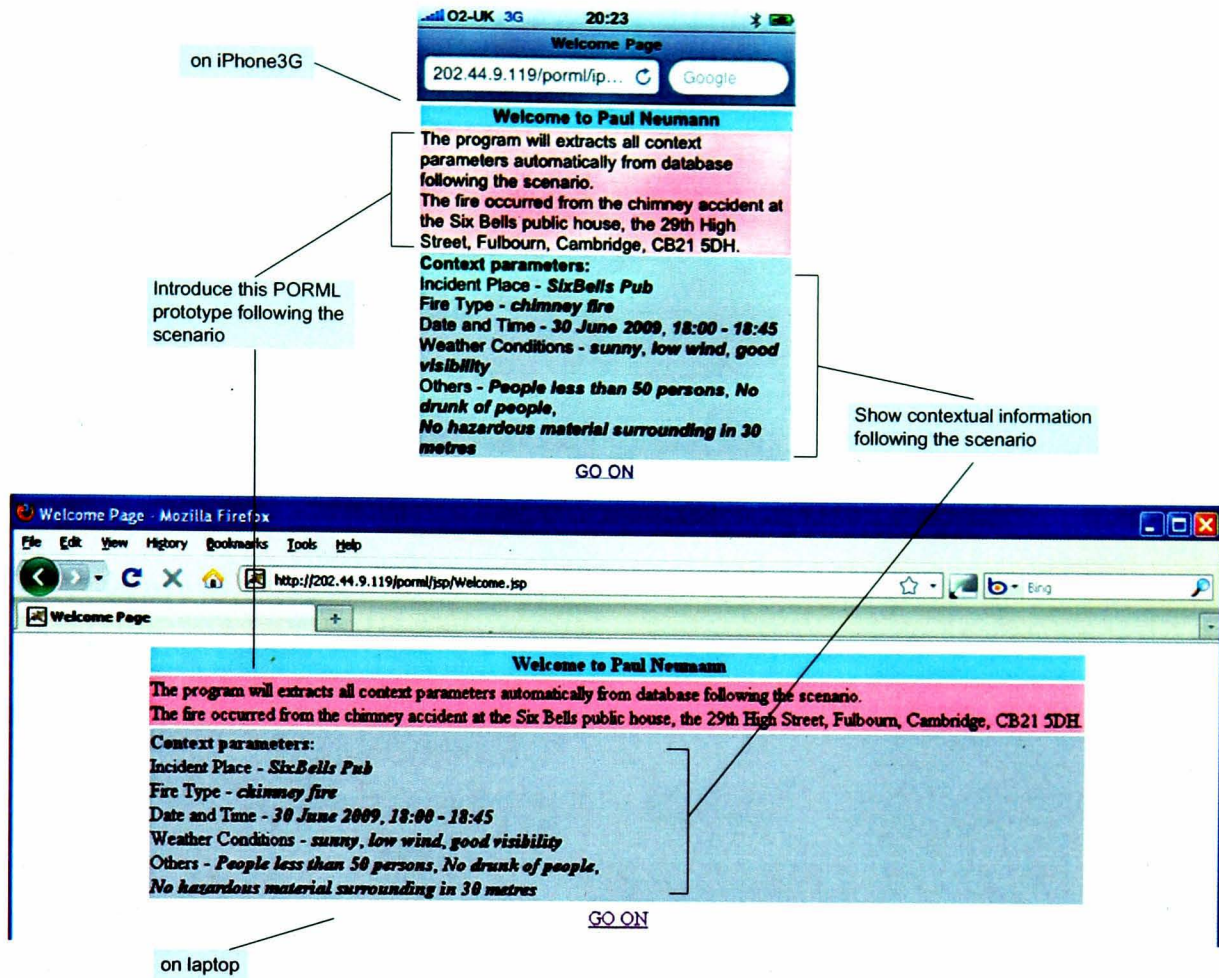


Figure 6.4 Context information page

The next page is the dialogue interaction page. The dialogue interactions between a user and a dialogue agent are performed during a user session. The input and output of the dialogue interactions are shown on the display screen as a single page with content that is changed or updated during the interactions according to the sequence of the Sequential DG episodes; starting from the InitialActionsDG episode and ending with the EndingDG episode. Figure 6.5 shows the dialogue interaction page for the Sequential DG episodes, e.g. an InitialActionsDG episode. Each episode uses the same layout on the display screen. The details and meaning of the information appearing on the layout are explained in Figure 6.5 to demonstrate where the current episode is indicated, where the agent utterance and selection of user utterance appears, and the functions of the 'Next Utterance', 'History', 'Explain' and 'End' command buttons. The selection of user utterances available depends on the inflexion of, and sometimes also the concept in, the question (see Table 5.3 in Chapter 5, Section 5.5.1). For example, (a) "Did you" is a Yes/No question and the selection of user utterances available consists of two options – "Yes, I did" and "No, I did not", (b) "What was the tactical mode ..." is a What question and the concept in the question is 'tactical mode', so the selection of user utterances available consists of three options – 'defensive mode', 'offensive mode' and 'transitional mode' etc. The 'Next Utterance' command button is used to submit

the current user utterance to the dialogue agent and obtain the next agent utterance. Concerning the User Interruption DG episodes (see Chapter 5, Section 5.3 and Section 5.4.3), the ‘History’ command button and ‘Explain’ command button are used to activate the Dialog History popup window by calling the HistoryDG episode and the Explain Concept popup window by calling the ExplanationDG episode, respectively. The End command button is used to end the dialogue interactions immediately by calling the UserEndingDG episode.

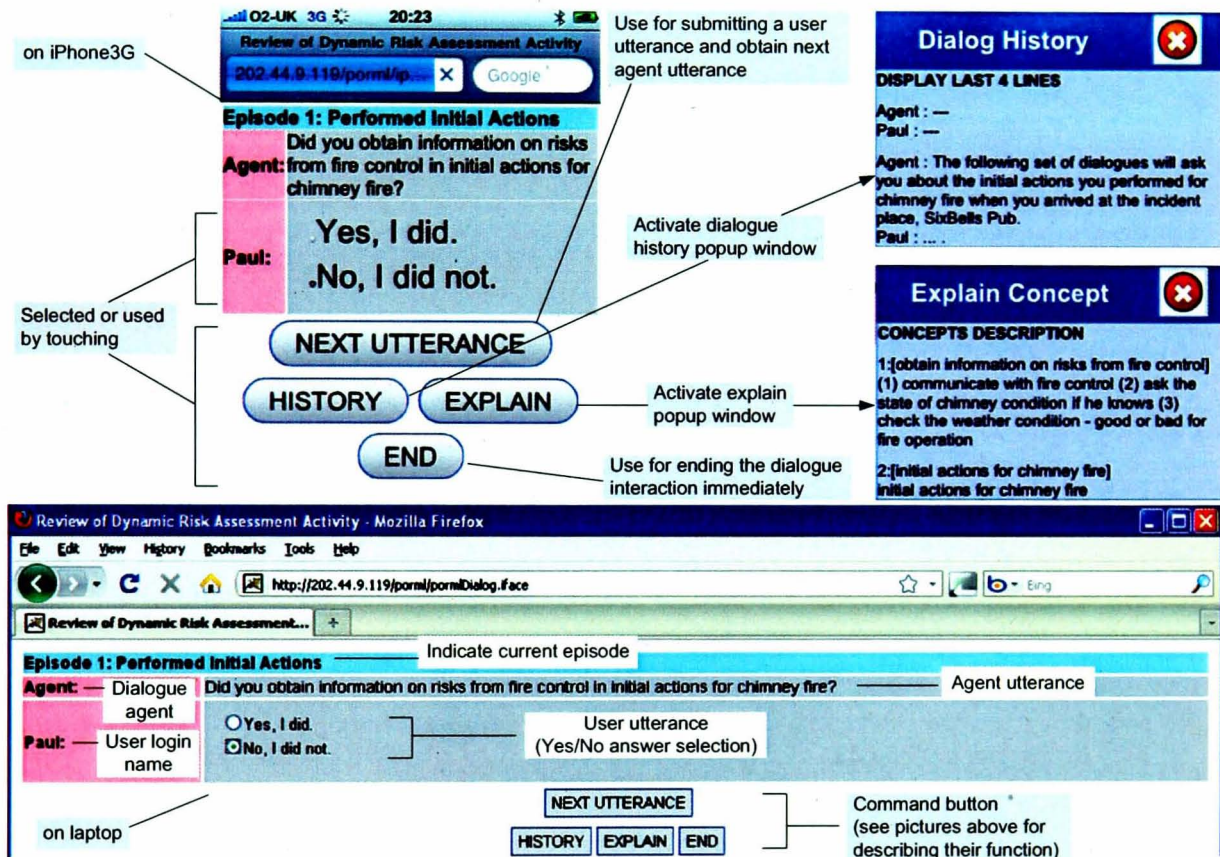


Figure 6.5 Dialogue interaction page for Sequential DG episodes

Figure 6.6 and 6.7 show what is seen on the dialogue interaction page when the Sequential DG episodes are interrupted by System Interruption DG episodes (see Chapter 5, Section 5.3 and Section 5.4.4) which use the same page and layout. The dialogue interaction page for the ReflectionDG episode is illustrated in Figure 6.6 and the dialogue interaction page for the FeedbackDG episode is illustrated in Figure 6.7. All issued agent utterances of System Interruption DG episodes, reflective questions and feedback messages, are non-OWL statements while the issued agent utterances of Sequential DG episodes are mostly OWL statements (see Chapter 5, Section 5.5.1). The user utterances of the ReflectionDG episode, i.e. reflective answers, are provided by entering free text input in the free text input box. The reflective answers are not analysed (see Chapter 5, Section 5.5.2). The only possible user utterance in the FeedbackDG episode is “Proceed to next question” which is analysed as “skip turn”.

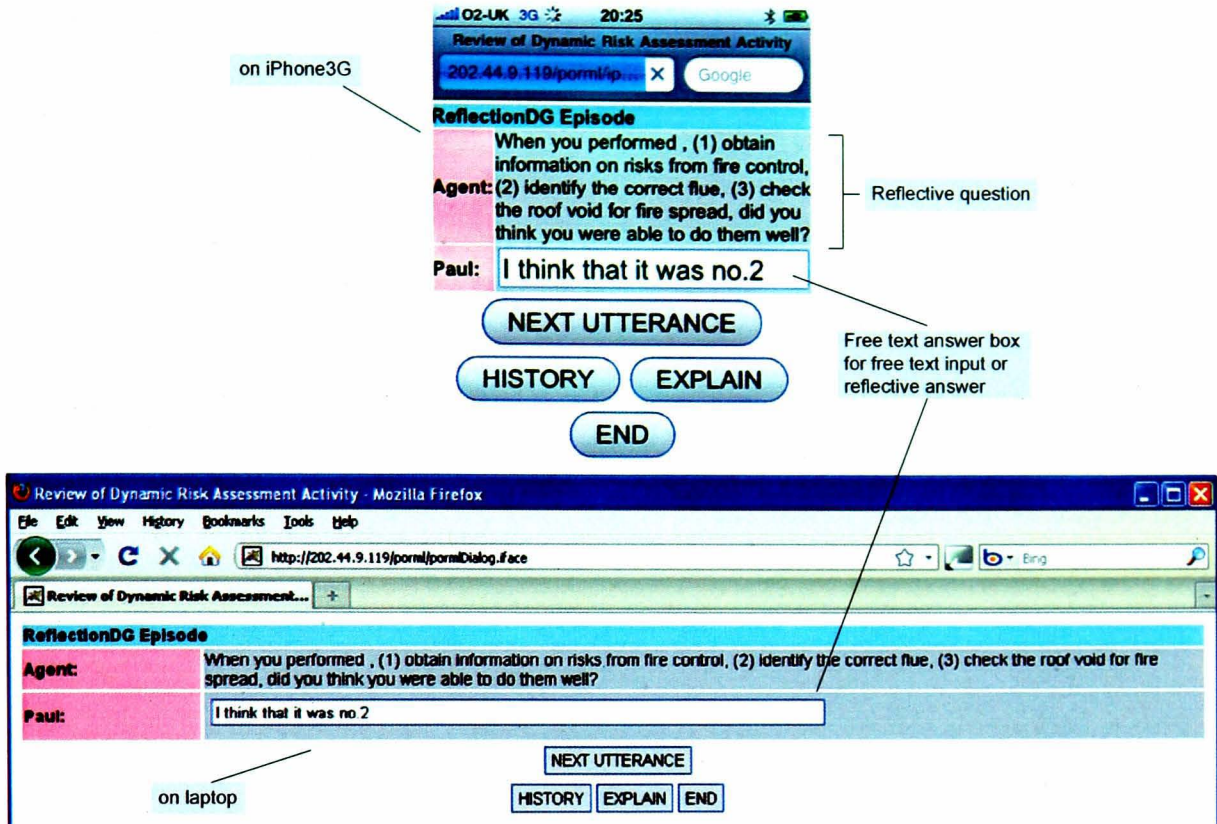


Figure 6.6 Dialogue interaction page for the ReflectonDG episode

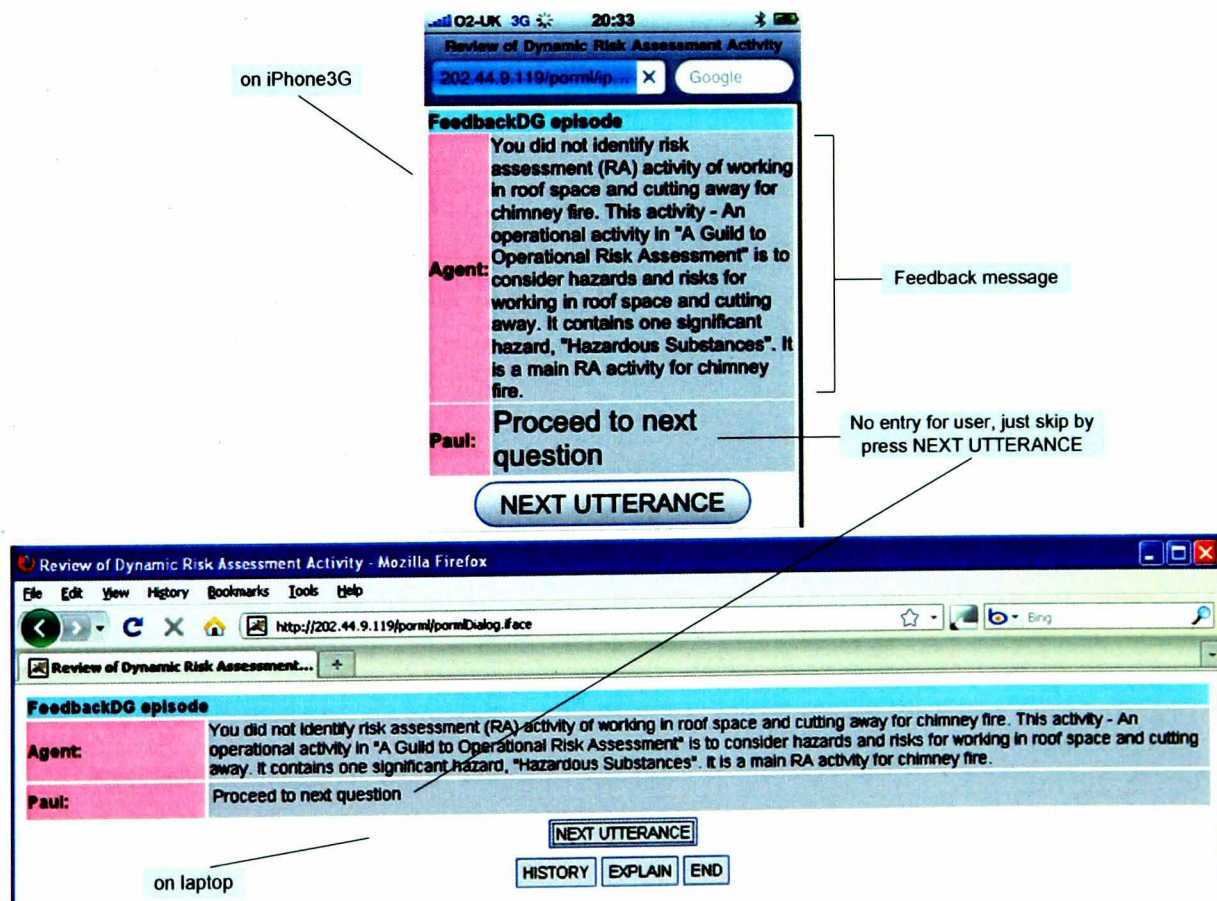


Figure 6.7 Dialogue interaction page for the FeedbackDG episode

6.4. Examples of Interaction in PORML

In this section, examples of dialogue interactions will be shown to illustrate the sequence of issuing agent utterances and obtaining responses from the user in each Sequential DG episode. The examples answer our research questions (see Chapter 1) by showing that: (a) the RA domain ontology (GRA.owl), which is informed and constructed using Activity Theory (see Chapter 4, Section 4.4), is used to design the PORML dialogue agent that promotes reflection on action (Schon 1983) in fire RA activities (b) the user and context modelling exploits the ontological model of generic RA, semantic-enhanced location information and user activities or experiences (c) the User Current Activity (UCA) model is used to design dialogue tailored to user activity in order to promote reflection on action focused on fire RA skills after an incident has been completed.

The examples also illustrate how and when the System Interruption DG episodes, i.e. FeedbackDG episode and ReflectionDG episode, interrupt each Sequential DG episode.

6.4.1. Example 1: InitialActionsDG with ReflectionDG

This example aims to show the review of the initial actions at the incident and the use of reflective questions to reflect on these initial actions. The initial actions are extracted from the UCA model and the content of the UCA model is derived from GRA.owl. After the prototype collects the contextual information, a review of the initial actions at the incident is started. To conduct the review, a number of agent utterances of inquiry are generated for the InitialActionsDG episode based on the type of incident occurring (FRS RA). The answer to each dialogue question in the episode consists of two options: “*Yes, I did*” and “*No, I did not*”. In the example below, the first four agent utterances of inquiry in an InitialActionsDG episode are shown. A user answers the questions of these agent utterances as follows:

First four agent utterances of inquiry (not including the first utterance which provides episode information) in the InitialActionsDG episode and the answers provided by user utterances:

[1.1] Agent utterance: “*Did you obtain information on risks from fire control in initial actions for chimney fire?*”

[1.2] User utterance: “*Yes, I did.*”

[1.3] Agent utterance: “*Did you identify the correct flue in initial actions for chimney fire?*”

[1.4] User utterance: “*Yes, I did.*”

[1.5] Agent utterance: “*Did you check the roof void for fire spread in initial actions for chimney fire?*”

[1.6] User utterance: “*No, I did not.*”

[1.7] Agent utterance: “*Did you consider attack from the grate as first firefighting option in initial actions for chimney fire?*”

[1.8] User utterance: “*Yes, I did.*”

In the example above, out of the seven agent utterances of inquiry generated for a chimney fire incident in the InitialActionsDG episode (not including the agent utterance used for episode introduction), the first four of them ([1.1], [1.3], [1.5], [1.7]) are illustrated. All of these agent utterances of inquiry are constructed in the same way using OWL statements (see Chapter 5, Section 5.5.1). As an example, the first agent utterance of inquiry [1.1] is derived from the combination of:

- (a) “*Did you*” – an inflexion ‘INQUIRE_YES_NO’ for Yes/No question;
- (b) “*obtain information on risks from fire control*” – a description of the first concept or class ‘Initial Chimney Fire Action-a’ in UCA model;
- (c) “*in*” – a relationship ‘subClassOf’;
- (d) “*initial actions for chimney fire*” – a description of the second concept or class ‘Initial Chimney Fire Action’ in UCA model.

All the initial actions for a chimney fire that are mentioned in the agent utterances of inquiry are provided by extracting the list of subclasses of initial actions for a chimney fire found in the UCA model as shown in Figure 6.8. Each subclass is used for the first concept in the construction of an agent utterance of inquiry. The second concept is the class of initial actions for a chimney fire (‘Initial Chimney Fire Action’) which contains seven subclasses (‘Initial Chimney Fire Action-a – g’). Therefore, each subclass of initial actions for a chimney fire (first concept) and the class of initial actions for a chimney fire (second concept) are extracted to generate seven agent utterances of inquiry.

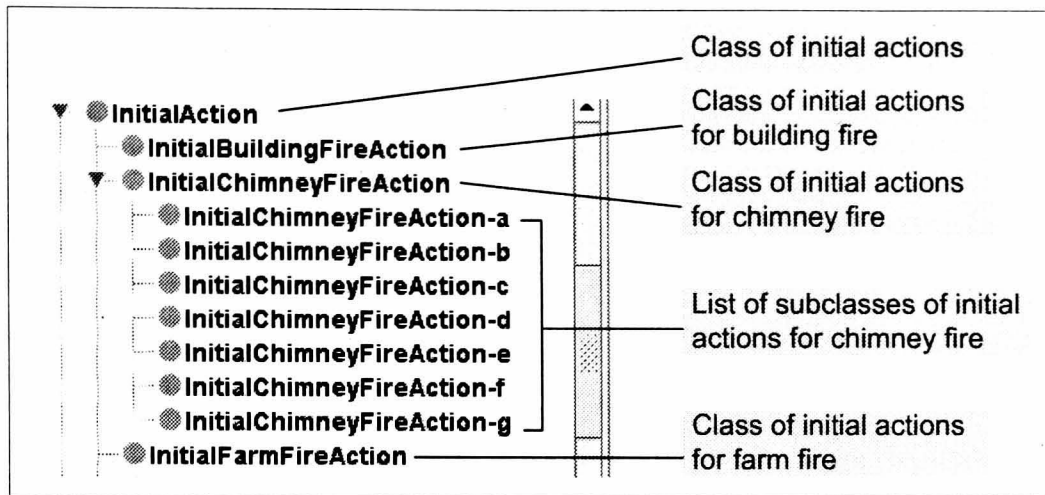


Figure 6.8 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to initial actions

For the first four agent utterances of inquiry, the number of “*Yes, I did*” answers (which is 3) are more than those of “*No, I did not*” (which is 1). As a result, the next two agent utterances of reflective questions ([1.9], [1.11]) are issued through a system interruption by the ReflectionDG episode (see Figure 5.2 in Chapter 5, Section 5.4.2) to initiate reflection on the four initial actions as follows:

ReflectionDG episode:

[1.9] Agent utterance: “*When you performed, (1) obtain information on risks from fire control, (2) identify the correct flue, (4) consider attack from the grate as first firefighting option, did you think you were able to do them well?*”

[1.10] User utterance: “[free text entry space]” [user can enter any text to reflect the actions]

[1.11] Agent utterance: “*What was the obstacle?*”

[1.12] User utterance: “[free text entry space]” [user can enter any text to reflect the actions]

Based on the answers given regarding the four initial actions, it is determined that the user tended to carry out the initial actions for a chimney fire (which are extracted from the UCA model) in generic risk assessment. So, the first reflective question aims to initiate reflection on how well he performed the actions that were carried out (actions [1.1], [1.3] and [1.7]), while the second reflective question aims to obtain more information about the obstacles that were involved if some actions were not performed well. These two reflective questions are extracted from reflection.txt (see Figure 6.2) using the following parameters: type of incident – ‘chimney fire’, Sequential DG episode – ‘InitialActionsDG’, reflective point – ‘middle’, type of inquiry and answer – ‘yes>no’. There are 2 reflective questions for this reflection: [1.9] and [1.11].

6.4.2. Example 2: InitialControlMeasuresDG with ReflectionDG

This example aims to show the review of the provision or use of control measures at the first situation of the incident and the use of reflective questions to reflect on the provision or use of these control measures. The control measures are extracted from the UCA model and based on these, the agent utterances of inquiry regarding possible control measures for FRS RA are generated. The number of generated utterances in the InitialControlMeasuresDG episode depends on the type of FRS RA. The answer to each dialogue question in the episode consists of two options: “*Yes, I did*” and “*No, I did not*”. The agent utterances are issued until the end of the InitialControlMeasureDG episode is reached. A user answers the questions presented by these agent utterances. The example below only shows the agent utterances which were answered with “*Yes, I did*” as follows:

[2.1] Agent utterance: “*Did you cordon off an unsafe area in chimney fire?*”

[2.2] Agent utterance: “*Did you use safe systems of hazard or risk for gaining access to and working on roof in chimney fire?*”

[2.3] Agent utterance: “*Did you complete training of hazard or risk for gaining access to and working on roof in chimney fire?*”

[2.4] Agent utterance: “*Did you use aerial appliances in chimney fire?*”

[2.5] Agent utterance: “*Did you use roof ladders in chimney fire?*”

[2.6] Agent utterance: “*Did you complete training of hazard or risk for working in roof space and cutting away in chimney fire?*”

[2.7] Agent utterance: “*Did you complete training of hazard or risk for applying extinguishing media in chimney fire?*”

In total, sixteen agent utterances of inquiry are generated for a chimney fire incident in the InitialControlMeasuresDG episode (not including the agent utterance used for episode introduction) and seven of these ([2.1] – [2.7]), which are answered “*Yes, I did*” to indicate the provision or use of the control measures, are illustrated in the example above. The agent utterances of inquiry for the InitialControlMeasuresDG episode are constructed using OWL statements by the same means as the agent utterances of inquiry for the InitialActionsDG episode. For example, the first agent utterance ([2.1]) is derived from the combination of:

- (a) “*Did you*” – an inflexion ‘INQUIRE_YES_NO’ for Yes/No question;
- (b) “*cordon off an unsafe area*” – a description of the first concept or class ‘Chimney Fire Control Measures-aa’ in UCA model;
- (c) “*in*” – a relationship related to chimney fire;

(d) “chimney fire” – a description of the second concept or class ‘Chimney Fire’ in UCA model.

All control measures corresponding to general RA activities for a chimney fire (e.g. gaining access to and working on the roof activity etc.) are provided by extracting the list of subclasses of control measures for a chimney fire found in the UCA model. Each subclass is used for the first concept in the example as shown in Figure 6.9. In total, there are sixteen subclasses (‘Chimney Fire Control Measure-aa – ag’, ‘Chimney Fire Control Measure-ba – bd’, ‘Chimney Fire Control Measure-ca – ce’) of control measures for a chimney fire. The second concept in the example comes from the type of incident, i.e. the class of chimney fire, found in the UCA model. Therefore, each subclass of control measures for a chimney fire (first concept) and the class of chimney fire are extracted to generate sixteen agent utterances of inquiry.

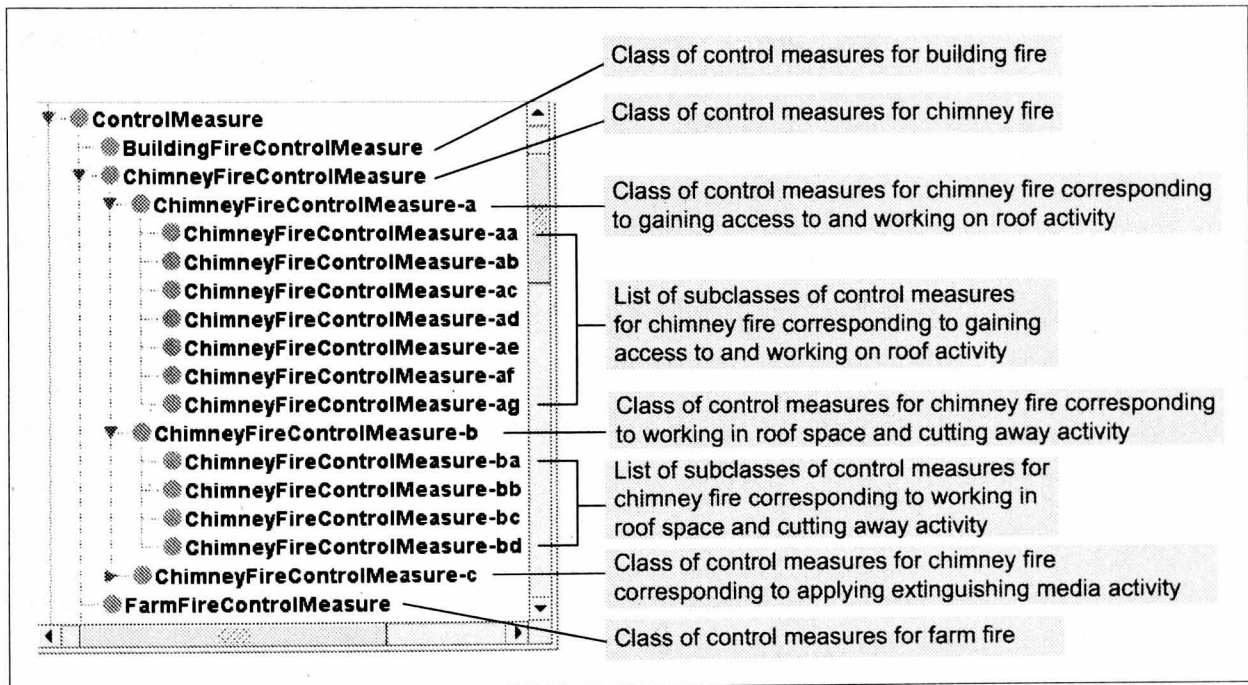


Figure 6.9 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses of control measures

The other nine out of the sixteen agent utterances of inquiry are answered “No, I did not” (not shown in the example). Out of all these agent utterances of inquiry, the number of “Yes, I did” (used) answers, which is 7, are less than those of “No, I did not” (not used), which is 9. As a result, the next agent utterance of a reflective question ([2.8]) is issued through a system interruption by the ReflectionDG episode (see Figure 5.3 in Chapter 5, Section 5.4.2) to reflect on the provision or use of control measures as follows:

[2.8] Agent utterance: “The control measure is an intervention technique to reduce risk. You didn't provide or use, (6) use work positioning and fall arrest systems, (7) complete training of hazard or risk for pitch and flat roof, (8) use hearth kit, (9) use safe systems for asbestos and

MMMF material, (10) use breathing apparatus and contamination procedures, (13) use safe systems of applying extinguishing media, (14) use thermal imaging camera, (15) use eye protection and mirror, (16) use full fire kit with helmet. Did you think these were redundant to assess the risk in this chimney fire or had any other reasons?"

[2.9] User utterance: "[free text entry space]" [user can enter any text to reflect the actions]

In this example, the user's answers suggest that his/her provision or use of control measures were insufficient for assessing some risks of the RA activities in a chimney fire (based on answer testing multiple times and checking the user's answered against the results of calculated risk rating). The reflective question aims to ask about the user's confidence regarding the provision or use of control measures he/she chose and to ascertain his/her reasons for choosing these control measures. The reflective question is extracted by using the following parameters (see Figure 6.2): type of incident – 'chimney fire', Sequential DG episode – 'InitialControlMeasuresDG', reflective point – 'end', type of inquiry and answer – 'yes<no'. There is just one reflective question for this reflection: [2.8].

6.4.3. Example 3: IdentifyRiskAssessmentDG with FeedbackDG and ReflectionDG

This example aims to show how the FeedbackDG and the ReflectionDG are used to respond to the user's answers regarding identifying the risks in a FRS RA. In the IdentifyRiskAssessmentDG episode, the agent utterances of inquiry regarding identifying the risk assessment activities for a FRS RA are generated. The number of generated agent utterances depends on the number of RA activities there are in the type of FRS RA being conducted. In a chimney fire RA, there are 3 main RA activities. Therefore, to conduct the review, 3 agent utterances of inquiry (not including the agent utterance used for episode introduction) are generated for the IdentifyRiskAssessmentDG episode. The answer to each dialogue question in the episode consists of two options: "Yes, I did" and "No, I did not". In the example below, the second agent utterance of inquiry in this episode asks the user whether he/she identified the hazards in working in roof space and cutting away RA activity and the answer is "No, I did not" as follows:

Second agent utterance of inquiry in the IdentifyRiskAssessmentDG episode:

[3.1] Agent utterance: "Did you identify hazards and risks in risk assessment (RA) activity of working in roof space and cutting away for chimney fire?"

[3.2] User utterance: "No, I did not"

The agent utterance of inquiry [3.1] is constructed using an OWL statement by the same means as the agent utterances of inquiry for the InitialActionsDG episode. The agent utterance is derived from the combination of:

- (a) “*Did you identify*” – an inflexion ‘INQUIRE_YES_NO_IDENTIFY’ for Yes/No question;
- (b) “*hazards and risks*” – a description of the first concept or class ‘Hazard’ in UCA model;
- (c) “*in*” – a relationship related to a RA activity for chimney fire;
- (d) “*risk assessment (RA) activity of working in roof space and cutting away for chimney fire*” – a description of the second concept or class ‘Chimney Fire Risk Assessment Activity-b’ in UCA model.

The first concept in the construction of the agent utterance of inquiry is the class ‘Hazard’. All RA activities for a chimney fire are provided by extracting the list of subclasses of risk assessment activity for a chimney fire found in the UCA model as shown in Figure 6.10. Each subclass is used for the second concept. Therefore, the hazards and risks (first concept) and each subclass of RA activities for a chimney fire (second concept) are extracted to generate 3 agent utterances of inquiry.

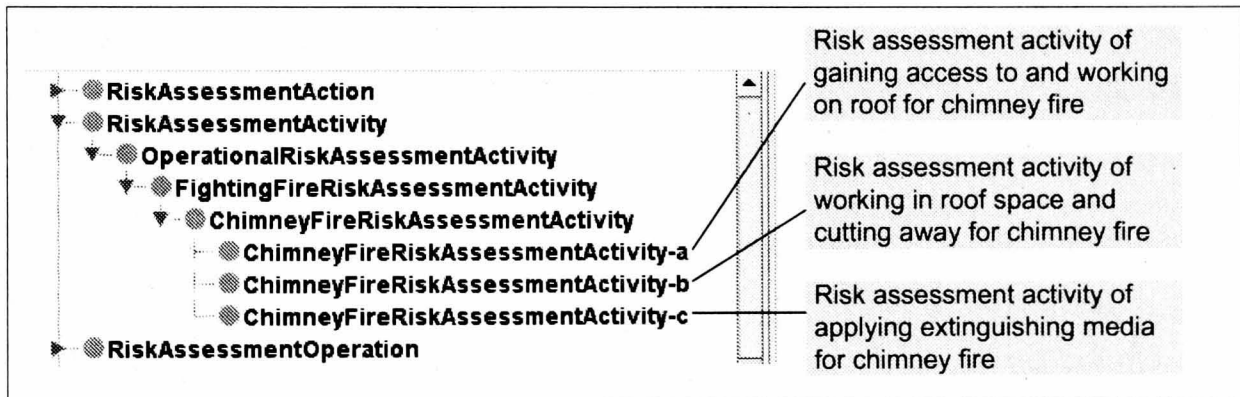


Figure 6.10 A part of the UCA model (derived from RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to risk assessment activity

Due to the answer [3.2] “*No, I did not*”, two agent utterances of feedback ([3.3], [3.5]) and an agent utterance of a reflective question ([3.7]) are issued through a system interruption by the FeedbackDG episode and the ReflectionDG episode respectively. These utterances are used to respond to and reflect on the negative answer given by the user (see Figure 5.4 in Chapter 5, Section 5.4.2) as follows:

FeedbackDG episode regarding the third agent utterance of inquiry:

[3.3] Agent utterance: “*You did not identify risk assessment (RA) activity of working in roof space and cutting away for chimney fire.*”

[3.4] User utterance: “*Proceed to next question*” [no answer, just skip turn to dialogue agent]

[3.5] Agent utterance: “*This activity – An operational activity in “A Guide to Operational Risk Assessment” is to consider hazards and risks for working in roof space and cutting away. It contains one significant hazard, “Hazardous Substances”. It is a main RA activity for chimney fire.*”

[3.6] User utterance: “*Proceed to next question*” [no answer, just skip turn to dialogue agent]

ReflectionDG episode regarding the third agent utterance of inquiry:

[3.7] Agent utterance: “*Did you have any reason why you didn't identify the hazards in this activity?*”

[3.8] User utterance: “*[free text entry space]*” [user can enter any text to reflect the actions]

The FeedbackDG episode issues the first agent utterance to inform the user that he/she did not identify one of the main RA activities in a chimney fire. The next agent utterance lists the significant hazards corresponding to that RA activity that might be relevant to the chimney fire incident. In the subsequent ReflectionDG episode, a reflective question is issued to inquire about the user's reasons for not identifying the hazards in that RA activity for a chimney fire incident. The reflective question is extracted by using the following parameters (see Figure 6.2): type of incident – ‘chimney fire’, Sequential DG episode – ‘IdentifyRiskAssessmentDG’, reflective point – ‘inside’, type of inquiry and answer – ‘no’. There is just one reflective question for this reflection: [3.7].

6.4.4. Example 4: SituationAssessmentDG with FeedbackDG and ReflectionDG

This example aims to show a comparison of the assessment of risk for a situation by calculation and the assessment of risk by a user to obtain feedback and encourage reflection regarding the user's answer. If the hazards/risks in a particular risk assessment activity are identified during the review process in the IdentifyRiskAssessmentDG episode, agent utterances of inquiry regarding the risk group and risk rating of the identified risk assessment activity in the current situation are generated in the SituationRiskAssessmentDG episode. For example, in the gaining access to and working on the roof activity in a chimney fire, there are two hazards for which risk assessment is to be carried out (actions); the first hazard being ‘Falling Masonry hazard’ and the second hazard being ‘Roof Condition hazard’. To conduct the review, four agent utterances of inquiry are generated for the SituationAssessmentDG episode. The first and third agent utterances are regarding risk group, while the second and fourth agent utterances are regarding risk rating.

In the example below, the dialogue agent asks the user about his/her decisions regarding the risk group who was impacted by the first hazard in the RA activity of gaining access to and working on the roof for a chimney fire ([4.1]) as well as about the risk rating of this hazard ([4.7]) as follows:

First agent utterance of inquiry regarding risk group in the SituationAssessmentDG episode:

[4.1] Agent utterance: “*What did you decide regarding who (risk group) might be harmed on hazards and risks in assessing falling masonry hazard/risk for gaining access to and working on roof activity?*”

[4.2] User utterance: “*That was whole time group*” [the answer matches the list of possible risk groups in falling masonry hazard]

The agent utterance of inquiry [4.1] is constructed using an OWL statement by the same means as the agent utterances of inquiry for the InitialActionsDG episode. The agent utterance is derived from the combination of:

- (a) “*What did you decide regarding who (risk group) might be harmed on*” – an inflexion ‘INQUIRE_WHO_MIGHT_BE_HARMED’ for Who question;
- (b) “*hazards and risks*” – a description of the first concept or class ‘Hazard’ in UCA model;
- (c) “*in*” – a relationship related to a RA action for chimney fire;
- (d) “*assessing falling masonry hazard/risk for gaining access to and working on roof activity*” – a description of the second concept or class ‘Chimney Fire Risk Assessment Action-aa’ in UCA model.

All RA actions (assessing falling masonry hazard/risk, assessing roof condition hazard/risk) relating to a RA activity for a chimney fire (gaining access to and working on the roof) are provided by extracting the list of subclasses of risk assessment actions for a chimney fire found in the UCA model as shown in Figure 6.11. Each subclass is used as the second concept. Therefore, the hazards and risks (first concept) and each subclass of RA actions relating to the risk assessment activity of gaining access to and working on the roof for a chimney fire (second concept) are extracted to generate two agent utterances of inquiry (an inquiry regarding the risk group for each of the two hazards).

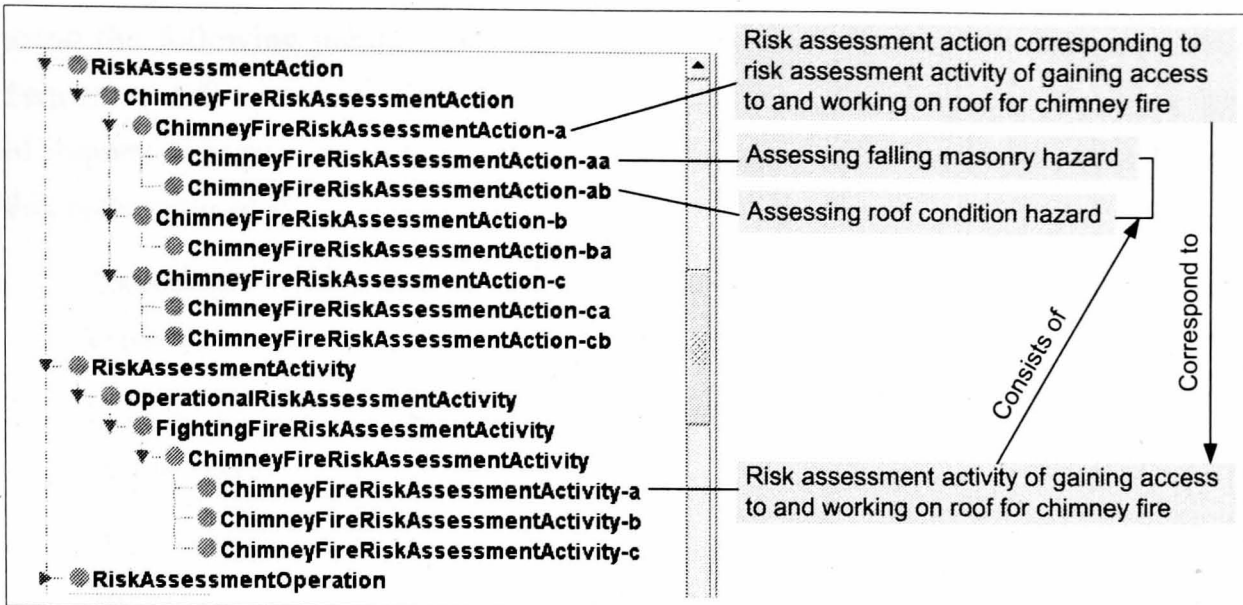


Figure 6.11 A part of the UCA model (derived from the RA domain ontology, GRA.owl) illustrating the classes and subclasses relating to risk assessment action/activity

The answer [4.2] *“That was whole time group”* matches the list of possible risk groups for this hazard (falling masonry hazard). As a result, an agent utterance of feedback ([4.3]) is issued through a system interruption by the FeedbackDG episode to indicate that it is a correct answer. Then, an agent utterance of a reflective question ([4.5]) is issued through a system interruption by the ReflectionDG episode to initiate reflection on how this risk group could be protected from the hazard (see Figure 5.5 in Chapter 5, Section 5.4.2) as follows:

FeedbackDG episode regarding the first agent utterance of inquiry:

[4.3] Agent utterance: *“I agree. A risk group you have selected whole time group is one of the possible risk group for this hazard. The possible risk group can be, (1) non service personnel group, (2) public group, (3) retained group, (4) volunteer group, (5) whole time group.”*

[4.4] User utterance: *“Proceed to next question”* [no answer, just skip turn to dialogue agent]

ReflectionDG episode regarding the first agent utterance of inquiry:

[4.5] Agent utterance: *“How did you protect or deal with whole time group for falling masonry hazard/risk?”*

[4.6] User utterance: *“[free text entry space]”* [user can enter any text to reflect the actions]

The SituationAssessmentDG episode is interrupted by the FeedbackDG episode to give feedback ([4.3]) confirming that the user’s answer is one of the possible correct answers and to inform the user of all the possible risk groups for this hazard (5 risk groups). Afterwards, a reflective question ([4.5]) is issued through a system interruption by the ReflectionDG episode to initiate reflection on how the user managed the safety of this risk group. The reflective question is extracted by

using the following parameters (see Figure 6.2): type of incident – ‘chimney fire’, Sequential DG episode – ‘SituationAssessmentDG’, reflective point – ‘inside’, type of inquiry and answer – ‘match risk group’. There is just one reflective question for this reflection: [4.5].

Second agent utterance of inquiry regarding risk rating in the SituationAssessmentDG episode:

[4.7] Agent utterance: “*What was risk rating in assessing falling masonry hazard/risk for gaining access to and working on roof activity?*”

[4.8] User utterance: “*That was low risk*” [assume the answer mismatch with calculation result which is medium risk]

The agent utterance of inquiry [4.7] is constructed using an OWL statement by the same means as the agent utterances of inquiry in the InitialActionsDG episode. The agent utterance is derived from the combination of:

- (a) “*What was*” – an inflexion ‘INQUIRE_WHAT_WAS’ for What question;
- (b) “*risk rating*” – a description of the first concept or class ‘Risk Rating’ in UCA model;
- (c) “*in*” – a relationship related to a RA action for chimney fire;
- (d) “*assessing falling masonry hazard/risk for gaining access to and working on roof activity*” – a description of the second concept or class ‘Chimney Fire Risk Assessment Action-aa’ in UCA model.

All RA actions (assessing falling masonry hazard/risk, assessing roof condition hazard/risk) relating to a RA activity for a chimney fire (gaining access to and working on roof activity) are provided by extracting the list of subclasses of risk assessment actions for a chimney fire found in the UCA model. Each subclass is used for the second concept. Therefore, the risk rating (first concept) and each subclass of RA actions which relate to the risk assessment activity of gaining access to and working on the roof for a chimney fire (second concept) are extracted to generate two agent utterances of inquiry (an inquiry regarding the risk rating for each of the two hazards).

The answer [4.8] “*That was low risk*” from the user is a mismatch of the calculation result ‘medium risk’. In this example, the dialogue agent calculates the risk rating from:

- (a) Check the answers “*Yes, I did*” of control measures, i.e. agent utterances [2.1] – [2.5] from Example 2: InitialControlMeasuresDG, and calculate the total reduced likelihood = ‘-3.0’ (see Chapter 4 Table 4.9);

- (b) Check the context parameters shown in Figure 6.4, only peak time (18:00 – 18:45) with narrow road or street can increase the likelihood = '+0.2' (see Chapter 3 Table 3.3 for narrow road extracted from Interest Area, and Chapter 4 Table 4.10 for the lists of context parameters);
- (c) Check the severity, likelihood, risk score and risk rating of falling masonry hazard without control measures and context impacts, i.e. severity = '7', likelihood = '6', risk score = '42' and risk rating = 'high risk' (see Chapter 4 Table 4.6, 4.7, 4.8);
- (d) Adjust likelihood from (a) and (b), then likelihood = '3.2', risk score = '22.4' and risk rating = 'medium risk'.

The risk calculation can be summarised as shown in Figure 6.12

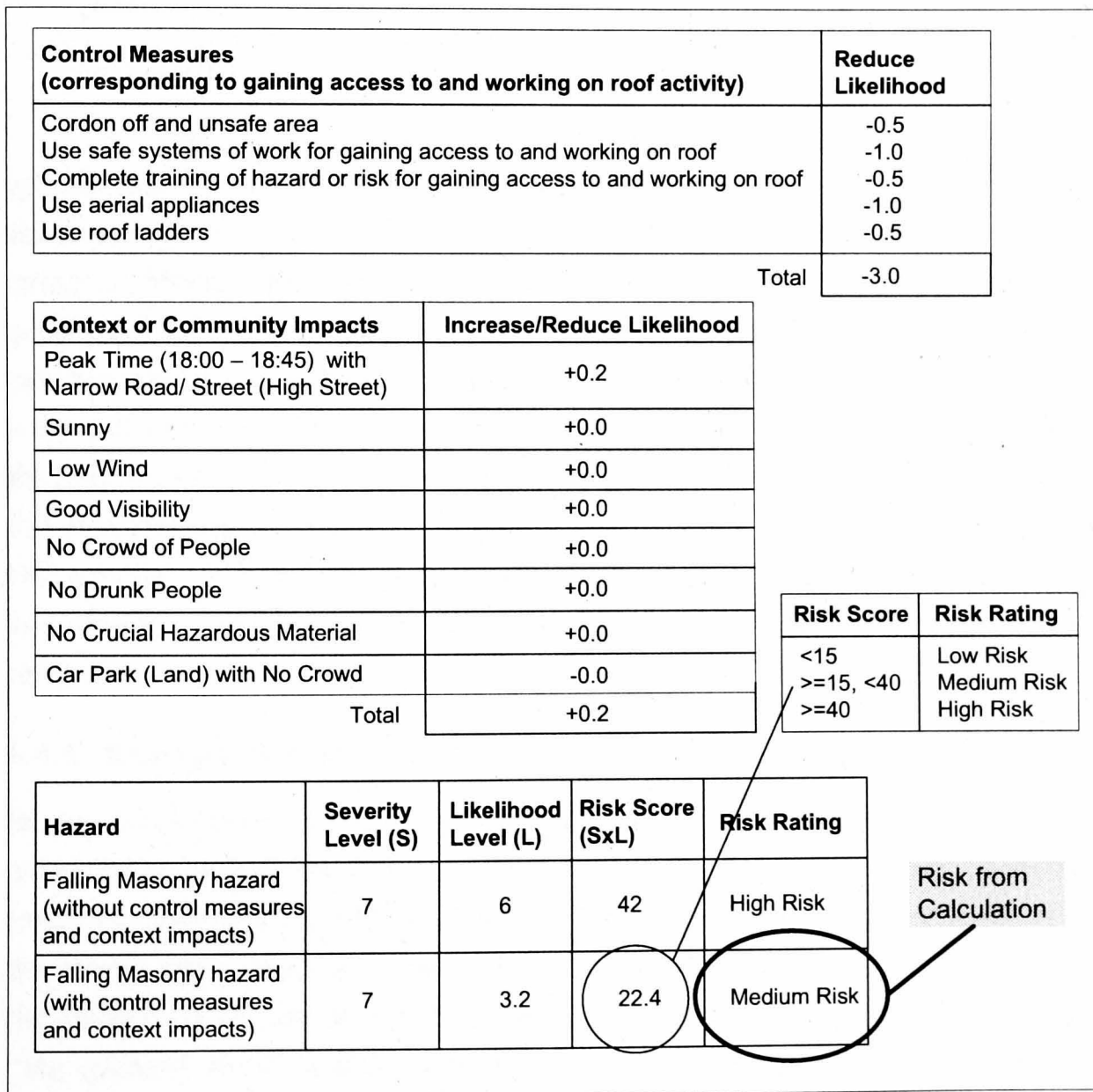


Figure 6.12 A summary of the risk calculation

As a result of the user's answer, the next agent utterance of feedback ([4.9]) and agent utterance of a reflective question ([4.11]) are issued through a system

interruption by the FeedbackDG and ReflectionDG episodes respectively (see Figure 5.5 in Chapter 5, Section 5.4.2) as follows:

FeedbackDG episode regarding the second agent utterance of inquiry:

[4.9] Agent utterance: *“I disagree but you may have some actions for solution. I think that the risk rating you have low risk may not match with the existing and availability of control measures in this hazard. It could be medium risk.”*

[4.10] User utterance: *“Proceed to next question”* [no answer, just skip turn to dialogue agent]

ReflectionDG episode regarding the second agent utterance of inquiry:

[4.11] Agent utterance: *“Why did you think that assessing falling masonry hazard/risk for gaining access to and working on roof activity could be low risk?”*

[4.12] User utterance: *“[free text entry space]”* [user can enter any text to reflect the actions]

The SituationAssessementDG episode is interrupted by the FeedbackDG episode (one utterance is generated) to give feedback informing the user that his/her assessment of the hazard being ‘Low Risk’ does not correspond to the calculated risk rating of ‘Medium Risk’. After the FeedbackDG episode is completed, a reflective question is issued by the ReflectionDG episode to initiate reflection on the user’s risk decision by asking him/her to explain why the answered ‘Low Risk’ was chosen when assessing the falling masonry hazard in the gaining access to and working on the roof activity for a chimney fire. The reflective question is extracted by using the following parameters (see Figure 6.2): type of incident – ‘chimney fire’, Sequential DG episode – ‘SituationAssessementDG’, reflective point – ‘inside’, type of inquiry and answer – ‘mismatch risk rating’. There is just one reflective question for this reflection: [4.11].

6.4.5. Example 5: ModeAndSystemDG with FeedbackDG

In the ModeAndSystemDG episode, only two agent utterances of inquiry are generated to conduct the review. The first agent utterance inquires about the tactical mode the user used, i.e. offensive mode, defensive mode or transitional mode; while the second agent utterance inquires about the system of work the user performed. In the example below, the answer to the first agent utterance regarding tactical mode is *“the offensive mode”* and the answer to the second agent utterance for system of work is *“access to and working on roof”* as follows:

First agent utterance of inquiry in the ModeAndSystemDG episode:

[5.1] Agent utterance: *“What was tactical mode in risk assessment activities for chimney fire?”*

[5.2] User utterance: *“That was offensive mode”*

The agent utterance of inquiry [5.1] is constructed using an OWL statement by the same means as the agent utterances of inquiry in the InitialActionsDG episode. The agent utterance is derived from the combination of:

- (a) “*What was*” – an inflexion ‘INQUIRE_WHAT_WAS’ for What question;
- (b) “*tactical mode*” – a description of the first concept or class ‘Tactical Mode’ in UCA model;
- (c) “*in*” – a relationship related to a RA activity for chimney fire;
- (d) “*risk assessment activities for chimney fire*” – a description of the second concept or class ‘Chimney Fire Risk Assessment Activity’ in UCA model.

The tactical mode (first concept) and the risk assessment activities for a chimney fire (second concept) are extracted to generate an agent utterance of inquiry. Given the answer [5.2] “*That was offensive mode*”, the next agent utterance of feedback ([5.3]) is issued through a system interruption by the FeedbackDG episode (see Figure 5.6 in Chapter 5, Section 5.4.2) as follows:

FeedbackDG episode regarding the first agent utterance of inquiry:

[5.3] Agent utterance: “*You have chosen OFFENSIVE MODE (default mode). That means you will have established that the potential benefits outweighs the identified risks, so you will be committing crews into a relatively hazardous area, supported by appropriate equipment, procedures and training.*”

[5.4] User utterance: “*Proceed to next question*” [no answer, just skip turn to dialogue agent]

The feedback for the answer “*offensive mode*” is issued to inform the user that in this mode, the crew can be committed into the hazardous area with the appropriate control measures (equipment, procedures, training etc.).

Second agent utterance of inquiry in the ModeAndSystemDG episode:

[5.5] Agent utterance: “*What was system of work in risk assessment activities for chimney fire?*”

[5.6] User utterance: “*That was access to and working on roof.*” [assume the answer does not match all requirement of identifying risk]

The agent utterance of inquiry [5.5] is constructed using an OWL statement by the same means as the agent utterances of inquiry in the InitialActionsDG episode. The agent utterance is derived from the combination of:

- (a) “*What was*” – an inflexion ‘INQUIRE_WHAT_WAS’ for What question;
- (b) “*system of work*” – a description of the first concept or class ‘System of Work’ in UCA model;

- (c) “in” – a relationship related to a RA activity for chimney fire;
- (d) “*risk assessment activities for chimney fire*” – a description of the second concept or class ‘Chimney Fire Risk Assessment Activity’ in UCA model.

The system of work (first concept) and the risk assessment activities for a chimney fire (second concept) are extracted to generate an agent utterance of inquiry. Given the answer [5.6] “*That was access to and working on the roof*”, the next agent utterance of feedback [5.7] is issued through a system interruption by the FeedbackDG episode (see Figure 5.6 in Chapter 5, Section 5.4.2) as follows:

FeedbackDG episode regarding the second agent utterance of inquiry:

[5.7] Agent utterance: “*Warning: The system of work you have chosen, - access to and working on roof -, requires to identify 2 risk assessment activities for hazards. You have identified only 1. However, the generic risk assessment information used by the system will be calculated for the risk assessment results and find out further actions.*”

[5.8] User utterance: “*Proceed to next question*” [no answer, just skip turn to dialogue agent]

The feedback regarding the answer “*access to and working on the roof*” is issued to the user. The feedback only informs the user of the mismatch between the risk assessment activities that are required to be identified for the selected system of work and the risk assessment activities that were identified by the user in the IdentifyRiskAssessmentDG episode. The mismatch does not affect the information about the risk results (risk rating) that were calculated and which are provided in the next episode, the AdditionalControlMeasuresDG episode.

6.4.6. Example 6: AdditionalControlMeasuresDG with ReflectionDG

In the AdditionalControlMeasuresDG episode, no utterances of inquiry are generated. Utterances for providing information and suggestions are issued instead. The information and suggestions given depends on the user answers and calculations made in the preceding episodes. In the example below, we see that if the offensive mode and system of work for access to and working on the roof were chosen in the preceding episode, the information and suggestions are issued regarding four hazards (only the first hazard ‘Falling Masonry hazard’ is shown here) as follows:

[6.1] Agent utterance: “*The ACTIONS could do for OFFENSIVE MODE: use additional control measures to manage the identified risks.*”

[6.2] User utterance: “*Proceed to next question*” [no answer, just skip turn to dialogue agent]

[6.3] Agent utterance: “*HIGH RISK in assessing falling masonry hazard/risk for gaining access to and working on roof activity, the IMMEDIATE ACTIONS are required. Work should*

not be started or continued for this hazard until the risk has been reduced using the hierarchy of control measures. The possible additional control measure actions have to be considered to reduce risk in this hazard. Continue...

[6.4] User utterance: *“Proceed to next question”* [no answer, just skip turn to dialogue agent]

[6.5] Agent utterance: *“List of possible additional control measures for this hazard, (1) cordon off an unsafe area, (2) use work positioning and fall arrest systems, (3) use aerial applications, (4) use safe systems of hazard or risk for gaining access to and working on roof, (5) complete training of hazard or risk for pitch and flat roof, (6) use roof ladders, (7) complete training of hazard or risk for gaining access to and working on roof.”*

[6.6] User utterance: *“Proceed to next question”* [no answer, just skip turn to dialogue agent]

In the example above, the first agent utterance ([6.1]) informs the user that with the selection of the offensive mode, additional control measures can be provided or used to deal with the hazards/risks in the current situation. The second and third agent utterances ([6.3], [6.5]) then suggest the actions the user can take in terms of provision and use of additional control measures when a high risk is found in a risk assessment of the hazard. Due to the result of high risk ([6.3]), after giving suggestions of control measures for the first hazard, the next utterance of a reflective question ([6.7]) is issued through a system interruption by the ReflectionDG episode (see Figure 5.7 in Chapter 5, Section 5.4.2) as follows:

ReflectionDG episode regarding the RA results and advice given:

[6.7] Agent utterance: *“If you had HIGH RISK in this hazard, assessing falling masonry hazard/risk for gaining access to and working on roof activity, what would you do first priority to respond the risk result immediately?”*

[6.8] User utterance: *“[free text entry space]”* [user can enter any text to reflect the actions]

The reflective question aims to initiate reflection on the result of high risk in the risk assessment of this hazard. Since a high risk level means that immediate action is required to reduce the risk for this hazard, the user could have prioritised one action over the others in order to respond immediately to the risk in the current situation. The reflective question is extracted by using the following parameters (see Figure 6.2): type of incident – ‘chimney fire’, Sequential DG episode – ‘AdditionalControlMeasuresDG’, reflective point – ‘inside’, type of inquiry and answer – ‘high risk’. There is just one reflective question for this reflection: [6.7].

6.5. Summary

This chapter presented the PORML prototype which was implemented based on the PORML framework in Chapter 3. The required technical specifications were described along with the architecture of the PORML prototype in terms of the hardware specifications, software specifications, utility tools and libraries needed for PORML implementation. The PORML user interface was addressed and the way the interaction screen was designed and presented on the web browser was illustrated. There are three main pages in the PORML prototype: the user authentication page, the context information page and the dialogue interaction page. The first two pages use JSP while the last page, which is a single dialogue interaction page used for all dialogue interactions, uses a JSF/Ajax-based interactive feature which provides a rich web presentation environment.

Examples of interactions in the PORML prototype were presented to show that the prototype is designed and developed to provide the answers to the problems posed by the research questions. The examples illustrated the series of Sequential DG episodes which play the major part in the dialogue interactions and described the rationale and characteristics of the dialogue interactions in each Sequential DG episode as well as the interruptions made by the System Interruption DG episodes i.e. FeedbackDG episode and ReflectionDG episode.

Chapter 7

PORML Evaluation

7.1. Introduction

The previous chapter presented the design of the PORML prototype explaining the hardware, software and tools used. A scenario based design was employed to implement the PORML prototype and the user of dialogue interaction was illustrated with examples on mobile and laptop user interface. This chapter will present an evaluation of the PORML prototype. The evaluation aims to verify the functionality of the PORML framework in terms of reviewing user activity and providing the means for reflective learning in risk assessment. In the evaluation process, the prototype is first tested in a pilot study. The resulting data is gathered and analysed, and based on this, the prototype is improved. Then, an experimental study is conducted to collect data using the prototype that implements the PORML framework. This study comprises two phases: formative evaluation and summative evaluation. The collected data is examined and analysed using computer tools to assess the usefulness and usability of the prototype. The formative evaluation gathers users' feedback in order to improve the prototype and ensure it is suitable for firefighter users. The summative evaluation is conducted with firefighters, focusing on the usefulness and usability of the PORML prototype.

The chapter is structured into the following sections: Section 7.2 presents the relevant evaluation approaches and methods to justify the selected evaluation method. The formative evaluation will be presented in Section 7.3. Then, the experimental study for summative evaluation will be presented in Section 7.4, and the results of the summative evaluation will be discussed in Section 7.5. Finally, Section 7.6 provides a summary of the chapter.

7.2. Overview of Relevant Evaluation Approaches and Methods

In general, there are three main approaches used for evaluating computer systems: (1) usability testing; (2) field studies; and (3) analytical evaluation (Sharp, Rogers et al. 2007). Usability testing is done by measuring users' performance on tasks. In this case, the testing environment and format of testing can be controlled by the evaluator. In contrast, field studies are done in a natural setting with the aim of understanding what people do naturally with the computer system (Bly 1997;

Fjermestad and Hiltz 2000). However, establishing realistic studies which capture key situations in the use context is usually challenging, with complicated data collection and limited control (Nielsen 1998; Brewster 2002; Kjeldskov and Stage 2004). Analytical evaluation is an approach to evaluation where end users are not directly involved. Instead, experts in the area are asked to provide feedback. There are two categories of evaluation methods for analytical evaluation (Sharp, Rogers et al. 2007): (1) inspection – heuristic evaluation (Nielsen and Molich 1990) and cognitive walkthrough evaluation (Lewis, Polson et al. 1990); (2) theoretically based models. The heuristic evaluation and cognitive walkthrough methods are also widely used in the usability testing approach, including for mobile learning.

In the heuristic evaluation method, the expert applies some knowledge or principles of usability on a certain program and environment developed in telematics, while the cognitive walkthrough involves simulating user tasks step by step (Magal-Royo, Peris-Fajarnes et al. 2007). Karoulis (Karoulis and Pombortsis 2003) points out that the application and employment of usability testing evaluation methods of any mobile or telematic interactive tool is essential in order to validate it against potential users. The theoretically based models, also called predictive models, are used primarily for comparing the efficacy of different interfaces for the same application using formulas to derive various measures of user performance (Sharp, Rogers et al. 2007).

The field-based approach is not convenient for evaluation in our case, as it requires engaging firefighters on the field which brings emergency and safety concerns. Users have to concentrate on extinguishing fire or rescuing people rather than attending to the evaluation. As for the analytical evaluation approach, the cognitive walkthrough is too slow. The theoretically based models are appropriate for comparative analyses of different interfaces, prototypes or relative specifications (Sharp, Rogers et al. 2007) and are used for user performance prediction. The usability testing approach appears suitable, as the testing environment and the format can be controlled by the evaluator. An appropriate combination of heuristic evaluation and user testing will be considered in our evaluation. This can be based on a set of criteria adapted to the PORML prototype and tested with potential users.

Intelligent tutoring systems (ITSs) are often validated in empirical studies with a system prototype (Akhras and Self 2000; Boulay and Luckin 2001). The ITS evaluation usually combines formative evaluation and summative evaluation (Mark and Greer 1993; Ainsworth 2005). Formative evaluation is conducted development of the program. It provides information for the required prototype modification (Robson 1993), and checks that the product meets users' needs (Sharp, Rogers et al. 2007). In summative evaluation, the effectiveness of the system is determined in real

environments (Mark and Greer 1993). In line with ITS evaluation methods, both formative and summative evaluation will be used in this PhD. The formative evaluation will employ both the heuristic evaluation method and user testing to obtain feedback from users who are in the fields of computer science and business in order to improve technical aspects as well as the user interface. In the summative evaluation, an experimental study with end users (firefighters) will be conducted following user testing in a controlled environment in order to validate the PORML framework and its usefulness in fire and rescue services.

Usability testing can be conducted in laboratories (Jones, Buchanan et al. 2002; Mizobuchi, Mori et al. 2002) or in real scenarios (Duh, Tan et al. 2006). Barnard (Barnard, Yi et al. 2005; Barnard, Yi et al. 2007) and Varsaluoma (Varsaluoma 2009) used scenario-based approaches to evaluate mobile applications. Barnard compared the use of sitting and controlled walking scenarios on a treadmill. The mobile device was evaluated by varying contextual conditions and recording resulting changes in behavior. The objective was to measure the effect on task performance. In our case, the sitting condition scenario is taken into account to test with firefighters rather than the walking scenario because the varying contextual conditions of use are not considered. Only contextual conditions of fire incident are involved in evaluation setting.

Varsaluoma reworked the existing heuristics and used of written use scenarios to create more awareness of mobile context. The context of use of mobile devices was examined with written scenarios in order to improve the reliability of heuristic evaluation. In our case, for the same reason as the above in Barnard (Barnard, Yi et al. 2007) the context of use of mobile devices is not considered and used to improve the reliability of the heuristic method. The user test with a written fictitious scenario is taken into account using the context of incident environment setting to evaluate the mobile and laptop prototype. The written fictitious scenario illustrated in Appendix D (D3) is adapted from real incidents recorded in an online document of Cambridgeshire Fire and Rescue Services⁴⁸. In usability testing, elaborate usability tests are a waste of resources and the best results come from testing no more than 5 users (Nielsen and Landauer 1993; Lewis 1994; Nielsen 2000). So, the small sample (e.g. 4 – 7) used in our experimental study can be well sufficient for establishing the usability problem.

A summary of the experimental study timescale is shown in Figure 7.1.

⁴⁸ <http://www.cambsfire.gov.uk/incidents.php>

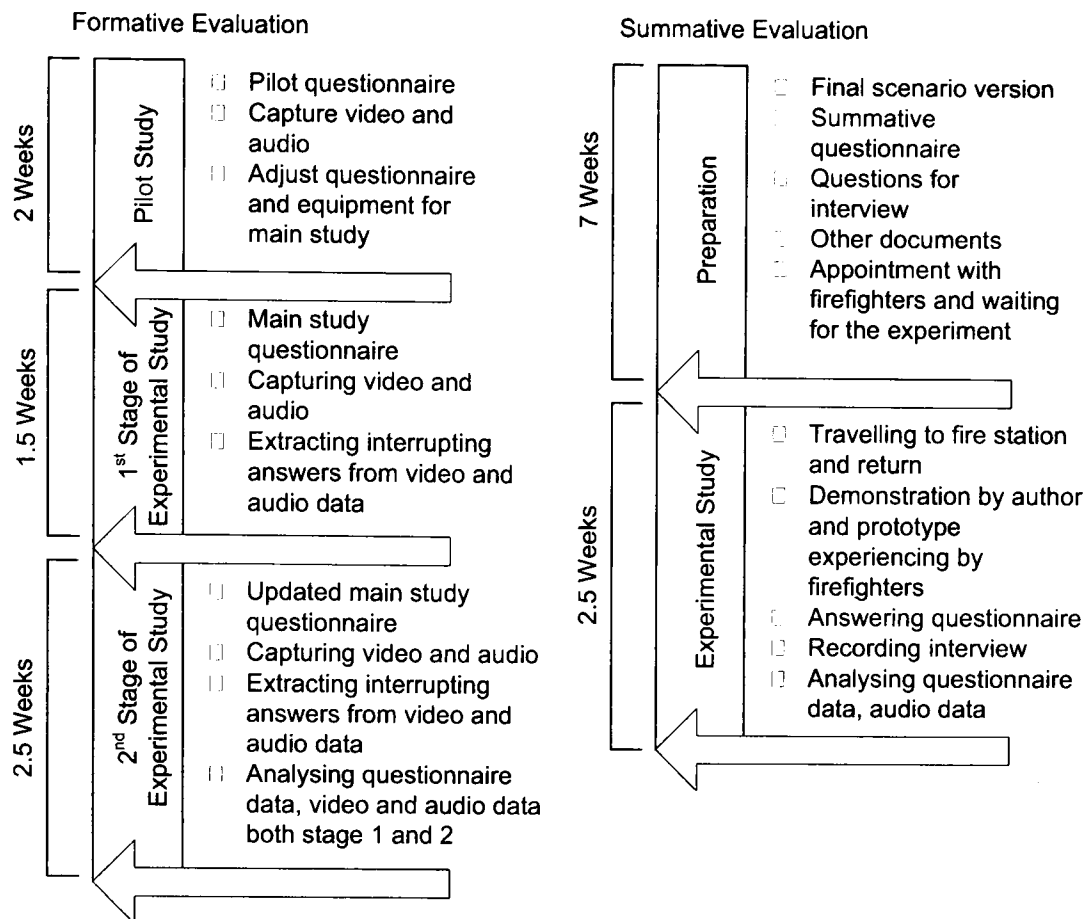


Figure 7.1 Experimental study timeline

7.3. Formative Evaluation

7.3.1. Aim and objective

The aim of the formative evaluation is to improve the PORML prototype and ensure its robustness. The data gathered and techniques used depend on the target of improvement of program components. The formative evaluation of PORML is concerned with indicating problems with the following system components:

- **The user interface:** *is the communication medium adequate for examining the review of risk assessment activity? In particular, can the dialogue agent provide the expressive power to utter the communicative act? Do the users have any problem with understanding what the agent conveys to them? Are users satisfied with the presentation (form template, functions of buttons, position of contents, the dialogue presentation layout e.g. text colour, background colour, text size, font style, or others)? Do users find the features of input selection provided by the dialogue agent sufficient for helping him/her answer the dialogue questions? Is the dialogue presentation suitable and convenient for usage on small screens in smart phone browsers and bigger screens in netbook or notebook browsers? Is the aim of the interaction clearly presented?*

- **The dialogue planning:** *are users satisfied with the way the system maintains dialogue? Are the reflective questions appropriate? Is the flow of dialogue suitable for reviewing the fire risk assessment activity? In particular, is the presented dialogue coherent for focusing on selected fire type at the specified incident place? Can the user understand and follow the dialogue easily? Is the sequence of dialogue moves suitable for reviewing the fire risk assessment activity?*

- **Overall impression:** *users' general comments about using the PORML prototype. In particular, are there any changes the users would like to see in the dialogue? How do users rate the overall quality of the dialogue? Do users find any knowledge that they were not aware of before the session and discovered during the session?*

7.3.2. Pilot study

A pilot study is conducted to make sure that the proposed evaluation method is viable before embarking on a real study (Sharp, Rogers et al. 2007). It is a small trial run of the main study to test data gathering techniques. The PORML pilot study was divided into two parts: the first part was to test the collecting of contextual information and the second part was to test the dialogue episodes. In the first part, two PhD students from the School of Computing, and one student from the School of Earth and Environment were involved. In the second part, three PhD students from the School of Computing were involved. The data gathering techniques, as well as the equipment, scenario and participant instructions were checked. The equipment used in the pilot study were video capture software for capturing the PORML screen during dialogue interactions, a laptop computer and a smart phone.

In the pilot study, participants were requested by the author to use the think aloud technique, with interrupting questions during their dialogue interactions with the prototype. The participants' feedback regarding their experiences was recorded and considered in order to check that the experimental procedure could be confirmed as viable and so that the questions for a questionnaire could be tested for clarity. Following the pilot study, certain questions in the questionnaire were adjusted in terms of language and the scenario was improved in terms of language and details of activity. Instead of using only video capture software, a video and/or audio recorder was also to be added in the formative evaluation for recording quality purposes.

7.3.3. Experimental study to improve the prototype

Participants

At the first stage, the evaluation focused on a computer science point of view for revision and improvement of the prototype, and involved three Computer Science

PhD students (participants F1, F2, F3). They were given information about the goal of the PORML project, general description of Fire and Rescue Services (FRS), and a risk assessment scenario.

At the second stage, the evaluation focused on a social science point of view for revision and improvement of the prototype after certain technical deficiencies in the first stage had been solved. Three PhD students and one Lecturer from Leeds University Business School were involved (participants F4, F5, F6, F7). The participants were provided with the same information as in the first stage. Participant profiles are given in Table 7.1.

Table 7.1 Profiles of participants in the PORML formative evaluation

Participant	Knowledge of Dialogue-Based Interaction 1 – Very good 2 – Good 3 – Fairly good 4 – Modest 5 – Limited 6 – Extremely limited 7 – No knowledge at all	Knowledge about Reflective Learning 1 – Very good 2 – Good 3 – Fairly good 4 – Modest 5 – Limited 6 – Extremely limited 7 – No knowledge at all	Knowledge about Fire Risk Assessment 1 – Very good 2 – Good 3 – Fairly good 4 – Modest 5 – Limited 6 – Extremely limited 7 – No knowledge at all
F1	6 – Extremely limited	6 – Extremely limited	6 – Extremely limited
F2	2 – Good	7 – No knowledge at all	6 – Extremely limited
F3	2 – Good	5 – Limited	6 – Extremely limited
F4	6 – Extremely limited	6 – Extremely limited	3 – Fairly good
F5	5 – Limited	2 – Good	5 – Limited
F6	6 – Extremely limited	3 – Fairly good	5 – Limited
F7	2 – Good	3 – Fairly good	4 – Modest

Procedure and materials

Participants attended individual sessions. Before each session started, the author prepared a laptop computer with PORML running, opened the browser with probing to the URL of the PORML prototype, prepared video capture and the voice recorder, and then followed the steps for the session shown in Table 7.2:

Table 7.2 Steps for the session of experimental study

Steps	Descriptions
1	The author introduced the research project to participant, and then participant read scenario adapted from records of a real chimney fire incident. It took about 5 minutes;
2	The participant answered the preliminary questionnaire about his profile in general and in knowledge related to the concept of prototype. It took about 1-2 minutes;
3	The participant started the dialogue interaction session while the author started recorder. During the session, participant would interact with the prototype using think aloud protocol and he could ask the author if he did not understand anything about the prototype. The author might interrupt the session to ask some questions or interview the participant. The dialogue interaction log file was recorded automatically by PORML prototype in laptop storage. It took 40-50 minutes;
4	The participant answered the questionnaire including open and closed style questions to get feedback about features and performance of prototype, and user's comment. He could use his log file to help him remember what he did during interaction for answering or use printed sample log file.

The necessary materials in the formative evaluation were prepared for participants to read before the prototype was started in order to help them understand what they would be interacting with. The materials consisted of a scenario sheet, a preliminary questionnaire on participants' general profiles and knowledge levels on the concept of the prototype, the main questionnaire, and a printed sample log file (see Appendix C – not include printed sample log file).

Data collection and analysis

Quantitative and qualitative data were collected from the questionnaire answers and video recordings. A summary of the collected data is presented in the Table 7.3.

Table 7.3 Summary of collected data

Preliminary Questionnaire	Participants were asked about their general profile and knowledge before the dialogue interaction session commenced.
Questionnaire (main)	Participants were asked about using the prototype, e.g. user interface features, dialogue features, performance etc. after dialogue interaction session was completed. In addition to quantitative data, comments were collected in the form of qualitative data. The latter were combined with video and audio records in order to identify problems with the prototype.
Video and Audio Records	While participants interacted with the PORML prototype, video capture program and audio recorder captured the video screen, think aloud comments, and interrupting questions.

The aim of data analysis was to identify any flaws of the prototype design. The data from the preliminary questionnaire was used to support the findings from other sources. The general profile of participants was divided into two groups: the computer science group and the social science group. Three kinds of knowledge levels of participants that related to the project were considered. Both general profile and prior knowledge helped to supplement the reasons for the problem findings of other sources. Quantitative data from the main questionnaire was analysed by grouping the problems into 3 main categories: user interface, dialogue planning, and overall impression.

The audio data that contained think aloud comments and interrupting questions was used as the main data to analyse the problems whilst the video data was used only to clarify certain problems that had to be checked on a video screen e.g. font size, screen layout etc. The comments in the main questionnaire were combined with the video and audio data to address the problems. These problems were analysed and classified into 3 main categories corresponding to the main questionnaire.

Each group from the main questionnaire and the video and audio data were combined and classified into subcategories that addressed the key problems and how to improve them.

Findings regarding the user interface

Interface to utter the communicative acts: Participants assessed the use of the prototype in terms of communication medium on the basis of their observations. Most participants could construct their utterances conveniently, and could follow the

interface provided for this. However, participants F1 and F4 felt that the prototype was not convenient in providing the words or phrases to be utilised as part of constructing a user utterance immediately after issuing an agent utterance (3-were positive, 2-were neutral, 2-were negative). Since the prototype generated limited options that restricted answers within the scope of knowledge in the RA domain ontology, it was not possible to fully satisfy every user; especially when it had to be used on a mobile with limited options corresponding to a particular user point of view. Besides the limited options, it might also depend on other aspects such as poor grammar usage in both agent and user utterances etc.

Improvement actions: By using limited options, the user is guided to construct user utterances and respond quickly to the dialogue agent, especially for input on mobiles. The options would also maintain answers within the scope of knowledge in the RA domain ontology. Therefore, no action was needed to change the method of constructing the user utterance. The following actions were undertaken to reduce the constraints when producing user utterances:

1. Reduce the steps in user utterance construction as shown in the figures below

- Remove input command button ‘ACCEPT’ and input command button ‘SEND’ as shown in Figure 7.2 and combine the functions of ‘ACCEPT’ and ‘SEND’;

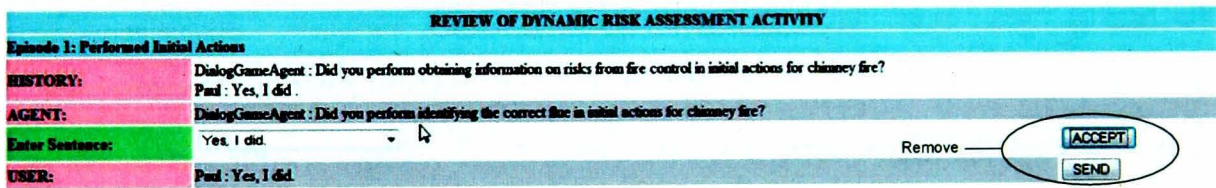


Figure 7.2 Interface to utter communication act: before correction

- The combination of these functions will be expressed as a single input command button ‘NEXT UTTERANCE’ instead, as shown in Figure 7.3. As a result of this change, the response of the user will be obtained faster, thus improving the performance of the prototype;

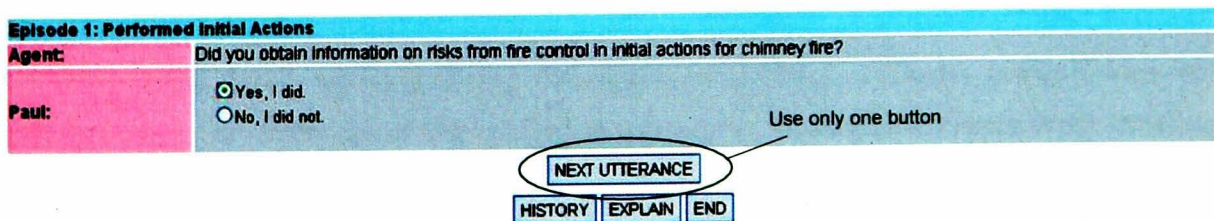


Figure 7.3 Interface to utter communication act: after correction (only specify)

2. Refine language of components of utterances and comments of concepts in the RA domain ontology.

Understanding what the system conveys: Participants F1 and F5 had problems understanding what the system conveyed to them (4-did not have any problem, 1-was neutral, 2-were negative). They sometimes did not understand certain statements of agent utterances (e.g. “*SKIP TURN TO AGENT*”, “*From your decision, who might be harmed on ...*”) created by the dialogue agent. The constructed agent utterances might have been unclear because the dialogue agent did not issue the question efficiently. Normally, the agent utterance is derived from a combination of its components i.e. originator, inflexion, subject, predicate and object. The subject and object were extracted from the RA domain ontology whilst the originator, inflexion and predicate were determined by the dialogue agent rules embedded in the program code.

Improvement actions: To reduce confusing dialogue and language problems which arose from the components of the constructed agent utterance, the following actions were carried out:

1. Check phrases, sentences and explanations in the issued utterance. Some general explanations in parts of the user interface, and annotations in RA domain ontology have to be improved.
 - The phrase “*Paul: SKIP TURN TO AGENT*” (*Paul* is an originator, *SKIP TURN TO AGENT* is an inflexion) is to be changed to “*Proceed to next question*” because users do not understand what “*skip turn*” is and what they have to do next;
 - The clause “*Agent: From your decision, who might be harmed on ...*” (*Agent:* is an originator, *From your decision, who might be harmed on* is an inflexion) is to be changed to “*What did you decide regarding who might be harmed on ...*” etc.

Figure 7.4 summarises participants’ opinions regarding the user interface. All participants understood the information in the form template provided. In general, the information was mainly interfaced to users containing the agent utterance, user utterance input field (part of utterance + choice of words or phrase) or user reflective free text input field, input button, and dialogue history. Mostly, participants were satisfied with the features of the dialogue. However, four participants were confused about the functions of some buttons i.e. ‘ACCEPT’ button and ‘SEND’ button. Three participants were not satisfied with the position of content on the form template. Two participants were not satisfied with the length of overall dialogue. They expressed that it took too long overall (about 45 - 60 minutes per session) during the experiment. And one participant could not comprehend the purpose of the dialogue questions presented to him/her.

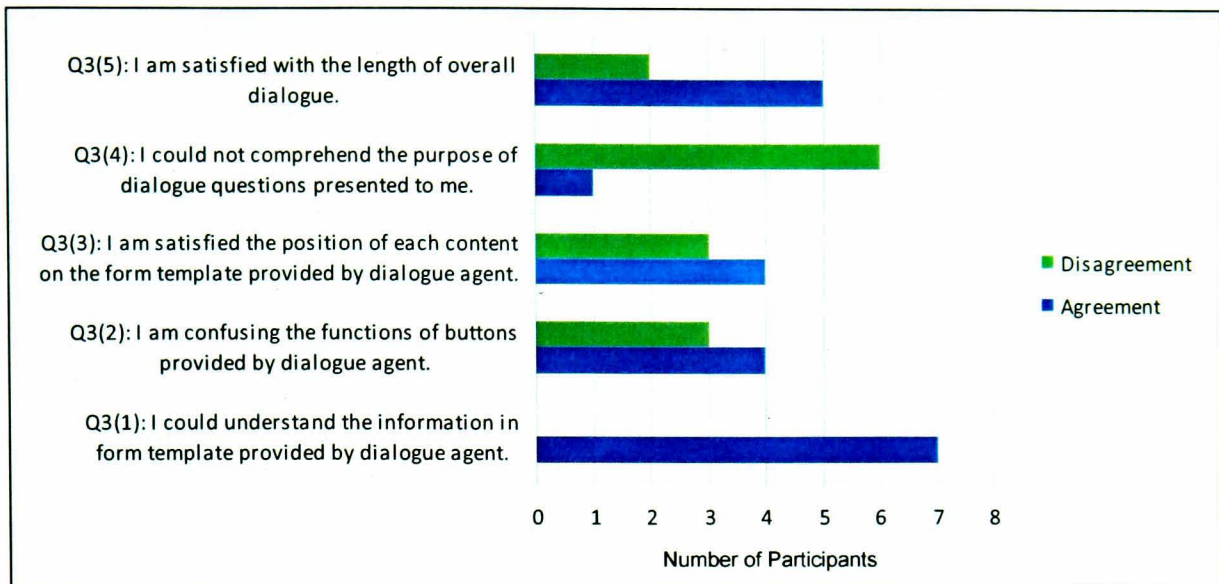


Figure 7.4 The agreement/disagreement with characteristics of the dialogue

Dialogue presentation layout: e.g. text colour, background colour, text size, font style, etc. In general, most participants thought that the presentation layout was acceptable. Only one participant felt negatively (4 were positive, 2 were neutral, 1 was negative). It was possible that the text size was too small, certain information was too detailed or was not necessary to be issued to user e.g. dialogue history, constant text title etc.

Improvement actions:

1. Change the layout e.g. reduce or merge row and column (history lines);
2. Remove unnecessary title block (row) 'Review Dynamic Risk Assessment Activity';
3. Add 'History' input command button to view the last 4 lines of utterances history using a popup window when user requests it instead of fixing this information onto rows of main screen. Figure 7.5 and 7.6 show the dialogue presentation layout before and after correction.

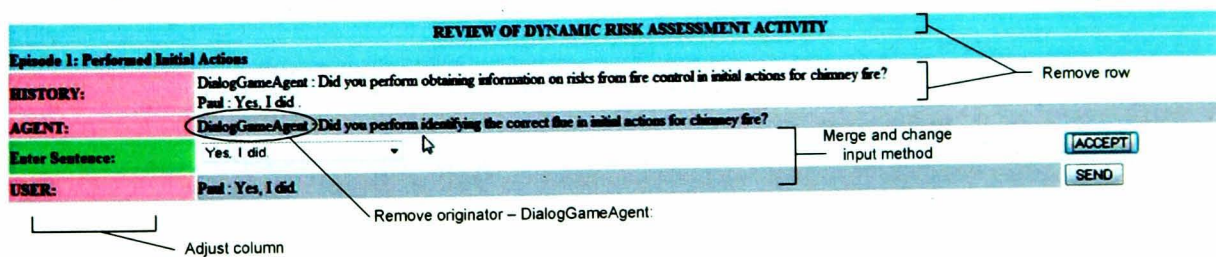


Figure 7.5 Dialogue presentation layout: before correction

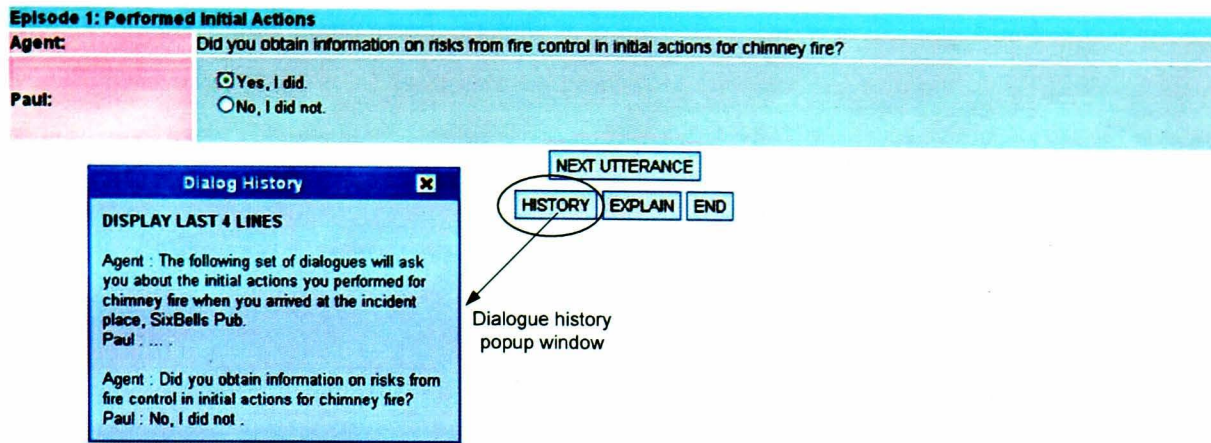


Figure 7.6 Dialogue presentation layout: after correction

Features of input selection: Most participants were satisfied with the features of input selection in which the dialogue agent guided the answer choice to help the user answer the questions. Only one participant felt disappointed (4 were satisfied, 2 were neutral, 1 was negative). Participants thought that the features of input selection were very helpful. However, although it could provide the relevant choices to guide the pertinent answer, some choices were not appropriate for input selection e.g. “End Dialog”, “Could you explain”. These choices tended to be a problem in the input method. After participants chose these choices, they expressed in the comments and video records that these choices did not make sense in the input selection. These choices should be separated from the input selection.

Improvement actions:

1. Improve input selection method

- Change some input combo boxes to an input radio box e.g. “Yes/No” answer etc. in order to simplify use and allow faster interaction, especially when it is displayed on mobiles and prototype provides default selection;
- Remove misused input (command text) i.e. “Could you explain ...” and “End Dialog” in input combobox as shown in Figure 7.7 because it makes user confused between actual input (e.g. “Yes”, “No”) and command text in the lists;

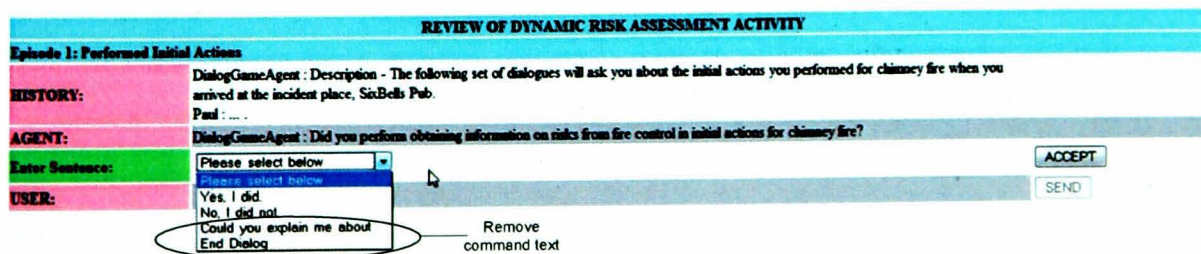


Figure 7.7 Input selection method: before correction

- Use input command button 'EXPLAIN' instead of command text "Could you explain ..." to explain concepts in the agent utterance, calling up a popup window to explain concepts; and use input command button 'END' to end dialogue instead of command text "End Dialog" to end dialogue, calling up a popup window to confirm end dialogue as shown in Figure 7.8.

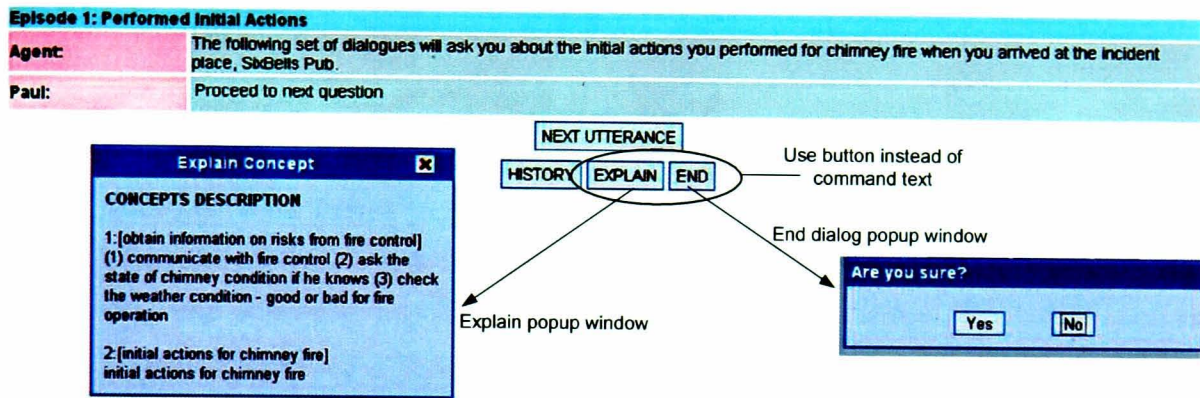


Figure 7.8 Input selection method: after correction

- The free text input method for reflective answer entry is not changed in this prototype but it might be possible to change this in future development e.g. using text input with voice activated system.

2. Shorten details of input

- Remove repeated text e.g. in the input combo box choice, there are 5 options with the same text "in assessing blow back for applying extinguishing media activity" in part of each option;
- Put numbers in front of the list of actions in feedback explanation e.g. "Which one or more of, (1) obtain information from fire control, (4) ..., (7) ...?". This will help users to answer quickly by entering only the necessary number in the reflective free text answer box to reduce untidy free text input;
- Separate each dialogue explanation into multiple small sentences.

Frustration with dialogue presentation on screen: In the case of a laptop, only one participant was frustrated with the presentation on screen (5 were positive, 1 was neutral, 1 was frustrated). However, in the case of a smart-phone (iPhone3G), it was the opposite. Most participants were frustrated with the presentation on screen, with only one participant not frustrated (1 was positive, 1 was neutral, 5 were frustrated). Because the prototype was a dialogue text-based presentation and it provided rich text, most participants found that there were too many details presented on the screen. Particularly, the text font was too small and text was too dense and thus not easy to follow on a smart-phone screen.

Improvement actions:

1. Adjust the font size of text – the font size of input and output text when displaying on a laptop is not changed. There is no problem in this case because it uses a default font size on a standard style sheet. The problem occurs only on a smart-phone (iPhone3G). Therefore, the author is to add a program code to detect the machine platform automatically via the browser to change font size on the style sheet if the machine is an iPhone3G. When a user views the prototype on an iPhone3G browser, the font size will be enlarged automatically to a size that can be read more easily. The input text and text on input command buttons will also be changed to a bigger size so that the user can key in input more easily via the iPhone3G touch screen. Figure 7.9 shows a sample screen output on iPhone3G after the font size is enlarged.

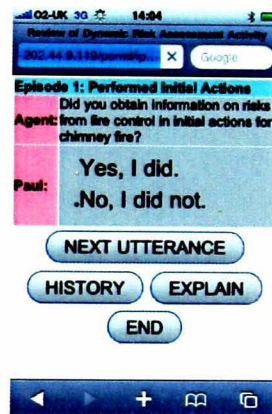


Figure 7.9 A sample screen output on iPhone3G after font size is enlarged

Understanding the aim of the interaction: Participants were asked about the aim of the interaction with PORML. A summary of the answers is presented in Figure 7.10. Only one participant chose the answer “*Others*” along with his suggestion that the question should be open to allow the user to enter the best answer into the system. He thought that the prototype was a review about a recent incident. In fact, his answer was very close to “*This was a basic review about the recent user activity*”. It should be noted that he has no knowledge (rate = 7) about reflective learning and extremely limited knowledge (rate = 6) about fire risk assessment. Thus, it might be possible that he was unclear about the purpose of reviewing user activity. Figure 7.10 affirms that all the different aims of the interaction could be supported by the PORML dialogue agent.

Improvement actions: No action was required to improve the aim of the interaction. The improvement actions that were carried out to address the other issues were able to result in an overall improvement, including regarding the aim of interaction.

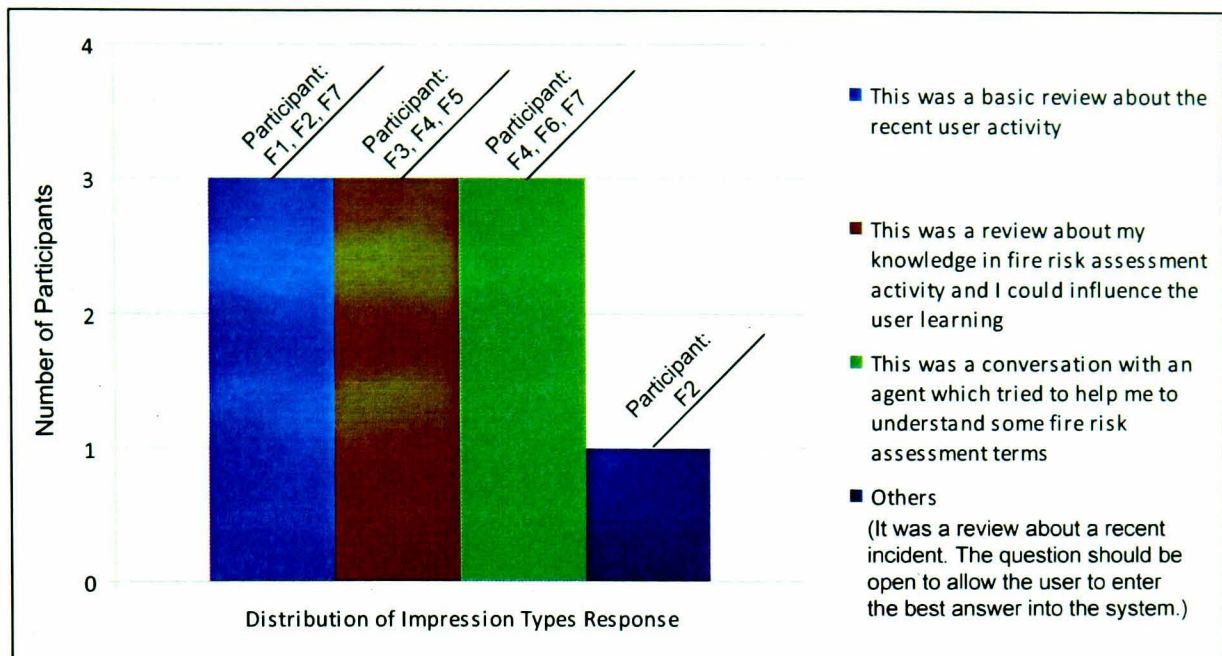


Figure 7.10 A summary of understanding the aim of the interaction with PORML

Findings regarding the dialogue planning

Dialogue planning mechanism: Most participants agreed with the planning mechanism of dialogue turns (5 were positive, 2 were neutral). The dialogue planning depended on the mechanism assigned in the particular type of dialogue episode, the user’s answer, and sometimes the order of the episode. All participants agreed with the concept of reflective questions and when the reflective episodes were positioned. The ReflectionDG episode would be active for intervention at the end of the InitialActionsDG episode and the end of InitialControlMeasuresDG episode. For the other episodes, it would not be the same. Normally, the ReflectionDG would be active to intervene these episodes depending on the chosen action in a particular episode. However, one participant suggested in his comments that the reflective questions should be used to intervene a main episode appropriately due to a significant number of questions in the main episode (e.g. InitialActionsDG episode).

Improvement actions:

1. Adjust the intervention of reflective questions in each episode to reduce dissatisfaction with the interaction e.g. intervene at the middle and the end of InitialActionsDG episode etc.;
2. Improve the reflective questions to be more specific to reflect the user actions, for instance, “Which one or more of, (1) obtain information on risks from fire control, (3) check the roof void for fire spread, (6) ..., you performed you took a lot of effort to deal with?” etc.

Free text answering in reflective questions: The purpose of using free text answering was to enable the user to freely enter any text to reflect on the specified previous action or group of previous actions using the keyboard on a laptop or the keypad on a smart-phone. Most participants expressed that the reflective free text answering was beneficial and allowed flexibility when writing the reflective answer in response to the reflective question (5 answered yes, 1 left blank) but it was inconvenient to enter text on the smart-phone because of the screen size and input method for mobiles which was not simple.

Improvement actions: Given that the screen size on a smart-phone cannot be changed, the font size of all text appearing on the mobile screen is enlarged to an appropriate font size for touch screen instead, as addressed earlier in the user interface. As a result, the text on the mobile screen can be easily activated and entered by touch screen and the mobile input for reflective questions becomes simpler.

Dialogue coherence: Before starting a dialogue interaction session, the prototype preset the contextual information or context parameters according to a designed scenario. This was the contextual information about, for instance, the type of incident i.e. incident 'Chimney Fire', and the name and type of incident place i.e. name 'SixBells Pub' and type 'Public House'. In a dialogue interaction session, there were a series of main episodes which played in sequence starting from the InitialActionsDG episode and ending with the AdditionalControlMeasureDG episode. The utterances were generated in each main episode. The dialogue agent used the type of incident as a main key to generate the group of agent utterances related to the concepts about chimney fire in the RA domain ontology. Most participants agreed that the dialogue was coherent (5-coherent, 1-not coherent).

Improvement actions: No action was taken to change utterance construction in the level of structure of dialogue. Only one participant expressed that the dialogue was not coherent and commented that this might be due to improper use of language. The improvement action about language has been addressed earlier.

Suitability of the sequence of dialogue turns for reviewing the FRA activity: All participants agreed that they could understand and follow the dialogue to capture the user risk assessment and that they could understand the sequence of dialogue turns to review the fire risk assessment activity. Nevertheless, this did not mean they completely understood the dialogue to capture the risk assessment and absolutely understood whether the sequence of dialogue turns was suitable for reviewing the FRA activity at the level of FRS experts or firefighters, because they mostly had very limited knowledge in the field of FRS (3-extremely limited knowledge, 2-limited

knowledge, 1-modest knowledge, 1-fairly good knowledge). This should be further checked in the summative evaluation with end users (firefighters).

Improvement actions: There were no actions required at this stage. However, it was noted that the usability of the prototype should be checked with end users (firefighters) who have knowledge in risk assessment.

Findings regarding the overall impression

Overall quality of the dialogue: Most participants weighed the overall quality of the PORML prototype positively (5-positive, 1-negative) but were not very positive, with an average rating point of about 2-3 on a 7-point rating scale where a rating point of 4 is neutral. Participants had comments (in both the questionnaire and video recording) about the flaws of the prototype and suggestions regarding the correction of the prototype that have been addressed earlier. Mostly, participants suggested improving the technical computer aspects e.g. user interface and general use of English language.

Improvement actions: The indicator of overall quality of dialogue showed that most participants were satisfied with the dialogue in general. However, the prototype had a significant amount of flaws regarding user interface and use of English language that have been addressed above.

7.4. Summative Evaluation

The summative evaluation phase focused on the impact of using the prototype for crew members or firefighters in FRS as part of their training and practice. It is important to note that the prototype used in this evaluation is different from the prototype used in the formative evaluation.

7.4.1. Aim and objective

The aim of the experimental study of the summative evaluation is to assess the success of the finished product (Sharp, Rogers et al. 2007) or the robust prototype. Because it is an evaluation of an intelligent tutoring system, it also focuses on the educational impact (Mark and Greer 1993) of the existing training in FRS including the usability and applicability of the overall approach. The PORML prototype, with a preset learning environment using context parameters, is evaluated with real firefighters.

The main aim of the experimental study is to test whether the concept of dialogue interactions using PORML prototype can be used and applied to the FRS training system. The following objectives are addressed:

- **The usability of the PORML prototype:** *can users follow the dialogue with the agent? Are users confused about the statements made by the dialogue agent? Do users find the reflection questions helpful? Can users comprehend the purpose of dialogue questions presented to them? Is the dialogue frustrating? Can the review help users learn about risk assessment? Will users use the system if it is available, recommend it to colleagues, never use this system? What do users see as the strongest/weakest points of the PORML prototype, and are they surprised by anything?*

- **The applicability of the PORML prototype:** *will the PORML prototype be suitable for training in risk assessment? How can PORML be used for training? What else may be needed to make this program useful for training? Can PORML be used in FRS practice, and what difference can this make?*

The issues above are indirectly related to the PORML objectives stated in Chapter 1. The usability and applicability are used to validate the concept of PORML and the design of the PORML framework.

7.4.2. Experimental design

The experimental study was conducted to assess the PORML prototype with real firefighters at Avon Fire and Rescue Services, Bristol, UK. This involved a demonstration of the program and feedback based on the key objectives outlined above.

Participants

The study involved 6 firefighters in different roles. The participant profiles are given in Table 7.4. All participants were members of the operational activity shift in Avon FRS. The night shift, during which the author performed the experimental study, contained more than 20 firefighters, out of which 14 firefighters were available for incident call. The 6 participants who evaluated PORML volunteered to do this during their “slow time” (i.e. They were not dealing with fire incidents then). Three participants (S1, S2 and S6) held more than one role depending on the size of the incident and other factors such as the frequency of incidents, the number of available firefighters for a shift etc. However, for this study, only their main role or highest rank held in their work in operational activity will be stated in future references to them (for instance, one participant held the role of watch manager as well as crew manager. Therefore only his main role will be stated i.e. watch manager).

Table 7.4 Participant profiles in summative evaluation

	S1	S2	S3	S4	S5	S6
Experiences in FRS	17	12	21	6	7	9
Fire incidents involved	All fires	All fires	Many	House fire, chimney fire, warehouse fire, car fire	Fire affecting gas cylinders, bin fire, car fire, house fire, skip fire, RTC (car crash), rope rescue, person in water, chemical incidents, removing objects (rings/locks) from people	Almost every type of fire
Role in FRS	Firefighter, Crew manager, watch manager	Crew member, crew manager	Crew member	Crew member	Crew member, officer in charge of (small) special appliance	Firefighter, crew manager, urban search and rescue
Level of experience in chimney fire	Some experiences	Good experience (4-5 times)	Good experience	Some experience	Some experience	Extensive experience
Role in dealing with chimney fire	Firefighter, crew manager	Crew member, crew manager	Crew member	Crew member	Crew member	Firefighter
Experiences computer programs for training	Yes, MINERVA	Yes, equality training	Yes	No	No	Yes
Experiences with iPhone3G	Used but not on regular basis	Never used	Never used	Own and use on regular basis	Never used	Own and use on regular basis
Experiences with touch screen on mobile device	Have a touch screen mobile device and use on regular basis	Have a touch screen mobile device and use on regular basis	Have a touch screen mobile device and use on regular basis	Have a touch screen mobile device and use on regular basis	Never used	Have a touch screen mobile device and use on regular basis

The participant who had the longest experience working with FRS had been a crew member for 21 years; while the shortest experience as a crew member was 6 years. The participant who had the highest rank of watch manager had experience working with FRS for 17 years. Two participants stated that they had been involved in all fires and the others had been involved in most fires. Notably, all participants had experiences in chimney fire, and half of them had good or extensive experience in dealing with chimney fire. The main roles of participants in this experimental study included one watch manager (S1), two crew managers or crew commanders (S2, S6), and three crew members (S3, S4, S5). However, the main roles of participants who had dealt with chimney fire were two crew managers (S1, S2), and four crew members (S3, S4, S5, S6).

Four participants (S1, S2, S3, S6) had experience using computer programs for training, for instance, MINERVA or equality training. Three participants (S1, S4, S6) had used an iPhone3G, and two of them (S4, S6) owned smart-phones, and were

using them on a regular basis. Additionally, five participants had touch screen mobile phones which they used on a regular basis. Only one participant (S5) had never used an iPhone3G or any touch screen mobile device.

One of the benefits of the different roles held by the participants in the studied individual sessions was the varied feedback according to their different points of view which corresponded to their roles.

Procedure

The procedure of the summative evaluation provided the steps in the prototype demonstration so as to use for participants evaluation illustrated in Figure 7.11.

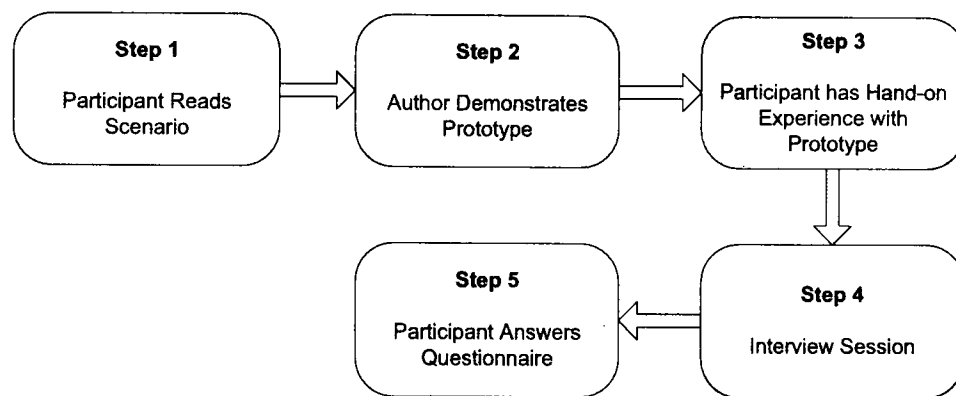


Figure 7.11 The Procedure of PORML summative evaluation.

The prototype demonstration was conducted by the author (interviewer) and it included the steps shown in Table 7.5:

Table 7.5 Details of the procedure of PORML summative evaluation

Steps	Descriptions
1	Each participant read the details in the information sheet and model participant consent form. If the participant agreed to take part in the research project, the participant and the author had to sign the consent form. After agreeing and signing the consent form, the participant read the fictitious scenario adapted from records of a real chimney fire incident. It took approximately 2-5 minutes;
2	The prototype demonstration of the PORML dialogue interactions was commenced and guided by author. The demonstration was arranged on both a laptop and a smartphone (Apple iPhone3G). On smartphone the author used mobile browser, enter the URL which was the location of the remote PORML server (system) outside the fire station, and interact with the PORML server via a 3G network service. The author commenced the demonstration on the smartphone with a few dialogue interactions until reached the first reflective question which took about 3-5 minutes. On the laptop the author could use any general browser e.g. FireFox3, IE8 etc., enter the local URL which was location of this laptop installed PORML server, thus normally the interaction response on laptop was faster than on smartphone. The author also commenced the demonstration on the laptop with a few dialogue interactions taking about 2 minutes, and then the demonstrations on both the smartphone and the laptop were continued by the participant in the next step;
3	The participant handed on experience with the program using the smartphone continuing from the author for a few further dialogue interactions taking about 3 minutes. And the participant also continued the dialogue interactions using the laptop continuing from the author until it was completed, and the dialogue interactions log file was recorded automatically by the PORML prototype in the laptop storage. The participant might ask any questions if he did not understand or did not clear about the usage during the dialogue interactions with the prototype. It took about 10-15 minutes;
4	The author interviewed each participant to get feedback from him including open and closed style questions about the applicability of the PORML prototype e.g. suitability for training risk assessment, application in FRS training, application in the FRS practice etc. The interview was recorded thoroughly with voice recorder. The interview transcript was extracted from audio recorder and analysed afterwards. This interview took about 5-10 minutes;
5	The participant answered the questionnaire including open and closed style questions to get feedback about the profile e.g. the experiences in FRS and chimney fire, and usability of the PORML prototype. It took about 5 minutes.

Materials

The materials shown in Table 7.6 consists of five documents, illustrated in Appendix D, which were to be used in the prototype demonstration including:

Table 7.6 Materials used in the prototype demonstration

Documents	Descriptions
Information Sheet	The information sheet helped a person to make an informed choice regarding whether or not to participate in a research project. An information sheet provided sufficient information to enable potential recruits to make an informed choice and clearly state that participants were free to withdraw at any time. This information sheet also informed that the researchers took the steps necessary to ensure that all participants in the research (a) understood the process in which they were to be engaged, including why their participation was necessary and (b) understood the purpose of the research and how and to whom its research findings would be reported;
Model Participant Consent Form	The form was signed by all parties, a participant and a person taking consent (author), to consent information provided by information sheet for taking part in this research project. The participants would receive a copy of the signed and dated participant consent form. The footnote of this form also informed participants that the letter/pre-written script/information sheet and any other written information e.g. information sheet, scenario, and questionnaire form could be provided to the participants;
Fictitious Scenario	The scenario, which was adapted from records available online of a real chimney fire incident at Cambridgeshire FRS in the 28 th March 2008, was followed in the PORML evaluation;
Questions for Interview	The questions were used for semi-structured interview to get feedback from participants about the applicability of the PORML prototype in the FRS training practice;
Questionnaire	The questionnaire was employed to ask participants about their profile and usability of the PORML prototype in the FRS training practice.

Data collection and analysis

Quantitative and qualitative data were collected: questionnaire transcripts were both in the form of quantitative data and in the form of qualitative data, while the log file transcripts and the interview transcripts were in the form of qualitative data only. A summary of the collected data is presented in the Table 7.7.

Table 7.7 Summary of collected data

Question no.1-8 in questionnaire	These questions were used to ask participants about their profiles including experiences in FRS, fires incidents involved, role in FRS, experiences in chimney fire, role in dealing with chimney fire, experiences in computer program for training, experiences with smartphone (iPhone3G), experiences with touch screen on mobile device.
Question no. 9 in questionnaire	All sub-questions in this question of questionnaire were used to assess the opinions to participants' satisfaction in term of a number of participants to the usability of PORML prototype e.g. the usability to follow the dialogue with the agent, help with reflection questions etc. They were analysed in the form of quantitative data.
Question no. 10-12 in questionnaire	These questions were used to ask participants more about usability of the PORML prototype including the strongest point and weakest point of PORML prototype, and other opinion. They were analysed in the form of qualitative data.
Log files	The log files were the dialogue interactions of 6 participants in the experimental study using PORML prototype. These dialogue interactions were recorded automatically in their log files by the PORML prototype. These dialogue interactions were used to observe particular participants who responded and reflected to the dialogue agent utterances. The dialogue interactions in participants' log files were analysed in the form of qualitative data and used for additional support to questionnaire.
Participants' interview	The semi-structured interview had both open and closed questions. For this, there were 4 closed questions. These questions were used to ask participants about applicability of PORML prototype and were analysed in the form of qualitative data.

The data analysis of this experimental study was conducted to ascertain the usability and applicability of the PORML prototype. Generally, the answers to the questions in the log files and questionnaires were used to reflect the usability of the PORML prototype. The log files were used to support the explanation of the

dialogue interaction episodes, benefits of the reflection, and negative feedbacks given as additional support to the questionnaire. The questionnaire data was analysed to ascertain participants' opinions in terms of: agreement or disagreement with the usability questions, the strongest points of using the prototype, the weakest points of using the prototype, the overall impression and other concerns. The answers to questions in the interview were used to reflect the applicability of the prototype. The analysed interview transcripts were used to obtain feedback in terms of applicability in RA debriefing, applicability in RA training, and applicability in RA management.

7.4.3. Findings regarding the usability of PORML prototype

The findings regarding the usability of the PORML prototype will be discussed following the analysis of log files recording each participant interaction and the responses to the questionnaire on participants' opinions about the usability of the PORML prototype. Figure 7.12 shows the analysed data in Appendix F from the answers to question no.9 in the questionnaire. It shows the number of participants expressing their agreement or disagreement with a list of statements about the usability of the PORML prototype. The questions assessed usability regarding user interface, dialogue planning, and overall impression of the prototype.

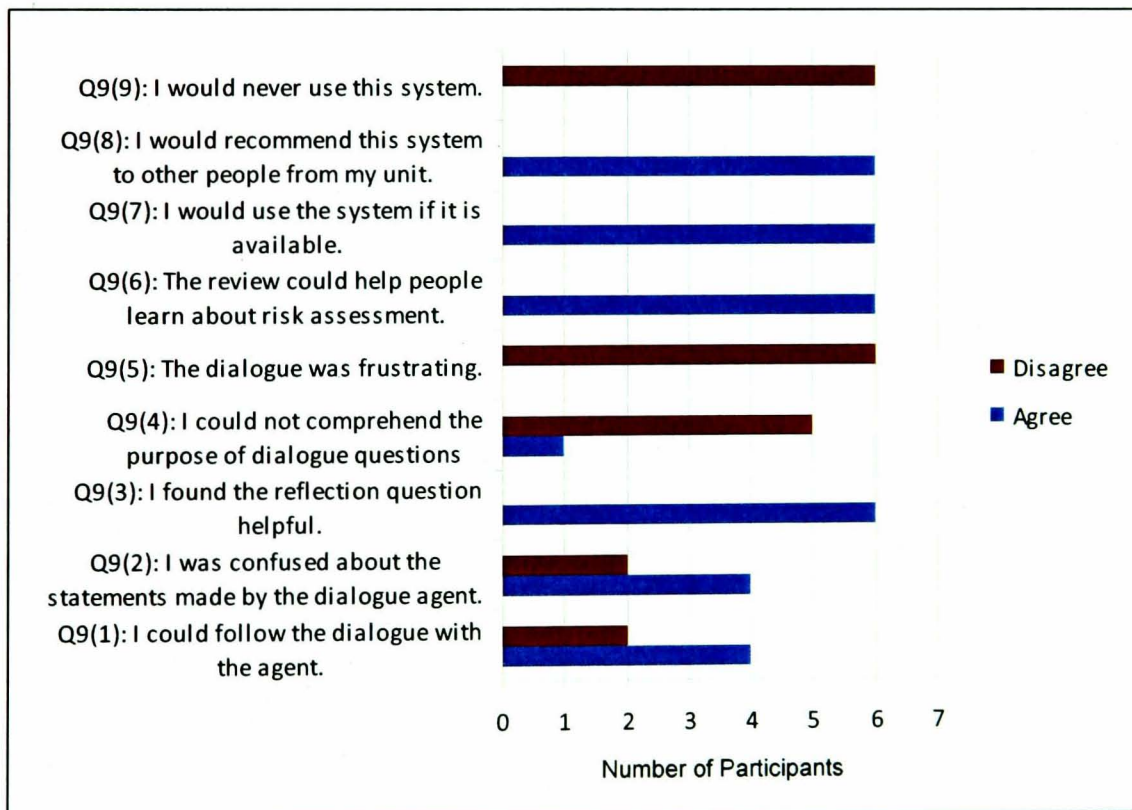


Figure 7.12 Participants' opinions about usability of PORML prototype. The numbers represent how many participants agreed or disagreed with the statements listed in the questionnaire.

Summary of the findings in Figure 7.12:

- **Q9(1):** The result shows that two participants were not clear about certain dialogue questions which caused them difficulty in following the dialogues. The detail analysis is addressed in the question: *Can users follow the dialogue with the dialogue agent?*
- **Q9(2):** The result shows that four participants were confused about the statements. The detail analysis is addressed in the question: *Are user confused about the statements made by the dialogue agent?*
- **Q9(3):** The result shows that all participants agreed that the reflection questions were helpful. The detail analysis is addressed in the question: *Do users find the reflection questions helpful?*
- **Q9(4):** The result shows that one participant could not comprehend the purpose of the dialogue questions presented to him. The detail analysis is addressed in the question: *Can users comprehend the purpose of dialogue questions presented to them?*
- **Q9(5):** The result shows that all participants thought that the dialogue was not frustrating. The detail analysis is addressed in the question: *Is dialogue frustrating?*
- **Q9(6):** The result shows that it is addressed in the question: *Can the review help users learn about risk assessment?*
- **Q9(7), Q9(8), Q9(9):** the results show that all participants would use the system if it is available and would recommend the prototype to their colleagues. They are addressed in the question: *Will users use the system if it is available, recommend it to their colleagues, never use this system?*

The results of Q9(2), Q9(4), Q9(5) are grouped into usability regarding user interface. The results of Q9(1), Q9(3), Q9(6) are grouped into usability regarding dialogue planning. The results of Q9(7), Q9(8), Q9(9) are grouped into usability regarding overall impression. All results are described in the following detail analysis.

Usability regarding user interface

Are users confused about the statements made by the dialogue agent? Four participants stated that they were confused about the statements (agent utterances) made by the dialogue agent (see Figure 7.12 Q9(2)). These problems might be due to the following: (1) the language used in the annotation of concepts in the RA domain ontology was not utilised properly with the appropriate FRS fire terms and operational activities; (2) the statements or utterances, which were created from the

utterances construction (opener, subject, predicate and object), did not look like natural language; (3) the limitation of input selection issued by the dialogue agent might not accurately match the answers in participants' minds.

Participants pointed out that certain utterances issued by the dialogue agent looked confusing and that the language used in parts of utterances was sometimes unsuitable. The example below is an excerpt of the SituationAssessmentDG in the form of dialogue interactions from participant S5.

"Agent: What was risk rating in assessing the roof conditions hazard/risk for gaining access to and working on roof activity?" [agent utterance: question to S5]

"Paul: That was medium risk in assessing the roof conditions hazard/risk for gaining access to and working on roof activity." [user utterance: response from S5]

"Agent: I think so. It could be medium risk." [agent utterance: agree with S5 response]

The user utterance contained the leading words, *"That was"*, and the option words e.g. *"medium risk ..."*. The leading words were fixed and could not be changed, while the option words could be chosen by the user. For instance, there was a choice of 3 option words in the example above: *"low risk ..., medium risk ..., high risk ..."*. This combination of words (leading words and option words) was generated automatically to construct the user utterance. Certain participants thought that it did not look like a good pattern of English. If only the short answer of *"Medium risk"* or *"It was medium risk"* was given, it might look better. The agent utterance's feedback *"Agent: I think so. It could be medium risk."* also seemed to be an inappropriate use of language for certain incident situations, as was commented on by participant S5 in his response to question no.11 of the questionnaire. He stated that:

"It can make general statements which may upset some people, since every situation is different and can not always be in a box." [answer from S5]

Participant S5 observed that the input selection only provided the limited options of *"low risk ..., medium risk ..., and high risk ..."* with no further explanation about the exact situation. He also stated that *"The English sentences are not yet 100% perfect."*. In this example the prototype provided the limited options for the user's answer, and the user did not have the opportunity to provide more details about the chosen option corresponding to the actual situation of the incident he attended. Therefore, the explanation sentences from agent utterances might not have described certain actions or activities clearly enough.

Can users comprehend the purpose of dialogue questions presented to them? Certain opinions highlighted the problems or inadequacies of the PORML prototype. One participant could not comprehend the purpose of the dialogue questions

presented to him (see Figure 7.12 Q9(4)) because the prototype might not have expressed certain dialogue questions efficiently, particularly due to the language used and the lack of clear explanations of the whole dialogue purpose.

Is dialogue frustrating? Although most participants were confused about the language used in certain statements (agent utterances) as addressed above, all participants thought that the dialogue was not frustrating (see Figure 7.12 Q9(5)). Responses indicated that all participants were satisfied with the dialogues and that the whole of the dialogue interactions was acceptable.

Usability regarding dialogue planning

Can users follow the dialogue with the dialogue agent? Two participants stated that certain dialogue questions were not clear and that these questions caused them difficulty in following the dialogues with the dialogue agent (see Figure 7.12 Q9(1)). This might have resulted from the language used in the dialogues which were unclear and because the PORML prototype might not have been explicit enough when explaining the purpose of each dialogue episode which was issued in sequence.

Do users find the reflection questions helpful? All participants agreed that the reflection questions were helpful (see Figure 7.12 Q9(3)). Their answers indicate that the reflection questions throughout the dialogue interactions were useful and impacted the learning activities that involved reflecting on RA experiences. In addition, the whole of the dialogue interactions could be considered acceptable and all participants were satisfied with the dialogues.

Can the review help users learn about risk assessment? All participants answered that the review could help them learn about risk assessment (see Figure 7.12 Q9(6)). These opinions indicated that not only might the PORML prototype benefit the crew manager, incident commander and all participants in the experimental study, but also that the prototype could benefit other roles in the FRS, and help or support their work in risk assessment activity. In addition, the RA domain ontology (addressed in Chapter 4) employed by the dialogue agent to generate the dialogues (agent utterances) interacting with user (user utterances) could be useful and was validated by these participants' opinions.

Usability regarding overall impression

Will users use the system if it is available, recommend it to their colleagues, never use this system? All participants agreed that they would recommend the PORML prototype to their colleagues. The opinions indicated that not only could the PORML prototype benefit the crew manager and incident commander, but also that

the prototype could benefit other roles in the FRS. It could help or support their work in risk assessment activity.

What do users see as the strongest/weakest points of PORML and are they surprised by anything? One participant was impressed by the prototype's help in the analytical process of evaluating decisions and reviewing actions. For instance, the crew commander could return to the station after the fire activity was completed, use the program to review the decisions he made and then compare them with the decisions advised by the PORML prototype. This would benefit him in supporting the process of analysis in his decision making. Most participants expressed in the same way that the language and confusing statements (agent utterances) in the dialogue questions were the weakest point of PORML prototype. One participant pointed out that the structure of the questions needed to be thought about so that they could be read and understood more easily. Another participant pointed out that, for example, the statement "*I think the situation was high risk*", might upset some people who had worked with the incident, since every situation is different and cannot always be put in a box.

7.4.4. Findings regarding the applicability of the PORML prototype

The aim of this section is to present another main objective – assessing the applicability of the PORML prototype. The author interviewed 6 firefighters on the applicability of the PORML prototype in FRS to collect qualitative data in the form of interview transcripts which were then analysed. The questions were asked during interviews, and the completed interview transcripts are presented in Appendix E. The results of the analysis can be divided into 3 categories: RA debrief, RA training, and RA management.

Applicability in RA debrief

All participants, especially the watch manager (S1) and crew managers (S2, S6), indicated in the same way that the prototype could be used for *debrief*.

Debrief at incident: The watch/training manager S1 added that he calculated the risk he had to take for every incident so that he could get the results of RA every time. He would use the prototype for occasions and incidents that seemed unusual. It would be too time consuming if he used it for every accident and he felt that this was not necessary. The prototype could definitely be used in operational RA activity which was quite generic (GRA) e.g. road traffic accident, rescue from high, building fire, high rise building fire and chimney fire etc. He would go in to personally check how well perform and check if something more could be done. This also included debriefing the incident.

In a part of risk management at the incident, risks will be analysed by analytical risk assessment techniques (see Section 4.4.1 and Figure 4.3 in Chapter 4 for dynamic risk assessment in risk management) after assessing the risks in a situation and carrying out the appropriate response (e.g. use offensive mode, provide and use safe system of work for asbestos). The result of analysed risks may impact tactical mode (e.g. tactical mode is changed from offensive mode to defensive mode etc.) and selected systems of work. The result and its related actions will be reported in a debrief by the incident commander to higher commanders or managers at strategic level (e.g. at fire control unit). The prototype can help the incident commander for quick risk analysis of incident debrief to provide RA's result and deliberate information of the risk situation to fire control unit.

Debrief in post incident: Crew managers S2 and S6 both thought that the prototype could be used for post incident debrief. The crew manager S2 stated that he would use the prototype in post incident debrief during a talk or discussion with the whole crew after he returned to the FRS station. They would discuss what actions they carried out, what actions the crew manager performed, and what risk assessment state they came up with. Therefore, the prototype could be used during verbal debrief for the whole team. The crew manager S6 would use the prototype for debrief to help him write a report. It was useful for reviewing the incident for his debrief, particularly when he forgot something about risk assessment at the incident.

Applicability in RA training

The interview showed that all participants were satisfied with the prototype and stated that it was suitable for *risk assessment training*.

Suitability for risk assessment training: All participants were satisfied with the prototype and stated that it was suitable for risk assessment training. However, a watch/training manager S1 stated that it needed to include more of other training as well e.g. practical training that was currently provided by the existing FRS training program. Similar to the watch/training manager, the crew manager S2 stated that the prototype could play a part in the FRS training. Participants S2 and S3 stated that they could use the prototype to learn about an incident in a reflective way. Other participants thought that the prototype was suitable for reviewing an incident and learning about other incidents in order to understand the process of gathering information when designing what to do and what options could be taken. All participants added that the prototype could also be used with or applied to other FRS RA for training in the same way e.g. road traffic learning, road rescue from high, fire in a high rise building, hazardous materials, and so on. The same design concept of the RA model using Activity Theory could be expanded to other FRS RAs by extending the scope of the RA domain ontology with added concepts and

relationships, and modifying certain modules (e.g. extending the main dialogue game agent to support other FRS RA, extending the ReflectionDG to reflect different kind of FRS RA etc.) in the PORML prototype.

Self training and personal training: Crew manager S6 stated that the prototype could be used in his own development. It is a self training tool for firefighters who can do the training on their own. It is also a personal training tool in that the prototype knows who is learning and records his/her learning experiences for personal use. This means that a crew manager, who would like to, could learn how an incident commander assesses risks for particular types of FRS RA activity if the prototype is developed to cover other types of GRA (e.g. high rise building fire, secure accommodation fire, rescue from high) and thus develop his/her skills and benefit his/her team. He/she could conceive certain situations in a fire incident, for instance, a situation with a building fire close to a petrol station has limited control measures etc. He/she could learn what activities/actions the prototype recommends, what control measures are involved, and what the risk level results are. The self training and personal training using the prototype not only benefits the crew manager by developing his RA skills, but can also benefit other firefighters: (1) who are being promoted to be crew managers or who show the potential to become crew managers. They can prepare themselves using the prototype with experiences in RA that make them more confident as new crew managers; (2) who are general crew members. The prototype can help them learn how an incident commander deals with RA in an incident and it may help them gain a better understanding of the process of operational RA to work with their team efficiently.

Group training or collaborative learning: Contrary to self training, crew manager S2 felt that the prototype might make the training less individually focused. He thought he would use it in talks with the whole crew (as stated above for application in RA debrief) upon returning to the FRS station. Therefore, training needs could be addressed without having to identify an individual. For instance, if the prototype was used in a traffic light system where you either did very well or failed significantly, you could use the prototype to reflect your work regarding a road traffic accident from the traffic light system and have a discussion on this with your team. Following this, it could be used as a reference in future training for your groups or your colleagues in the FRS department. The key point of this finding is a RA application for a group development environment. The prototype can provide FRS operation information regarding the RA experiences of a crew manager functioning as an incident commander in a working group. All members in the group could discuss their experiences as part of group training or collaborative learning within that FRS operation with involvement of the information provided by the

prototype. The prototype would help the crew manager and provide supplementary information related to GRA of the FRS operation to the group for discussion. Then, the group, or even other firefighters, can use the result or summary of the discussion for further training in the future.

Learning and Training needs: Crew member S4 addressed the impact of the prototype in terms of training exercises and accuracy of responses. A highlight of the prototype could be its role in learning and training needs in circumspect practice. After firefighters complete their existing training exercises, they could use the prototype as a part of the exercise and training scenario to supplement the existing training. According to S4, the results could be used accurately and the task would be responded to accurately by a large number of people which would even give him a good way of determining training needs.

Improving effectiveness of the current training: All participants thought that PORML could improve the effectiveness of the current training. They offered different points of view on how it could be applied to the current practical training. The watch/training manager S1 stated that the prototype could be utilised as part of training for work strength which would supplement the current practical training, especially in reflective training. He could decide which areas of training would be concentrated on by using the prototype to strengthen crews in the areas that help to improve effectiveness of the current training.

Applicability in RA management

One of the participants, watch/training manager, indicated that the prototype was also suitable for reviewing risk related decision making and risk control management.

Reviewing risk related decision making and risk control management: A highlight of the prototype was its role in the analysis of the risk. Participants stated that the prototype helped direct them toward the right course of action, and it could verify their decisions in operational risk assessment. When an incident commander uses the prototype to review the crew's recent actions in operational RA activity and provides his/her own risk decision of the actions, this risk decision will be compared against the outcome from the risk decision advised by the prototype in the SituationAssessmentDG episode using the calculation of the action states (did or did not use) of the control measures in previous episodes as given by him. As a result, participants will get feedback based on the outcome of a comparison between their actual risk decision and the risk decision advised by the dialogue agent risk calculation e.g. the participant's own risk decision classifies the situation as low risk

while the dialogue agent calculates the risk as medium risk. Therefore, the feedback from the prototype will be articulated in a response like this:

“I disagree but you may have some actions for alternative solution. I think that the risk rating you have selected low risk may not match with the existing and availability control measures in this hazard. It could be medium risk.” [agent utterance: respond to user decision as low risk]

However, participant S4 and S5 highlighted the problem that there are a significant amount of situations where it is difficult to use the prototype at the incident or near the incident because of the nature of the current work routine. In most situations, the firefighters had to return to the station after the operational FRS activity was completed in order to get ready for the next call and the crew manager had to make himself available to any other operational FRS crews. In the station, they might spend some time to use the prototype for debrief or reviewing, if they were free before the next call. This feedback provided relevant information for applying the prototype into FRS working practice. It seemed to be a negative point because the prototype was mainly designed for mobility in on-the-job learning and it needed to get contextual information at the incident e.g. location, weather conditions, environment impacts etc. However, it is still possible to use the prototype at the incident in future training if the commanders know more about the prototype and deploy it into working practice in the case that they have time to stay at the incident and use the prototype on a smartphone. Another case for using it in the future would be if they came back to the station and used the prototype on a laptop, with contextual information from the central database of a FRS data centre that would record the information in that incident. An example of answers from participant S4 stated the following:

“Some situations might be difficult to do it straight after incident because of the nature having get back call being call other incident.” [answered from interview with S4]

Recording experiences: The dialogue agent would record the user activities (experiences) of dialogue interactions, including the reflective answers, in the form of log files. Hence, somebody could use it later on to recall users' (firefighters') critique on what firefighters had done. These records helped them to identify anything that should have been done and also helped them to remember what they should do next. This indicates that every time a firefighter uses the prototype to review his recent RA activity or to learn any RA activity by himself, RA experiences of the firefighter including his reflection of these experiences will be recorded. These experiences are kept in the form of text files in user's directory. For the current prototype, the user can either copy his recorded experiences and modify them

for his documents or print them out to discuss and critique with the others and keep them as a reference.

7.5. Discussion

The design concept of the PORML framework was validated by the results of the analysis of summative evaluation in Section 7.4. Both quantitative and qualitative data analysis techniques were used to determine the usability and applicability of PORML prototype. Our findings can be discussed as follows:

7.5.1. Usability of PORML prototype

The results of the analysed dialogue log files data and questionnaire data will be used to assess the usability of the prototype.

Usability regarding user interface

The PORML user interface was found as simple focusing on text-based dialogue and use with a web browser. Users might not have to specifically learn how to use it and do not need to spend a considerable amount of time to use it to review and reflect on their activities at the incident. The user interface is tailored to a mobile phone screen size or a desktop/laptop screen size, depending on the application of its use.

However, the firefighters provided some negative feedback about the user interface regarding language use and a limitation of the input selection. The main reason for the language problem could be attributed to the author who implemented the PORML prototype and built the RA domain ontology. The author is not a native English speaker and does not have any experience in real fire RA practice which might be important in the details of building and presenting utterances. Also, there was the complexity of providing the combination of input (option selection + free text input) in the option words of user utterance, then recording them and using them later for reviewing the learning experiences, that needed further improvement.

Usability regarding dialogue planning

The reflective questions in the ReflectionDG had positive feedback from all participants. The findings indicated that the reflection prompts embedded in the PORML prototype could facilitate reflection on RA experiences. The prototype was regarded as beneficial by all participants for learning about risk assessment. It was used to review the RA activity and it helped participants to see sequences of actions that occurred during risk assessment.

However, some dialogue questions issued to participants were not clear. The questions sometimes caused them difficulty in following the dialogues. This

problem also came from the language used in the dialogues which might have been unclear.

Usability regarding overall impression

All participants stated that they would recommend the prototype to their colleagues and other firefighters. They were pleased in different ways. One participant was pleased by how the prototype assisted in the analytical process of evaluating decisions and reviewing actions. Another was pleased that it helped him to remember what he did well or badly. Others were pleased regarding the review and reflection features of the prototype.

However, they also pointed a negative aspect of the prototype, namely that the dialogue language was confusing. Some phrases in the dialogues could potentially confuse people e.g. "*I think the situation was high risk*" (in this case, it is unclear why the situation is high risk). Since every situation was different, the prototype could include an opportunity for providing more details.

7.5.2. Applicability of PORML prototype in FRS

RA training

On the one hand, there are benefits in using the PORML prototype for RA training. The prototype can be used as a part of training to review the decisions made, and so to check and compare the result of the crew manager's work practice. For instance, comparison with the fault decision etc. Therefore, the prototype can indicate how the crew manager has done and he can learn and check what the right way is from this comparison. The prototype can also be applied to learning about other incidents as part of self training or personal training and to understand the process of gathering information when designing what to do and what options can be taken regarding FRS operational risk assessment activity in the FRS training, for instance, road traffic learning, rescue from height, hazardous material etc. The managers become aware of future incidents which can help them deal with the incidents more carefully. In addition, the prototype can be applied to group training, which helps development of firefighter teams. All members in a group can discuss their experiences as part of group training or collaborative learning in a FRS operation with involvement of the information provided by the prototype. Another highlight of the prototype is its use in learning and training needs in circumspect practice. The firefighters can use the prototype as a part of the exercise and training scenario to supplement the training that helps them assess risks more accurately.

On the other hand, there are also certain disadvantages which could affect the use of the PORML prototype for RA training. For instance, a crew manager

addressed and was concerned about a problem that was a possible drawback of the prototype. Certain crew managers/commanders might change some of their answers to include better words or actions in their reports rather than strictly writing plain facts or actual actions that occurred in practice. This might have an impact on their personal assessment for operational RA if they manipulated their answers after reflection using the PORML prototype. In a worse case, if the manipulated data was passed on to a higher manager in a report, the result would impact management decisions. The crew manager answered as follow:

“Main problem would be when people come back from the incident and they have time to reflect. They may change some of the answer, so this appears that a word to better of system they actually did in practice.” [answered from interview with S2]

RA practice

Based on the user feedback, it was confirmed that an incident commander could use the prototype immediately after an incident was complete. The prototype is used to review and reflect on the risk decision-making and to record the experiences of the incident commander. It can be used for debrief during FRS operational activity for dynamic risk assessment to report the current situation to strategic level at fire control used as information involving with further actions from strategic level. It can also be used for post incident debrief in talks and discussions with the whole crew after the firefighters return to the FRS station, and for help in writing a report.

Nevertheless, there are a significant amount of situations in which it is difficult to use the prototype at the incident or near the incident because of the nature of the current work routine. In most situations, the firefighters have to return to the station after the operational FRS activity is complete in order to get ready for the next call and the crew manager has to make himself available to any other operational FRS crews. Besides that a participant addressed *the potential problem in the case of possible fear of investigation*. There might be an accident where a firefighter was injured and the correct risk assessment was not carried out. This suggests that when you use the prototype to review and check the result of risk assessment, it does not mean that all firefighters will be 100% safe for the case. This is because some situations might be so complicated that even though the prototype can analyse and cover all environment impacts, they might also be influenced by other unknown environments which are not present in the context parameters of the prototype.

Possible users

The design of the PORML was originally aimed at RA for the incident commander. Thus, the author focused on the crew commander who can act as the incident commander and use PORML for reflective learning at the incident. Nevertheless, the

evaluation of the PORML prototype was not only tested with crew commanders, but also with firefighters in other roles. The findings of the experimental study indicates that the prototype can be beneficial to other roles in operational FRS. Although the incident commander – which is a role that can be filled by a commander or a manager – is the one who assesses the risks in the incidents and the PORML prototype provides the use to him/her, the prototype is a learning tool that can also be used by firefighters in other roles to learn how to assess the risks.

It is possible that the following crew members can benefit from the use of the prototype: (1) a crew manager, a training manager, a watch manager, and the other managers in operational FRS; (2) a crew member who is promoted to be a new crew commander; (3) a crew member who shows the potential to become a crew commander; (4) a new firefighter or a new crew member who can use the prototype to obtain an overview of what activity or process of risk assessment might be involved for him; (5) a general or existing crew member who would like to improve himself and gain a better understanding of the process of RA in order to work with his team more efficiently.

Application to other activities

- *Other RA activities*: The GRA manual divides RA into 5 categories: (1) responding to an emergency; (2) rescues; (3) fighting fires; (4) incidents involving transport systems; (5) generic hazards. A chimney fire RA is one out of 11 types of fire RA under the category of 'fighting fires'. Using the same methodology to design the RA domain ontology, the scenarios for other RAs could be used and the RA domain ontology could be extended to cover all other RAs found in the GRA. The program code of the PORML prototype must also be improved to support the RA extension, e.g. dialogue game (DG) agent module, DG analyser module and other DG modules – ReflectionDG, FeedbackDG etc.
- *Fire extinguishing and rescue activity*: In an incident, firefighters not only deal with risk assessment of the situation, but also have to carry out other activities to achieve the goal of operational FRS. Fire extinguishing and rescue at incidents are activities involved in incidents of fire activity and rescue activity. If the result of fire or rescue RA is safe enough (low risk), the incident commander will normally send his team to deal with the fire by fire extinguishing or rescuing people. Although the prototype is designed originally for RA activity, it is possible to apply the activity concept to cover fire extinguishing and rescue services. It may be possible to either extend the RA domain ontology to cover fire extinguishing and rescue services or to

create a new domain ontology for fire extinguishing and rescue activity to be used in collaboration with the RA domain ontology.

7.5.3. Further improvements

Dialogue language: The dialogue language could be improved to include the use of natural language processing to analyse user's answers before issuing the utterances. The components of dialogue construction are mostly derived from knowledge description in the RA domain ontology. Therefore, language use in the RA domain ontology could also be refined. It is possible that a native English speaker or an English expert might be involved in language improvement in the RA domain ontology. It would be even better if the expert is an experienced firefighter who can facilitate language use in FRS practice.

Dialogue options: A participant in the experimental study thought that every situation was different and could not always fit in a box of user utterances. Therefore, the user could be given the opportunity to provide more details about the chosen option corresponding to the actual situation in the incident he attended. It is true that the prototype provides limited options for a user's answer to create a user utterance. Users cannot describe a situation freely and in a way which corresponds completely and accurately to the actual situation. Therefore, the explanatory sentences from certain feedback of agent utterances may not be able to describe certain actions or activities clearly enough in relation to the actual situation. The information used to construct the options is pulled from concepts and their descriptions in the RA domain ontology that are limited by our RA scope that follows FRS manuals (GRA manual, fire service manuals, firemanship manuals). It is possible to improve the PORML prototype with regards to this issue by adding another option called 'others' with an added free text input method. In this option, users would be able to enter any text freely giving a more precise description of their actual situation if the existing options are not able to explain the situation accurately. However, the texts entered by the users may have to be analysed regarding their meaning. This poses the challenge of text analysis which can use natural language processing to analyse these texts. The dialogue agent must have the capability to use the result of natural language processing and convert it to knowledge concepts. The dialogue agent could also have another dialogue game to add these concepts into the RA domain ontology. For instance, if the result of natural language processing from a user sentence points to another hazard of a fire RA which differs from the 5 hazards of the existing fire RA, the dialogue game will ask the user to check whether it is a new hazard. The user has to confirm this hazard and the dialogue game will then store the new hazard concept. However, it is a risk to open up the prototype for anyone to freely add a new concept. The prototype must contain a process for the

new hazard concept to be validated by experts in the area before actually adding the concept into the RA domain ontology. If validation is given, the fire RA will then have 6 hazards and the RA domain ontology is extended by a new hazard concept. The capability of analysing the texts using natural language processing and adding the knowledge concepts during dialogue interaction could be another PhD research challenge.

Summary of the dialogue: Another challenge is the summary of results of dialogue interactions at the end of the program as stated by a participant in the experimental study. Although the PORML prototype keeps records of the dialogue interactions in the form of text in a log file for each user, it does not summarise any results for the user after the dialogue interactions are complete. The dialogues between user and agent are issued in each dialogue episode that may provide interesting information to the user. Since whole dialogues contain a considerable amount of information, the user cannot remember all the information in the dialogues and may not be able to conclude what the key points are. It would be interesting for further improvement if the PORML prototype could analyse whole dialogues and conclude by summarising the crucial points for the user. As a result, the user would get the benefit of understanding the crucial points quickly after dialogue interactions are complete instead of having to go back to read through the log file and trying to extract the key points from the whole dialogues.

Summary of practice: After an incident is complete, an incident commander uses the prototype to record contexts at an incident. It could be possible for the contextual information regarding the incident to be summarised (e.g. the type of fighting fire, the weather conditions, incident building, date and time of incident etc.) and linked to Google Maps for reference use afterwards. This application could be used to inform the incident commander when a future incident occurs near this location. It could help increase his awareness in dealing with fire, RA or other FRS activity e.g. the conditions of building surroundings etc.

Another possibility of applicability is an e-portfolio (Roberts, Aalderink et al. 2005; Garrett and Jackson 2006). The prototype might be used to create an e-portfolio that keeps incident commanders' reflective writing and associated evidence for incidents. This e-portfolio could help firefighters' development e.g. enhancing lifelong learning, stimulating reflection and deep learning etc.

7.5.4. Limitations of study

Experimental design

- *Experimenter background:* The author, who is also the experimenter, does not have any background in Fire and Rescue Services. Therefore, the gathered

information on RA during PORML implementation, as well as the questionnaire and interview questions in the experimental study may have been impacted. The gathered information may have been better if the author knew more about FRS e.g. sources of collection, which firefighters can be contacted, and more benefits for the experiment etc. It is also a limitation that the experimenter was not able to provide the appropriate questions or powerful questions to get certain feedback from firefighters that might be significant.

- *English language and specific jargon:* The use of English was a problem in the author's prototype design and experimental study. The author is not a native English speaker and certain words or sentences which were used might not have been clear enough for the firefighters. They may also sometimes use specific jargon in their work, and as such, information collected from manuals might differ from that in practical use. For instance, the experimenter used the term 'crew commander' as per the GRA manual whereas the participants in the experimental study use the term 'crew manager' in daily practice. Another example is the type of fire RA. The experimenter used the term 'fire type' but firefighters do not use this word and refer to it as 'fighting fires' instead.
- *Scenario-based design:* The author used a scenario-based design to build the RA domain ontology that is used by the dialogue agent to plan the dialogues including possible activities or actions. A scenario of RA in a chimney fire was built. A participant stated that it was a good scenario and that it looked like a real situation. The scenario shows a possible scene that is able to clarify a RA situation in terms of which activities and actions are involved. However, this scenario might not cover all possible aspects of RA situation that might be beneficial for building the RA domain ontology used for the PORML prototype. To overcome this, we could build more than one scenario for this fire in order to look at more possible activities or actions involved. In addition, the RA domain ontology might be built more effectively.
- *Number of users:* Although different roles of the firefighters are considered in the experimental study, only a small number of firefighters working the night shift in an operational FRS team was involved. Most firefighters in the FRS station were busy. As firefighters do not know when an incident might occur and who will be requested to cover it, only 6 firefighters were available for the experimental study period in the FRS station to use the PORML prototype and test with our questionnaire and interview. Although only 6 firefighters were available, which is a limitation of our work, the impact of

the study has far-reaching implications for all firefighters and not just those who were questioned.

- *Specific fire unit:* Not only was just a small number of firefighters available for the experimental study, but all of them were from the same team at the Avon FRS station. Thus, the information from their feedback might not be sufficiently representative. Other teams in the same FRS station and other teams in other FRS stations could have touched on different aspects in their feedback that may be significant for the improvement of the prototype. In addition, due to the availability of documents that the author could access, the scenario used in the experiment is referred to a real incident recorded by Cambridgeshire FRS, while the risk level calculation data (e.g. a number of severity levels and likelihood levels) are closed to the West Yorkshire FRS, and the risk group is referred from the GRA manual. However, the information used in the prototype is not specific to any FRS, it is mainly derived from the GRA manual for generic use.

Data collection

All the data from the questionnaire and interview was collected at the FRS fire station. There was a limited time of about six hours at night to do this. A point of interest is that if we could have had more time to look around the FRS fire station, especially during the existing training, we might have the opportunity to clarify how firefighters learn and develop in their department, as well as what tools they normally use in training. This might help us for further development.

Dialogue analysis

The dialogue interactions from each participant were recorded in log files. The author did not analyse the dialogues for each participant. These dialogues were used only to support the explanations given in the questionnaires and interviews e.g. use of reflection. As the time of experimental study and the availability of the firefighters were limited during the use of the prototype, the dialogue answers from each participant may not reflect the actual use in their practice. From examining the reflective answers, the author found that most answers were short and sometimes did not even seem to be reflective answers.

7.6. Summary

In this chapter, the relevant evaluation approaches and methods were reviewed to point out the methods used. The experimental study of formative evaluation was

presented and discussed to improve the prototype. The evaluation was begun with the pilot study to test the procedure and adjust it as necessary before embarking on the formative evaluation process. Participants, procedure, materials, data collected and analysis in the formative evaluation were addressed. This data gathering technique was used to collect both quantitative and qualitative data. The questionnaire and video data with think aloud protocol were employed to collect the data, which was then analysed.

The findings were discussed to analyse the problems found and to improve the prototype to robustness. The findings regarding the user interface of dialogue were discussed along with the improvement actions e.g. interface to utter the communicative acts, understanding what the system conveys, dialogue presentation layout, features of input selection and understanding the aim of the interaction. The findings regarding the dialogue planning were discussed along with the improvement actions e.g. dialogue planning mechanism, free text answering in reflective questions, dialogue coherence and suitability of the sequence of dialogue turns for reviewing the FRA activity. The findings regarding the overall impression were discussed along with the improvement actions e.g. overall quality of the dialogue.

In the next part, the summative evaluation of the robust prototype was presented and discussed to validate the PORML framework with end users. Participants, procedure, and materials in the summative evaluation needed to be prepared before collecting data. The log files, questionnaire answers and interview transcripts were collected from the participation of 6 firefighters. The collected data was analysed using a combination of quantitative and qualitative methods. The usability and applicability of the prototype are reflected in the analysis of the collected data.

The findings were discussed and they showed the benefits and drawbacks of the prototype to firefighters. The findings regarding the usability of the PORML prototype were discussed e.g. user interface, dialogue planning and overall impression. On one hand, most participants comprehended the purpose of the dialogue questions presented to them and could accept the whole of dialogue interactions as satisfactory. They were able to follow the dialogue with the dialogue agent, found the reflection questions helpful and found that the review helped them learn about risk assessment. They also found that not only was the prototype of benefit to the crew manager or incident commander, but also to those in other roles in the FRS.

On the other hand, certain participants were confused about the statements made by the dialogue agent e.g. the language used in the annotation of concepts in the RA domain ontology lacked FRS fire terms, the limitation of input selection

issued by the dialogue agent might not accurately match the answers in participants' minds etc. Certain dialogue questions were not clear and these questions caused them difficulty in following the dialogue.

The findings regarding the applicability of PORML prototype were discussed e.g. RA debrief, RA training and RA management. The benefits of RA debrief are: debrief in practical application or at the incident and post incident debrief. The benefits of RA training are: suitability for risk assessment training, self training and personal training, group training or collaborative learning, learning and training needs and improving effectiveness of the current training. The benefits of RA management are: reviewing risk decision-making and risk control management, and recording experiences. However, there are certain drawbacks in applicability as follows: (1) the review could lead to certain crew managers changing some of their answers to include 'better' words in their reports rather than strictly writing plain facts or actual actions which occurred in practice; (2) in the case of possible fear of investigation, there might be an accident where a firefighter was injured and the correct risk assessment was not carried out.

Chapter 8

Conclusion

This PhD presented a study in developing innovative technology-enhanced learning solutions that address current needs of workplace training/learning which is rapidly growing in modern, digitally empowered organisations. The thesis has proposed a new approach to support reflective on-the-job training at workplace, illustrated in emergency services. The approach utilises an ontology which represents an activity context in a review-like reflective dialogue to provide opportunities for reflection-on-action based on job activities performed by the learner. Our aim has been to formalise the design and implementation of the overall approach, so it could be applied in a range of domains and use cases. The formalisation is based on linking two foci: a methodology for real world activities based on Activity Theory; and a computational approach for developing tutorial dialogues based on Dialogue Games. The main contribution of this thesis lies in the design of a computational framework for Personalised On-the-job Reflective Mobile Learning (PORML), which is exemplified in a case study of risk assessment training in Fire and Rescue Services and validated in a prototype that is evaluated with firefighters in a UK FRS unit.

This chapter will conclude the work of this thesis. Section 8.1 will provide a summary of the work. The generality of our approach will be discussed in Section 8.2. We will highlight the contributions to the relevant research areas in Section 8.3. Finally, Section 8.4 will discuss improvements to address the existing limitations, and will outline directions for future research.

8.1. Synthesis

The thesis has presented a computational framework to support on-the-job workplace training with reflective dialogue, adapted to the area of emergency services. In the thesis we have: (a) proposed a reflective dialogue for on-the-job training framework called PORML; (b) provided a method to build a Geographic Location Database and extract the location context data that corresponds to the specified incident place; (c) developed a methodology to build an activity-based ontological model; (d) developed a dialogue game-based mechanism for dialogue management; (e) built a prototype to put all components together and validate the PORML framework; (f) performed experimental studies (both as formative and summative evaluation) to identify areas for improvement and examine the applicability of the prototype in FRS practice.

- **A framework for reflective dialogue for on-the-job training** (presented in Chapter 3). The key characteristics of the framework include: (a) ubiquitous access; (b) proactive system-driven interactions; (c) on-the-job training by reflecting on action; (d) user activity is affected by location and environment in close proximity; (e) available topographic data which indicates and describes the place where the activity is conducted. The framework has been designed with these characteristics in mind, and is adapted to promote reflective learning in emergency services. The framework includes five main components: Web-Based Interface, User Authentication and User Profile Collection, Location Context Data Query, Dialogue Manager and Planner, and Log File Viewer. The components have been outlined, and illustrated in a case study of risk assessment on FRS.
- **A method to build a Location Context from a Geographic Location Database** (presented in Chapter 3). We have described a mechanism for using topographic area feature properties defined in GML (a widely used data format for geographical data bases) to derive ontological constructs with feature objects, which are used as a location context model in the PORML framework. The GML data is collected by querying a service with topographic data from a key UK map service provider (Ordnance Survey MasterMaps) by specifying a location area that corresponds to the Interest Area of an incident described in a realistic risk assessment scenario.
- **A methodology to build an activity-based ontology model** (presented in Chapter 4). We have outlined a set of constraints for the development of ontology to model a job activity. Following these constraints, an ontology construction methodology has been defined. The methodology utilises the second generation of Activity Theory (AT) to identify the context dimensions of an activity model at an abstract level, including activity, actions and operations. The AT is used to capture contextual knowledge and create the conceptual entities of an activity model that are described in corresponding knowledge glossaries. The conceptual model is then converted to a logical model, where activity components are coded as classes and properties in ontology represented in OWL (a widely accepted ontology representation standard). This allows querying the model using OWL APIs, which enables the activity model to be exploited both for modelling a user's current activity and for dialogues management.
- **A dialogue game-based mechanism for management of a reflective activity-based dialogue** (presented in Chapter 5). We have outlined the main characteristics of the dialogue management mechanism in PORML which are driven by two main goals – activity review and reflection. A dialogue-game

based planner is presented. Dialogue games are defined to generate two type of episodes: Sequential DG episodes and Interruption DG episodes. The Sequential DGs provide activity review conducted as an incident review session corresponding to the sequence of actions in the activity model, as defined in the activity ontology. Interruption DGs are injected in the Sequential DG episodes and provide reflective questions to promote a learner's reflection on his/her actions. Interruption DGs are triggered when key actions from the activity ontology have been reviewed.

- **A prototype implementing the main PORML components** (presented in Chapter 6). Required technical specifications for the implementation of the prototype are described in terms of hardware specifications, software specifications, utility tools and libraries needed for the PORML implementation. The prototype user interface is adapted for interaction via either a PC or a mobile device. Examples of user interaction with the PORML prototype are presented to illustrating a series of Sequential DG episodes. The rationale and characteristics of the dialogue interactions in each episode are described. The examples also include several Interruption DG episodes aimed at promoting reflection.
- **An experimental study with the PORML prototype** (presented in Chapter 7). The evaluation of the prototype is conducted in two stages – formative and summative evaluation. Formative evaluation aimed at testing the PORML prototype and preparing it for an evaluation study with real users. As a result, several problems with the user interface and dialogue planning have been identified and fixed. The improved prototype is used in an experimental study of summative evaluation with firefighters aimed at assessing the usability and applicability of the PORML prototype in FRS practice. Regarding usability, most participants understood the dialogue questions presented to them, were satisfied with the overall dialogue interaction, and were able to follow the dialogue with the PORML agent. The participants found the reflection questions helpful and felt that the review helped them learn about risk assessment. They also pointed out that the prototype could benefit not only the crew commander, but also the other crew members taking part in the fire risk assessment activity. The study also highlighted problems with the prototype which should be addressed in future work. Some participants were confused with the dialogue statements, which was caused by several factors. Firstly, there inappropriate language formulation was used in the annotation descriptions of concepts in the RA domain ontology since the ontology author was unaware of working jargon used by firefighters. This highlights a general problem when an ontology is built following guides and then utilised in applications with end users who speak a practical language, often

different from the formal description in the guides. Secondly, on occasions, users were presented with limited selection options issued by the dialogue agent, which did not match the answers user want to give. This points at a problem with dialogue interactions when the user's choices are generated from a pre-defined knowledge source (an ontology in our case). A more flexible approach could be to allow the users to type their answers exploiting sophisticated natural language understanding techniques. Thirdly, some dialogue questions were formulated in poor English and were hard to follow. This is easy to fix by asking a native speaker aware of FRS practices to proof read the dialogue move templates. Regarding applicability of the PORML prototype in FRS practice, three main areas to use the prototype in FRS practice have been identified: (a) for a debrief after a RA activity (in the form of a post incident debrief); (b) for RA training (as self-training, personal training, group training, and training needs analysis); and (c) for RA management (reviewing risk decision-making and risk control management, and recording job experiences). The study also pointed at some issues that could hinder the applicability of the PORML prototype in FRS practice, such as: (a) the users may not give an accurate picture of what they actually did (this is a common issues with any system relying on subjective information from the user; to address it, a flexible trust model would be needed); (b) users may be unwilling to provide information fearing that it could be used for further investigation, e.g. there might be an incident where a firefighter was injured and the correct risk assessment was not carried out. The results of the evaluation study have indicated further improvements of the PORML prototype discussed as future work in Section 8.4.

8.2. Generality of Our Approach

The generality of the approach presented in this thesis can be discussed in terms of the overall PORML framework, its applicability, the development of an activity ontology, and the dialogue management model. These aspects are revisited below.

- **The PORML framework.** The PORML framework is designed to promote reflective learning in fire risk assessment to support informal on-the-job training in FRS work practice. The framework can be applied to promote reflective learning in a range of emergency services, such as fire and rescue services, police, ambulance services. These domains have several main characteristics, as specified in Chapter 2, Section 2.5.1.: training/learning is informal, on-the-job, and is based on activities/actions performed at the work practice; reflection is used as a main method for training; and there are guides/descriptions of what activities/actions learners/workers do. The implementation of the client

component of the PORML prototype is independent from the mobile platform, and can be used on any mobile devices which provide Internet web browser interaction. The framework requires geographic data with key topographic features related to the user activity. The framework is independent from the actual geographic source, and can use any data provided that it is in GML (considered as a standard geographic markup language). Similarly, to represent the domain ontology (RA ontology in this case), an approved semantic web ontology language, OWL, is used. This enables the implementation to be independent from the utilised OWL API and reasoner.

- **Applicability.** The PORML prototype can be used as a part of training to review the decision made, and so to check and compare the result of the crew manager's work practice. Therefore, the prototype can indicate how the crew manager has done and he can learn and check what the right way is from this comparison. The prototype can also be applied to learning about other incidents as part of self training or personal training and to understand the process of gathering information when designing what to do and what options can be taken regarding FRS operational risk assessment activity in the FRS training, for instance, road traffic accident, rescue from height, hazardous material etc. The managers can become aware of future incidents which can help them deal with the incidents more carefully. In addition, the prototype can be applied to group training, which helps development of firefighter teams. All members in a group can discuss their experiences as part of group training or collaborative learning in a FRS operation with involvement of the information provided by the prototype. Furthermore, the framework can be applied in other emergency services to provide debrief after an activity is conducted, to improve training, and to collect user experiences at the work place.
- **Domain ontology.** The domain ontology presented in this thesis is designed for fire RA which is a specific activity in FRS practice. However, our ontology construction methodology can be followed for development of any activity ontology. The knowledge sources obtained from the scenario-based method and the other knowledge sources collection methods can be used in ontology development when there is limited availability of domain experts, yet there are guides with descriptions how job activities can be performed. The RA ontology can be applied and extended in other FRS RA activities, e.g. building fire, rescue from height, by extending the scope and identifying which concepts and relationships are involved. By following the Activity-Theory-based approach described in this thesis it can be possible to conceptualise other activities in emergency services, e.g. police patrol, road traffic accidents. The AT-driven

methodology would enable capturing the contextual information and identifying the main concepts and relationships.

- **Dialogue model.** We have developed the dialogue model based on dialogue games with finite state machines to manage the dialogue. The dialogue model is aimed at supporting activity review and reflective learning. The input to the dialogue model is an activity ontology in OWL, dialogue game definitions, and dialogue move templates. Although the dialogue model is designed for a specific case study of fire risk assessment, the dialogue model can be adapted for reflective debrief on other activities by providing an appropriate ontology. The activity review episodes follow the sequence of actions as defined in domain ontology, and requires an appropriate API to query an OWL ontology. The DGs to collect the initial context are not dependent on the ontology, and would have to be reimplemented if the activity is changed. The reflection episodes are quite generic and can be applied to any job-related activity.

8.3. Contributions

This section will highlight the significance of the achievements in this thesis and the contribution of our work to the relevant research areas.

8.3.1. Contribution to Technology-Enhanced Learning

This thesis has presented a novel computational framework to support informal on-the-job training in work practice encompassing technology-enhanced learning environments. The use of TEL for informal workplace training is in the spot light of research that supports adult learning outside the formal curriculum. It is growing continuously in both research and educational software industry. There are several existing projects developing TEL solutions for informal, on-the-job training, such as APOSDLE (Lindstaedt, Ley et al. 2007), ALPS (Dearnley, Haigh et al. 2008), ImREAL (Hetzner, Steiner et al. 2011), KP-Lab (Paavola and Kai 2009), MIRROR (MIRROR 2010), MATURE (Schmidt 2005).

A key challenge to on-the-job training addressed in this thesis is to find creative ways for integrating training within the context of learner activities at the work practice. Adding to recent approaches which look at promoting reflection as the main training method, this thesis provides a new way of linking work practice and training by engaging the learner in a review-like dialogue which promotes reflection by revisiting the main aspects of a job activity the learner has conducted. The proposed reflective learning approach follows the concept of reflection-on-action (Schon 1983), which is facilitated by interruption episodes which prompt the

learner to reflect on their actions after the main mission of the work practice is complete.

8.3.2. Contribution to Artificial Intelligence in Education

This thesis has presented the design of a new intelligent pedagogical dialogue-based agent which performs a tutorial dialogue which uses semantic web technology to query an ontological model. The design of the intelligent dialogue agent follows an extensive review of existing methods for managing tutorial dialogues. We combine a dialogue game approach (Levin and Moore 1977; Dimitrova 2003c) and finite state machines approach (Jordan, Ringenberg et al. 2006) to implement our dialogue game-based management. The dialogue model is applicable to dialogues for activity review which include interruptions to facilitate reflection. Such dialogues are applicable to emergency services work practice to promote post-practice reflection (Katz, Connelly et al. 2007) or as debriefs on emergency incidents.

8.3.3. Contribution to Ontology Engineering

In our ontology creation, the ontology authoring tools, i.e. ROO (Denaux, Dimitrova et al. 2009) and Protégé (Horridge, Drummond et al. 2009), are used for coding a RA domain ontology. The knowledge sources obtained from the scenario-based method (see Table 4.3 in Chapter 4) and other knowledge sources collection method (see Table 4.4 in Chapter 4) in our methodology can be an alternative or a new way for specific domain development which has the following main characteristics: (a) very limited availability of domain experts involved; (b) general procedures explained in guides/manuals; (c) activity is complex and not clear about the dimensions; (d) author is not a domain expert and is unfamiliar with the domain; (e) author lacks experience in ontology engineering and needs more intuitive and efficient way to define the knowledge construction; (f) iterative design is needed because of author's unfamiliarity with the domain and inexperience in ontology engineering. Therefore, in this approach the author who creates a domain ontology but is not familiar with the domain, or has little or no experience in ontology engineering can benefit. The ontology conceptualisation follows the Activity Theory to help us understand the context in order to develop a conceptual model of an activity and to identify the concepts and relationships in the activity ontology.

8.4. Future Work

In the previous section we have outlined the main achievements and contributions of the thesis. This section will discuss possible improvements and outline future work. We will present: (a) immediate improvements of the PORML prototype; (b) possible

future improvement of the PORML framework; (c) more elaborated knowledge base using activity-based approach; (d) conducting an extended experimental study; (e) applying the PORML framework to other activities in emergency services.

8.4.1. Immediate improvement of the PORML prototype

Beyond the time limitation of PhD work, the prototype may be improved to (a) widen the activity scope; (b) extend the personalisation to particular user; (c) add support for more than one situation in an incident. The feedback from the experimental study with firefighters also identified immediate improvements, such as improving the interface. The immediately improvements of the PORML prototype can include the following:

- **Expanding the scope of the RA domain ontology.** The current scope is driven by a scenario of RA in chimney fire. Additional chimney fire scenarios can be followed to expand the concepts and relationships within the current activity scope. Furthermore, following the same approach, realistic scenarios involving other types of fire can be created, which will enable adding corresponding concepts and relationships for these fire types.
- **Extending the personalisation features.** The information of user profiles provided in the PORML prototype, such as first name, last name, login name, password, and address, was used to identify and authenticate the users. More information about the user can be added to the user profiles, such as physical abilities, cognitive abilities and the user cognitive model (e.g. general knowledge, work experiences). The extended user profile can be used to enhance the personalisation by tailoring the interaction to the user profile (e.g. a dialogue move can have several templates associated with it which depend on the learner's knowledge and experience, taken from the learner prototype).
- **Adding support for more than one situation in an incident.** Generally, risk assessment in practice is dynamic, meaning that the situation can change or develop during the incident. Following a dynamic approach, a crew manager will re-assess the situation approximately every 20 minutes (as pointed in an interview with project manager for South England Fire Control). This process is referred to as dynamic risk assessment. The current prototype is designed to support only reviewing the first situation of an incident (i.e. the first instance of a RA activity). To enable support for more than one situation, further actions must be added in the RA domain ontology, which identify what happens as the incident develops. These further actions will include additional control measures for assessing the risks in the next situation.

- **Extending the dialogue selection options.** As highlighted in the PORML evaluation, situations may differ and may not always fit in a box of user utterances. Users cannot describe a situation freely and in a way which corresponds completely and accurately to the actual situation. Therefore, the explanatory sentences in the agent feedback may not be clearly related to the actual situation. The information used to construct the options is pulled from concepts and their relationships in the RA domain ontology that are limited by our RA scope based on FRS manuals (GRA manual (HM Stationary Office 1998), fire service manuals (HM Stationary Office 2000; HM Stationary Office 2002), firemanship manuals (Great Britain Fire Department 1971)). An immediate improvement of the PORML prototype can be made by adding an option allowing the user to type free text input when the available options are insufficient. In this way, the users may be able to explain the situation more accurately. However, the texts entered by the users would have to be analysed regarding its meaning, which requires appropriate natural language processing methods.

8.4.2. Possible future extension of the PORML framework

The results from the evaluation with end users point at future improvements of the PORML prototype, such as considering the user past experiences, adding text analysis, adding a dialogue summary, adding a summary of work practice, linking to e-portfolio.

- **User past experiences (activities).** The user current activity can be extended for the past experience involvement by recording the User Current Activity model as the user past activity. The dialogue agent will have to check information from both User Current Activity model and User Past Activity model for enhancement of dialogue interactions. For example, the past activity and the current activity can be compared to point the user to actions they have already performed or to activity aspects which they tend to overlook.
- **Text analysis.** If a user is given an option to type a free answer, the dialogue agent must have the capability to employ natural language processing and use the result of it to relate to knowledge concepts. The dialogue agent could also have another dialogue game to add new concepts into the RA domain ontology. For instance, if the result of natural language processing from a user sentence points to another hazard of a fire RA which differs from the five hazards in the existing RA ontology, the dialogue game can confirm with the user whether this is an important hazard and should be included in future interactions. If the user confirms, the new hazard concept can be added into the RA domain ontology.

However, it is a risk to open up the domain ontology to freely add new concepts based on the dialogue with users (e.g. users may be inexperienced and may express subjective opinions that are not shared with other users). The prototype must contain a process for the new hazard concept to be validated by experts in the area before actually adding the concept into the RA domain ontology. The capability of analysing the texts using natural language processing and adding the knowledge concepts during dialogue interaction might be the possible future improvement of the prototype or could be a challenge of another PhD research for analysing the texts in the area of natural language processing.

- **Adding dialogue summary.** As point out in the PORML evaluation, a useful extension would be to add a summary of the dialogue at the end of the interaction. Although the PORML prototype keeps a record of the dialogue interaction in a log file, there is no option to end the dialogue with a summary of what has been discussed. The whole dialogues may contain a considerable amount of information, which the user may not remember and may not be able to grasp the key points. Further improvement of the PORML prototype could include some analysis of the dialogues log to extract the crucial points and bring them to the attention of the user in a summary. Although the benefit of this feature is apparent, its implementation requires further research. One way to approach this may be to collect example interactions with the current prototype and to identify all aspects that could be indicated from the log files of these interactions.
- **Summary of practice.** After an incident is complete, an incident commander can use the PORML prototype to record the incident contexts. It could be possible for the contextual information regarding the incident to be summarised and linked to Google Maps for reference and use afterwards. This application could be used to inform the incident commander when a future incident occurs near this location. It could help increase the awareness in dealing with fire, RA or other FRS activity e.g. by identifying commonly occurring pattern (e.g. activity aspects that tend to be overlooked across activities and across users).
- **Link to e-portfolio.** The PORML prototype might be used to create an e-portfolio that keeps incident commander's reflective writing and associated evidence for incidents. This e-portfolio could help firefighters' development e.g. enhancing lifelong learning, stimulating reflection and deep learning etc.

8.4.3. More elaborated knowledge base using activity-based approach

Our knowledge base using activity-based ontological model is designed with the limitation of a case study for chimney fire risk assessment (RA) in Fire and Rescue

Services (FRS) domain with specific constraints addressed in the process of ontological methodology. The ontological model can be extended as follows:

- **Adding other fire types related to the RA activity.** The ontological RA model for other RA types of Fighting Fires group in Generic Risk Assessment (GRA) (HM Stationary Office 1998), such as building fire, rural area fire, public entertainment venue fire, secure accommodation fire, can be expanded by using the gathered knowledge sources addressed in Table 4.4 in Chapter 4, Section 4.3.3 without the use of additional interview, questionnaire and scenarios because the core structure of activity-based ontological model (activities, actions, operations, control measures) designed in hierarchical way seems to be the same pattern and most additional knowledge data can be collected and analysed from the GRA manual.
- **Adding activities of other groups in GRA.** Activities for other groups in GRA, such as Responding to an Emergency group (turning out, proceeding to an incident), Rescues group (rescue from height, rescue from lift and escalators), Incidents Involving Transport Systems group (road traffic accident, railways, aircraft), Generic Hazards group (electricity, acetylene, explosives), could be added by following the gathered knowledge sources addressed in Table 4.4 in Chapter 4, Section 4.3.3. with the expansion will also require additional interviews, questionnaire and scenarios for other activity groups, because certain core concepts or classes of those groups might be differently arranged in the core structure using Fighting Fires group.
- **Fixing the problem concerning the language use.** The components of dialogue construction are mostly derived from knowledge description (or description of classes) in the RA domain ontology. Therefore, language use in the RA domain ontology affects the dialogue and should be further refined. It is possible that a native English speaker or an English expert might be involved in language improvement in the RA domain ontology. It would be even better if the expert is an experienced firefighter who can facilitate language use in FRS practice.
- **More axioms to enrich the queries:** More axioms could be considered and added to the ontological model in order to enrich the queries from performing ontological inference model and improve the smartness of the PORML dialogue agent. For instance, additional axioms can be added to define relationships among specific building types, topographic feature object (building or place) properties depending on location, and specific activity type. A major limitation of the RA ontological model is that the logical model does not represent time. This hinders the handling of dynamicity (e.g. performing instances of RA

activities as part of dynamic risk assessment). Adding time requires future research of how to represent, capture, and query time dimensions.

8.4.4. Conducting an extended experimental study

The design concept of PORML framework was studied and only validated by the results of summative evaluation to prove that it was an interesting issue to firefighters in an organisation. The PORML framework may be used in future empirical studies which examine the learning effect and the acceptance of the new technology.

- **Learning effect.** The results of summative evaluation with a group of firefighters showed that the prototype was suitable for RA training in FRS work practice, and could be applied for self and personal training, group training or collaborative learning, learning and training needs, and improving effectiveness of the current training. However, further experimental study is needed to examine the effectiveness of training when using the PORML prototype. One way to address this is to consider the learning effect, based on pre and post knowledge and confidence assessment, and skill/ability change survey (Curran, Lockyer et al. 2006). The results from the pre and post knowledge and confidence assessment, and skill/ability change survey can be analysed in terms of effect size as a “*measure of educational importance of any performance changes produced*” (Spencer 1991), which is calculated by the use of the average score difference of pre and post scores (Curran, Lockyer et al. 2006).
- **Technology acceptance model framework.** The technology acceptance model (TAM) is a theory in information systems which models how users come to accept and use a technology. The theoretical framework of TAM can be seen on (Venkatesh 2008). TAM suggests that when users are presented with a new information technology, a number of factors influence their decision about how, why and when they will adopt and use it in the workplace (Venkatesh 2008). TAM provides two technology acceptance measures: usefulness and ease of use (Davis 1989; Davis, Bagozzi et al. 1989). The determinants of perceived usefulness and determinants of perceived ease of use can be examined to determine the technology acceptance for the PORML framework considering, for instance, its robustness, validity and reliability.

8.4.5. Applying PORML to other activities in emergency services

Further extension of the PORML framework can expand and test it to other activities in emergency services, including other activities in FRS, as well as activities in other emergency services.

- **Other activities in FRS.** In an incident, firefighters not only deal with risk assessment of the situation, but also have to carry out other activities to achieve the goal of operational FRS, e.g. fire extinguishing or rescue. If the result of fire RA is safe enough (low risk), the incident commander will normally send the fire crew to extinguish the fire or rescue any endangered people. Although the PORML framework is illustrated with a prototype in a RA activity, it is possible to apply the activity concept to cover fire extinguishing and rescue services. It may be possible to either expand the RA domain ontology to cover fire extinguishing and rescue services, or to create a new domain ontology for fire extinguishing and rescue activity which can be used in collaboration with the RA domain ontology.
- **Activities in other emergency services:** The practices of emergency services are dynamic and often depending on location and activity context. The PORML framework seems applicable to activities in other emergency services, where training can benefit from a post-practice activity review. For instance, in the police domain activities where PORML might be applied include review with reflection for police patrol, review with reflection for dealing with crime incidents in an urban area. In medical services domains, PORML might be applied for review with reflection for urgent care practice or review with reflection for nurse practice. The research methodology followed in this thesis can be followed. Further research is required to test the applicability of PORML in other emergency services.

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Appendix - A

A-1 Authentic Accident Description from Cambridgeshire FRS

This appendix provides information of a real incident record on 28 March 2008 from Cambridgeshire FRS. We adapt this incident record for creating our scenario. The table shows the detail of this incident record and we also provide additional information for the incident place “Six Bells” public house to illustrate its location and surroundings using Google Maps below.

Chimney fire – Fulbourn – South Cambs

28 March 2008, 7.37pm

Two crews from Cambridge and a turntable ladder from Cambridge were called to a chimney fire at the Six Bells public house on the High Street in Fulbourn.

This is a thatched property.

Crews used the turntable ladder to extinguish the fire and to dampen down the thatch.

They inspected the roof void and first floor with a thermal imaging camera to ensure there were no further hotspots which could reignite and returned to base by 8.49pm.

The cause of the fire was accidental.



Using Google Maps – Sattelite and Walking Street
to show the location of “The Six Bells”

A-2 Generic Scenario of Use of Reflective Dialogue for On-the-job Training in Operational FRS Work Practice

An incident occurs at a place called incident place. The firefighters are called for attending the incident. A few minutes later, a crew of firefighters with fire vehicle and fire equipment arrive at the incident. The incident place name, the type of incident (e.g. building fire, road traffic accident, rural area fire) and the context (e.g. weather conditions, traffic condition, people surrounding, time etc.) are checked and recorded. The crew commander, a member of the crew, and his colleagues spend a few minutes to perform some initial actions for that incident depending on the type of incident (e.g. obtain information from fire control station etc.).

The crew commander assesses the risk of hazards in the incident from his experiences and knowledge for another few minutes to perform the task (e.g. fire actions, rescue people). He assesses all hazards relating to the type of incident, and then makes a decision. If the hazards are low risk and safe enough for the crew, he can take actions by sending his colleague to dealing with fire or rescue people. This is an offensive mode. The necessary equipment, relating to low risk, could be used to deal with the task (e.g. hose reel, thermal imaging camera, eye protection etc.). In contrast, if the hazards are medium or high risk, the defensive mode could be used until the low risk is met by reducing risk procedure. Assuming that fifteen minutes later, all fires are able to be extinguished and no more risk assessment activity for next situation is required. So, the main mission of dealing with this incident is complete.

A few minutes later (e.g. 15 minutes) a crew commander uses a smart-phone, providing GPS receiver to detect location, to review and reflect on the recent risk assessment activity. It is assumed that he is still near the incident place in range of 'Maximum Distance from Mobile' (see Chapter 3, Figure 3.7) that can detect the incident place. He uses a browser on the smart-phone and goes to the PORML address URL. The PORML dialogue agent prompts for entering login name and password. After the authentication succeeds, the dialogue agent will check the buildings and places surrounding the smart-phone location and issue the list of place names inside the 'PORML Working Area'. He chooses one of them which is an incident place. The dialogue agent will check the buildings and places surrounding the incident place location and extract the properties of these buildings and places inside the 'Interest Area' for later use in risk calculation. Then, the dialogue agent will ask the type of incident (e.g. building fire, road traffic accident, chimney fire) and he chooses a type of incident. Then the dialogue agent will start the dialogue interaction episodes.

The first episode called 'CollectContextInformationDG' will be used to collect more contextual information e.g. wind, sunny, start time and end time of incident etc. The second episode called 'InitialActionDG' will be used to review his recent initial actions and will provide feedback and reflection during interaction. Other episodes (see Chapter 5, Figure 5.1) will be used to review and reflect the actions in the operational FRS practice such as actions for control measures, identifying the risk, assessing the risk, issuing tactical mode and system of work, suggesting the additional control measures for risk reduction. The crew commander spends time around 15 – 30 minutes to complete the reflective on-the-job training.

Appendix - B

Knowledge Glossary Table

This appendix will provide the list of knowledge glossary of risk assessment concepts which are related to the defined scope.

Term	Concept	Synonym	Natural Language Description	Source
Acceptance Point	Secondary Concept		A place where fire calls are received. Normally located in the Mobilising Control.	HO Manual – Fire Service Training Manual
Aerial Ladder Platform	Secondary Concept	Aerial Appliance	An aerial appliance consisting of hydraulically operated booms, the first boom having telescopic sections with an operator cage at the upper end. Appliances range in size, can be operated from the cage or console, elevated and rotated through 360 degree. Full size ladders attached to the booms offer a continuous rescue capability.	HO Manual – Fire Service Training Manual
Ambulance	Secondary Concept		A vehicle for taking sick or injured people to and from hospital	Oxford English Dictionary
Analytical Risk Assessment	Secondary Concept		A formalised assessment of the hazards, who or what is at risk from those hazards, the likelihood and severity of risk	Fire Service Manual Volume 2 (Incident Command)
Appliance	Core Concept		Any Fire Service operational vehicle	HO Manual of Firemanship (Ladders and Appliances)
Asbestos	Core Concept		A naturally occurring silicate mineral with long, thin fibrous crystals.	A Guide to Operational Risk Assessment
Bad Visibility	Core Concept		Bad visibility	-
Blow Back	Core Concept		When water reaches the seat of a chimney fire, steam is generated. The steam then rises and leaves the chimney, normally at the highest point. The velocity at which the steam will leave the chimney depends on the size of the fire and the amount of water used. There is a danger that personnel who are working close to the chimney pot or other outlet e.g. open vent will receive scald injuries.	A Guide to Operational Risk Assessment
Breathing Apparatus	Core Concept	BA	(1) An apparatus which is used to take air into the lungs and send it out again./ (2) An apparatus which is provided with its own supply of oxygen or compressed air, designed to enable the wearer to breathe in irrespirable atmospheres.	(1) Oxford English Dictionary/ (2) HO Manual - Fire Service Training Manual
Building	Core Concept		A structure that has a roof and walls and stands more or less permanently in one place.	WordNet
Building Fire	Secondary Concept		A type of fighting fire involving building.	A Guide to Operational Risk Assessment
Bus Station	Secondary Concept		A structure where city or intercity buses stop to pick up and drop off passenger.	Wikipedia
Carbondioxide Fire Extinguisher	Secondary Concept		An extinguisher containing liquid carbon dioxide (CO ₂), which is released as a gas on the actuation of the extinguisher.	HO Manual – Fire Service Training Manual
Cage	Secondary Concept		The personnel carrying compartment fitted to the topmost boom of a hydraulic platform or turntable ladder.	HO Manual of Firemanship (Ladders and Appliances)
Car Park	Core Concept		A clear area or place that is more or less level and is intended for parking vehicles.	Wikipedia
Church	Core Concept			
Chimney	Core Concept		(1) A vertical pipe which takes smoke and gases up from a fire or furnace./ (2) A vertical flue that provides a path through which smoke from a fire is carried away through the wall or roof of a building	(1) Oxford English Dictionary/ (2) WordNet
Chimney Breast	Secondary Concept		A part of an inside wall that comes out to surround a chimney	Oxford English Dictionary

Term	Concept	Synonym	Natural Language Description	Source
Chimney Component	Secondary Concept		Chimney component	-
Chimney Fire	Core Concept		A type of fighting fire. The combustion of residue deposits referred to as creosote, on the inner surfaces of chimney tiles, flue liners, stove pipes, etc.	Wikipedia/ A Guide to Operational Risk Assessment
Chimney Gear	Secondary Concept		Chimney gear	A Guide to Operational Risk Assessment
Chimney Kit Box	Secondary Concept		Chimney kit box	A Guide to Operational Risk Assessment
Chimney Pot	Secondary Concept		A pipe at the top of a chimney	Oxford English Dictionary
Chimney Rods	Secondary Concept		Jointed rods to which the tubing of a stirrup pump or hose reel can be connected for dealing with chimney fires.	HO Manual – Fire Service Training Manual
Chimney Stack	Secondary Concept		The part of a chimney that sticks up above a roof	Oxford English Dictionary
Command	Secondary Concept		The authority for an agency to direct the actions of its own resources (both personnel and equipment)	Fire Service Manual Volume 2 (Incident Command)
Commander	Core Concept		An officer who is in charge of a group of fire crew or particular fire activity	Adapted from Longman Dictionary of Contemporary English
Command Support	Secondary Concept		A role undertaken by one or more staff at an incident, the role typically provides recording, liaison, detailed resource management and information gathering for the Incident Commander. At large incidents Command Support may comprise a dedicated team working from a mobile command unit and may include individuals tasked with supporting Sector Commanders.	Fire Service Manual Volume 2 (Incident Command)
Congested Traffic Road	Core Concept		Congested traffic road	-
Control Measures	Core Concept		An intervention technique to reduce risk. This could include the use of PPE, BA, specialist equipment and safety officer(s) etc.	HO Manual – Dynamic Management of Risk at Operational Incidents
Control Unit	Core Concept		A vehicle equipped as a mobile control room for use by the Officer-in-Charge at large incidents. Usually equipped with radio and, sometimes, field telephones. Normally identified by red and white chequered markings.	HO Manual – Fire Service Training Manual
Crew	Core Concept		A crew comprises a body or a class of people who work at a common activity, generally in a structured or hierarchical organisation.	Wikipedia
Crew Member	Core Concept		A member of a crew	-
Crew Commander	Core Concept		An officer or firefighter tasked with supervising specific tasks or meeting specific objectives utilising one or more firefighters.	Fire Service Manual Volume 2 (Incident Command)
Crowd of People	Core Concept		A large number of people who gathered together.	Oxford English Dictionary
Date	Core Concept		Date	-
Day	Core Concept		Day	-
Decontamination	Concept		The process of removing dangerous substances from a person's body, clothing or equipment.	HO Manual of Firemanship (Ladders and Appliances)
Defensive Mode	Core Concept		This is where the operation is being fought with a defensive approach. In defensive mode, the identified risks outweighs the potential benefits, so no matter how many additional control measures are put into place the risks are too great. In these circumstances the incident commander would announce defensive mode, fight the fire with ground monitor jets and aerial jets, and protect exposure risks and adjoining property without committing crews into the hazard area.	Fire Service Manual Volume 2 (Incident Command)
Delivery Hose	Secondary Concept		Hose used on the delivery side of the pump. The standard sizes are 45 mm, 70 mm and 90 mm	HO Manual – Fire Service Training Manual

Term	Concept	Synonym	Natural Language Description	Source
Defensive Mode	Core Concept		This is where the operation is being fought with a defensive approach. In defensive mode, the identified risks outweighs the potential benefits, so no matter how many additional control measures are put into place the risks are too great. In these circumstances the incident commander would announce defensive mode, fight the fire with ground monitor jets and aerial jets, and protect exposure risks and adjoining property without committing crews into the hazard area.	Fire Service Manual Volume 2 (Incident Command)
Delivery Hose	Secondary Concept		Hose used on the delivery side of the pump. The standard sizes are 45 mm, 70 mm and 90 mm	HO Manual – Fire Service Training Manual
Drunk People	Core Concept		People who are drunk or who often drink too much.	Adapted Meaning
Dynamic Risk Assessment	Core Concept	DRA	The continuous assessment of risk in the rapidly changing circumstances of an operational incident, in order to implement the control measures necessary to ensure an acceptable level of safety. Dynamic Risk Assessment is only appropriate during the time critical phase of an incident which is usually typical of the arrival and escalation phase of an incident. At the earliest opportunity the Dynamic Risk Assessment should be supported by a more analytical risk assessment.	Fire Service Manual Volume 2 (Incident Command)
Emergency Response	Concept	E-Response, Emergency Services	Official organisations such as police, fire service, ambulance	-
Emergency Tender	Secondary Concept		An appliance carrying specialised equipment for use at special services.	HO Manual – Fire Service Training Manual
End Point	Secondary Concept		End point	-
Extension Ladder (13.5 m with props)	Secondary Concept		A three-section ladder with jacks, plumbing gear and supporting props. Extended by means of a line.	HO Manual – Fire Service Training Manual
Extension Ladder (7, 9 or 10.5 m)	Core Concept		A two-section ladder extended by means of a line.	HO Manual – Fire Service Training Manual
Eye Protection	Core Concept		Eye protection	A Guide to Operational Risk Assessment
Fall Arrest Systems	Secondary Concept		Fall arrest systems	A Guide to Operational Risk Assessment
Falling Masonry	Core Concept		It is often the case that, particularly with older property, the linings of the chimney can spall away from the flue and fall to the hearth. In addition, there is a risk that chimney brickwork and pots will become dislodged and fall to the ground during firefighting activities. Chimney pots have been known to break up, with explosive effect, on the application of water and have caused serious injury to personnel on the roof.	A Guide to Operational Risk Assessment
Farm Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
Field	Secondary Concept		Field	-
Fighting Fire	Core Concept		A category of generic or operational risk assessment (there are five categories: responding to emergencies, carrying out rescues, fighting fires, incidents involving transport, generic hazards)	A Guide to Operational Risk Assessment
Fire and Rescue Services	Core Concept	FRS, Fire Brigade, Fire Department	Fire department	-

Term	Concept	Synonym	Natural Language Description	Source
Fire Apparatus	Core Concept		Fire apparatus	-
Fire Appliance	Core Concept		Any fire service operational vehicle	Manual of Firemanship – Ladders and Appliances
Fire Brigade	Core Concept	Brigade	An organised body of firefighters employed to put out fires	Oxford English Dictionary
Fire Danger Area	Core Concept		Fire Danger area	-
Fire Engine	Secondary Concept		Fire engine	-
Fire Equipment	Core Concept		Any fire service operational equipment	-
Fire Evacuation Area	Core Concept		Fire evacuation area	-
Fire Extinguisher	Core Concept		(1) A portable device that discharges a jet of liquid, foam, or gas to put out a fire./ (2) An active fire protection device used to extinguish or control small fires, often in emergency situations.	(1) Oxford English Dictionary/ (2) Wikipedia
Fire Kit	Core Concept	Firefighting Kit	Fire kit	A Guide to Operational Risk Assessment
Fire Obstruction Area	Core Concept		Fire obstruction area	-
Fire Officer	Core Concept		A senior ranking firefighter or fire safety inspector in the UK	Wikipedia
Fire Pump	Core Concept		Fire pump	-
Fire Portable Pump	Secondary Concept		Fire portable pump	-
Fire Safety Area	Core Concept		Fire safety area	-
Fire Spread	Core Concept		Fire can spread externally from a chimney fire due to flying sparks and brands. This is a particularly serious problem if surrounding buildings or crops are readily combustible, e.g. thatched property, standing corn. Fire may also travel through the elements of structure that are adjacent to the chimney. This internal spread can occur undetected through concealed voids within the building e.g. under the hearth.	A Guide to Operational Risk Assessment
Fire Station	Core Concept		Fire station	-
Fire Vehicle	Core Concept		Fire vehicle	
Firefighter	Core Concept	Fireman	A person whose job is to put out fires	Oxford English Dictionary
Fireground	Core Concept		The area in which firefighting operations are in progress.	HO Manual – Fire Service Training Manual
Fireplace	Secondary Concept		A special place in the wall of a room, where you can make a fire	Longman Dictionary of Contemporary English
Fireman	Core Concept	Firefighter	A person whose job is to put out fires	Oxford English Dictionary
First-Aid Box	Core Concept		The medical first-aid box carried on appliances.	HO Manual – Fire Service Training Manual
Foam	Core Concept		The product of a mixture of foam concentrate, water and air	HO Manual – Fire Service Training Manual
Foam Fire Extinguisher (gas cartridge)	Secondary Concept		An extinguisher from which mechanical foam is expelled by pressure from a cartridge of compressed gas attached to or fitted into the extinguisher.	HO Manual – Fire Service Training Manual

Term	Concept	Synonym	Natural Language Description	Source
Foam Fire Extinguisher (stored pressure)	Secondary Concept		An extinguisher from which mechanical foam is expelled by pressure stored within the body of the extinguisher as a whole.	HO Manual – Fire Service Training Manual
Fragile Ceiling Material	Secondary Concept		Fragile ceiling material	-
Fragile Roof	Secondary Concept		Fragile roof	-
Freeze	Core Concept		Freeze	-
Full Fire Kit	Core Concept		Full fire kit	A Guide to Operational Risk Assessment
Gaining Access to an Working on the Roof	Core Concept		An operation activity described in 'A Guide to Operational Risk Assessment' is to consider hazards and risks for gaining access to and working on roof. It contains two significant hazards, 'Falling Masonry', 'Roof Conditions'.	A Guide to Operational Risk Assessment
Garage	Core Concept		A building for keeping a car in, usually next to or attached to a house	Longman Dictionary of Contemporary English
Generic Risk Assessment	Core Concept	GRA, Operational Risk Assessment	Due to the size and nature of the Fire Service there are a wide range of activities to cover, potentially making risk assessment a very time-consuming activity. To minimise this and avoid the "reinventing of the wheel", or even worse having and inconsistent approach and outcomes, generic risk assessment have been produced to help brigades in their response to regulatory requirements.	A Guide to Operational Risk Assessment
Gloves	Secondary Concept		Gloves	A Guide to Operational Risk Assessment
Good Visibility	Core Concept		Good visibility	-
Grate	Secondary Concept		(1) A metal frame preventing coal or wood from falling out of a fireplace./ (2) A frame of an iron bars to hold fuel for a fire	(1) Oxford English Dictionary/ (2) Wikipedia
Harm	Core Concept		This includes death, injury, physical or mental ill-health, damage to property, loss of production/service, or any combination of these.	HO Manual – Dynamic Management of Risk at Operational Incidents
Hazard	Core Concept		Something with the potential to cause harm. This could be anything from a slippery domestic kitchen floor to a radiation leak from a nuclear reactor.	HO Manual – Dynamic Management of Risk at Operational Incidents
Hazardous Substances	Core Concept		As with any fire, toxic fumes will be produced by the heating or burning of materials including such substances as Man Made Mineral Fibre (MMMF). Fire fighters also risk incidental exposure to asbestos during both firefighting and cutting away operations.	A Guide to Operational Risk Assessment
Hearth	Secondary Concept		A brick- or stone-lined fireplace or oven used for cooking and/or heating.	A Guide to Operational Risk Assessment
Hearth Kit	Core Concept		A kit of tools required for dealing with hearth fires and cutting away.	HO Manual - Fire Service Training Manual
Helmet Visor	Secondary Concept		Helmet visor	A Guide to Operational Risk Assessment
High Level Likelihood	Core Concept		The level of likelihood is high	-
High Level Severity	Core Concept		The level of severity is high	-

Term	Concept	Synonym	Natural Language Description	Source
High Rise Building Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
High Risk	Core Concept		The rating or level of risk is high	-
High Wind	Core Concept		The level of wind is high	-
Hook Ladder	Core Concept		A short ladder with a hook at one end by which it can be suspended for climbing.	HO Manual of Firemanship (Ladders and Appliances)
Hose	Core Concept		A hollow tube designed to carry fluids from one location to another.	Wikipedia
Hose Reel	Core Concept		Fitted to appliances and used to deal with small fires. Water carried in a tank on an appliance is pumped through 20 mm bore rubber hose at high or low pressure. The hose is wound on a revolving reel and has small diameter nozzles or fog/spray nozzles attached to the end.	HO Manual – Fire Service Training Manual
Hour	Core Concept		Hour	-
House	Core Concept		House	-
Hydraulic Platforms	Core Concept	H.P.	An appliance carrying two hydraulically operated booms with a cage attached at the upper end. Larger sizes have an additional short boom from the upper main boom. The booms can be operated either from the turntable or from the cage and can be rotated through 360 degrees. The cage is fitted with a monitor and can also be used for rescue purposes.	HO Manual – Fire Service Training Manual
Garage Service	Core Concept		Garage	-
Incident	Core Concept		Incident	-
Incident Commander	Core Concept		The officer having overall responsibility for dictating tactics and resource management. Overall responsibility for a fire remains with the senior fire brigade officer present under the Fire Service Act Section 30(3), but subject to this a more junior officer may retain the role of Incident Commander.	Fire Service Manual Volume 2 (Incident Command)
Incident Control	Secondary Concept		A site, possibly a mobile Control Unit, which acts as a focus for communications and command at an operational incident.	HO Manual – Fire Service Training Manual
Incident Ground	Core Concept		The area in which fire service operations are taking place. This may, or may not involve a fire.	HO Manual – Fire Service Training Manual
Incident People	Secondary Concept		People at the incident	-
Incident Place	Core Concept		Incident place	-
Ladder	Core Concept		Steps consisting of two parallel members connected by rungs; for climbing up or down	WordNet
Light Water Foam	Secondary Concept	AFFF, FFFP	An extinguishing medium having the ability to assist water to float on the surface of flammable liquids and provide a seal to prevent re-ignition.	HO Manual – Fire Service Training Manual
Likelihood	Core Concept		The degree to which something can reasonably be expected to happen	Longman Dictionary of Contemporary English
Low Level Likelihood	Core Concept		The level of likelihood is low	-
Low Level Severity	Core Concept		The level of severity is low	-
Low Risk	Core Concept		The rating or level of risk is low	-
Low Wind	Core Concept		The level of wind is low	-
Man-Made Mineral Fibre Material	Core Concept	MMMF Material	Man-made mineral fibre material	A Guide to Operational Risk Assessment

Term	Concept	Synonym	Natural Language Description	Source
Medium Level Likelihood	Core Concept		The level of likelihood is medium	-
Medium Level Severity	Core Concept		The level of severity is medium	-
Medium Risk	Core Concept		The rating or level of risk is medium	-
Minute	Core Concept		Minute	-
Mirror	Core Concept		Mirror	A Guide to Operational Risk Assessment
Mobilising Control	Secondary Concept		A permanently staffed and fully equipped room on Fire Service premises in which emergency calls are received and subsequent action taken to mobilise personnel, appliances and equipment.	HO Manual – Fire Service Training Manual
Month	Core Concept		Month	-
Narrow Road	Secondary Concept		Narrow road	-
Negative Pressure Ventilation	Secondary Concept		NPV refers to extracting the smoke and hot gases from the outlet vent. This will have the effect of reducing the pressure inside the building, relative to the atmospheric pressure. It can be achieved by fans or water sprays.	HO Manual of Firemanship (Tactical Ventilation of Buildings and Structures)
Non Fireground	Secondary Concept		Non fire ground	-
Non Service Personnel Group	Core Concept		Non service personnel group	A Guide to Operational Risk Assessment
Off-Peak Time	Core Concept		Off-Peak time	-
Offensive Mode	Core Concept		This is where the operation is being tackled aggressively. The incident commander will have established that the potential benefits outweighs the identified risks, so the incident commander will be committing crews into a relatively hazardous area, supported by appropriate equipment, procedures and training. An offensive approach is appropriate when identified risks are managed by additional control measures. Offensive mode is the normal mode of operation used at, for example, house fire, road traffic accidents and industrial premises to fight the fire, effect rescues, or close down plant etc.	Fire Service Manual Volume 2 (Incident Command)
Operational Risk Assessment	Core Concept	Generic Risk Assessment	Risk assessment in operations Due to the size and nature of the Fire Service there are a wide range of activities to cover, potentially making risk assessment a very time-consuming activity. To minimise this and avoid the “reinventing of the wheel”, or even worse having and inconsistent approach and outcomes, generic risk assessment have been produced to help brigades in their response to regulatory requirements.	A Guide to Operational Risk Assessment
Peak Time	Core Concept		Peak time	-
Person	Core Concept		Person	-
Personnel Protective Equipment	Core Concept		Personnel protective equipment	A Guide to Operational Risk Assessment

Term	Concept	Synonym	Natural Language Description	Source
Petrol Station	Secondary Concept		Petrol station	-
Place	Core Concept		Place	-
Police	Secondary Concept		An official body of people employed by a state to prevent and solve crime and keep public order	Oxford English Dictionary
Portable Pump	Secondary Concept		A self-contained portable pumping unit.	HO Manual – Fire Service Training Manual
Positive Pressure Ventilation	Secondary Concept	PPV	PPV can be achieved by forcing air into a building using a fan. The effect of this will be to increase the pressure inside, relative to atmospheric pressure. PPV simply refers to blowing air in through the inlet vent.	HO Manual of Firemanship (Tactical Ventilation of Buildings and Structures)
Positive Pressure Ventilation Fighting Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
Powder Fire Extinguisher (gas cartridge)	Secondary Concept		An extinguisher containing powder which is expelled by pressure from a cartridge of gas, attached to, or fitted into the extinguisher.	HO Manual – Fire Service Training Manual
Powder Fire Extinguisher (stored pressure)	Secondary Concept		An extinguisher containing powder which is expelled by pressure stored within the body of the extinguisher as a whole.	HO Manual – Fire Service Training Manual
Public Entertainment Venue Fire	Secondary Concept		A type of fighting fire.	A Guide to Operational Risk Assessment
Public House	Core Concept		The formal name for a pub in Britain which is a drinking establishment licensed to serve alcoholic drinks for consumption on or off the premises in countries and regions of British influence	Wikipedia
Public Group	Core Concept		Public group	-
Pump (appliance)	Core Concept		A self-propelled appliance having a built in pump with a minimum capacity of 2270 l/mm. carries either a 7, 9 or 10.5 m extension ladder and hose-reel equipment with a minimum tank capacity of 1370 litres.	HO Manual – Fire Service Training Manual
Rain	Core Concept		Rain	-
Refuse Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
Register Plate	Secondary Concept		Register plate	HO Manual of Firemanship Book 11
Restaurant	Secondary Concept		Restaurant	
Resuscitation Apparatus	Secondary Concept		An apparatus for supplying oxygen or a mixture of oxygen and air to a person needing artificial respiration.	HO Manual – Fire Service Training Manual
Retained Group	Core Concept		Retained group	A Guide to Operational Risk Assessment
Risk	Core Concept		A measure of the likelihood that the harm from a particular hazard will occur, taking into account the possible severity of the harm.	HO Manual – Dynamic Management of Risk at Operational Incidents

Term	Concept	Synonym	Natural Language Description	Source
Risk Assessment	Core Concept		(1) A risk assessment involves an identification of hazards, and an estimation of the risks, taking into account the existing precautions available and used, and a consideration of what else needs to be done./ (2) The process of analysing the level of risk, considering those in danger and evaluating whether hazards are adequately controlled, taking into account any existing control measures.	(1) Fire Service Manual Volume 2 (Incident Command)/ (2) HO Manual – Dynamic Management of Risk at Operational Incidents
Risk Assessment Activity	Core Concept		Activity for risk assessment	-
Risk Assessment Action	Core Concept		Action for risk assessment	-
Risk Assessment operation	Core Concept		Operation for risk assessment	-
Risk Group	Core Concept		Risk group	A Guide to Operational Risk Assessment
Risk Rating	Core Concept		The level of assessed risk measured in high, medium and low risk	-
Road	Secondary Concept		Road	-
Role	Core Concept		Role	-
Roof	Core Concept		(1) The upper covering of a building or vehicle./ (2) The covering of the uppermost part of a building	(1) Oxford English Dictionary/ (2) Wikipedia
Roof Conditions	Core Concept		There will often be occasions when dealing with chimney fires that personnel will have to work from the roof. Causes of serious injury when working on roofs include: (1) falling through fragile roofs (2) falling off the roof due to the slippery surface and lack of fall protection (3) using a weak chimney stack as an anchorage which subsequently fails (4) equipment, roofing material and debris falling onto people below. Hazards within the roof space include: (1) trip hazards (2) live electrical apparatus (3) exposed ceiling joists (4) fragile ceiling materials (5) possibility of nesting insects (bees, wasps, etc) (6) fibrous insulation e.g. asbestos.	A Guide to Operational Risk Assessment
Roof Ladder	Core Concept		A small, portable ladder used for working on roofs.	HO Manual of Firemanship (Ladders and Appliances)
Roof Slippery Surface	Secondary Concept		Roof slippery surface	A Guide to Operational Risk Assessment
Roof Space Exposed Ceiling Joist	Secondary Concept		Roof space exposed ceiling joist	A Guide to Operational Risk Assessment
Roof Space Fibrous Insulation	Secondary Concept		Roof space fibrous insulation	A Guide to Operational Risk Assessment
Roof Space Live Electrical Apparatus	Secondary Concept		Roof space live electrical apparatus	A Guide to Operational Risk Assessment
Roof Space Nesting Insect	Secondary Concept		Roof space nesting insect	A Guide to Operational Risk Assessment
Roof Space Trip Hazard	Secondary Concept		Roof space trip hazard	A Guide to Operational Risk Assessment
Rural Area Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
Safe Systems of Work	Core Concept		(1) A formal procedure which results from systematic examination of a task in order to identify all the hazards and risks posed. It defines safe methods to ensure that hazards are eliminated or risks controlled as far as possible.	(1) Fire Service Manual Volume 2 (Incident Command)/ (2) A Guide to Operational Risk Assessment
Safety	Core Concept		A state where exposure to hazards has been controlled to an acceptable level.	Fire Service Manual Volume 2 (Incident Command)
Safety Device	Core Concept		A mechanical device incorporating a line and a belt. The device must be attached to the head of a TL or HP or to the anchorage of a drill tower.	HO Manual – Fire Service Training Manual

Term	Concept	Synonym	Natural Language Description	Source
Safety Officer	Core Concept		Officer delegated specific responsibility for monitoring operations and ensuring safety of personnel working on the incident ground or a designated section of it.	Fire Service Manual Volume 2 (Incident Command)
Secure Accommodation Fire	Secondary Concept		A type of fighting fire	A Guide to Operational Risk Assessment
Severity	Core Concept		The degree of something undesirable e.g. pain, weather etc.	WordNet
Situation	Core Concept		Situation	-
Shop	Core Concept		Shop	-
Short Extension Ladder	Secondary Concept		A light ladder in two sections extending to approximately 4 metres.	HO Manual – Fire Service Training Manual
Snow	Core Concept		Snow	-
Special Fire Area	Secondary Concept		Special fire area	-
Start Point	Secondary Concept		Starting point	-
Street	Core Concept		Street	-
Suction Hose	Secondary Concept		Hose specially constructed to withstand external pressure. For use on the suction side of the pump. Normally referred to simply as 'suction'. The standard sizes are 75 mm, 100 mm and 140 mm bor.	HO Manual – Fire Service Training Manual
Sunny	Core Concept		Sunny	-
Systems of Work	Core Concept		The incident commander will then need to review the options available in terms of standard procedures. Incident commanders will need to consider the possible systems of work and choose the most appropriate for the situation. The starting point for consideration must be procedures that have been agreed in pre-planning and training and that personnel available at the incident have sufficient competence to carry out the tasks safely.	A Guide to Operational Risk Assessment
Tactical Control	Core Concept			Fire Service Manual Volume 2 (Incident Command)
Tactical Mode	Core Concept		A procedure is to assist the incident commander to manage an incident effectively without compromising the health and safety of personnel by – ensuring that firefighting operation being carried out by a single crew, or sector, do not have adverse effects on the safety or effectiveness of firefighters in other crews or sectors, and generating a record of the outcome of the dynamic risk assessment process conducted by the incident commander. There are three tactical mode: offensive mode, defensive mode, and transitional mode.	Fire Service Manual Volume 2 (Incident Command)
Task	Secondary Concept		A specific piece of work to achieve an objective.	HO Manual – Dynamic Management of Risk at Operational Incidents
Thatched Fire	Secondary Concept		Thatched fire	-
Thatched Property	Secondary Concept		Thatched property	-
Time	Core Concept		Time	-
Time Condition	Core Concept		Time condition	-
Time Interval	Secondary Concept		Time interval	-
Time Point	Secondary Concept		Time point	-

Term	Concept	Synonym	Natural Language Description	Source
Transitional Mode	Core Concept		This should be declared where there is a combination of offensive and defensive modes in operation at the same incident, in two or more sectors. The main purpose of the announcement of 'Transitional Mode' is to keep commanders of sectors operating in defensive mode, using large jets and perhaps aerial monitors, aware that other personnel on the incident ground may be operating in areas of risk, which could be affected by their operations or tactics.	Fire Service Manual Volume 2 (Incident Command)
Triple Extension Ladder	Secondary Concept		A light of three extensions of a push-up type extending between 5.6 and 6 m.	HO Manual – Fire Service Training Manual
Turntable Ladder	Core Concept	T.L.	A sectional ladder mounted on a self-propelled chassis which is extended by steel cables. It is operated hydraulically and can be rotated through a complete circle. It is usually fitted with a monitor at the head of the ladder	HO Manual – Fire Service Training Manual
Vaporising Liquid Fire Extinguisher (gas cartridge)	Secondary Concept		An extinguisher containing a vaporising liquid which is expelled by pressure from a cartridge of compressed gas, attached to, or fitted into the extinguisher.	HO Manual – Fire Service Training Manual
Vaporising Liquid Fire Extinguisher (stored pressure)	Secondary Concept		An extinguisher containing a vaporising liquid which is expelled by pressure stored in the body of the extinguisher as a whole.	HO Manual – Fire Service Training Manual
Visibility	Core Concept		Visibility	-
Volunteer Group	Core Concept			
Water Fire Extinguisher (gas cartridge)	Secondary Concept		An extinguisher in which water is expelled by pressure from a cartridge of compressed gas, attached to, or fitted into the extinguisher.	HO Manual – Fire Service Training Manual
Water Fire Extinguisher (stored pressure)	Secondary Concept		An extinguisher from which water is expelled by pressure stored within the body of the extinguisher as a whole.	HO Manual – Fire Service Training Manual
Weather Condition	Core Concept		Weather condition	-
Weather Type	Core Concept		Weather type	-
Whole Time Group	Core Concept		Whole time group	A Guide to Operational Risk Assessment
Wide Road	Secondary Concept		Wide road	-
Wind	Core Concept		Wind	-
Working in Roof Space and Cutting away	Core Concept		An operation activity described in 'A Guide to Operational Risk Assessment' is to consider hazards and risks for working in roof space and cutting away. It contains one significant hazard, 'Hazardous Substances'.	A Guide to Operational Risk Assessment
Year	Core Concept		Year	-

Appendix - C

Formative Evaluation Materials

This appendix contains formative evaluation materials provided to participants during the main experimental study presented in Chapter 7, Section 7.3. The materials consist of formative evaluation guide (C-2, C-3), scenario1 sheets (C-4, C-5), questionnaire1 or scenario1 evaluation script (C-6 – C-8), scenario2 & 3 sheets (C-9 – C-14), preliminary questionnaire (C-15), main questionnaire or scenario2 & 3 evaluation scripts (C-16 – C21).

It is noted that the scenario1 sheets and scenario1 evaluation script (C-2 – C-8) are used during pilot study only before embarking the main study. The scenario2 & 3 sheets, preliminary questionnaire and main questionnaire (C-9 – C21) have already been improved for use with the main study.

Formative Evaluation

Date of evaluation:

Number of person:

7 persons – 3 from computer sciences or engineers, 4 from non-computer sciences or engineers

About PORML project:

The PhD project links mobile computing with reflective learning in emergency services. It develops a framework for an intelligent mobile personalised agent which interacts with a user, builds a model of the current user activity, and promotes reflection to facilitate on-the-job learning. This research will explore how activity theory can be used to inform the design of intelligent learning environments that facilitate mobile on-the-job training and are tailored to the learner's current and past activities. The main goal of this PhD project is to examine how to design personalised m-learning environments to support reflective on-the-job learning in the emergency sector. As a case study, we will consider risk assessment skills acquired by crew commanders at Fire and Rescue Services (FRS). We have developed a prototype of a mobile personal assistant which takes a crew commander through dynamically generated reflective dialogue scripts after an incident has finished. The interaction can be conducted via a smart phone, netbook or notebook, and assess how a crew commander has performed the latest risk assessment activity by taking into account contextual information about the task, location, and last activity. During the interaction, the crew commander can use this dialogue interaction to review his/her recent risk assessment activity.

Definitions

PORML: Personalised On-the-Job Reflective Mobile Learning

FRS: Fire and Rescue Services

Tutorial Dialogue

Goal of PORML prototype evaluation

The goal of the evaluation is to elicit responses from the PORML users that will inform the design of the quality PORML and outlining potentials of the framework so that it can be improved and employed in the intelligent learning environments.

PORML prototype

The prototype is divided into 3 dialogue stages:

Stage I: Collect basic information

Stage II: Collect specific information

Stage III: Review of dynamic risk assessment activity

Evaluation Script:

- Explain definition, goal and PORML prototype
- Explain structure of evaluation. Three scenarios will be used to evaluate PORML prototype.
 - Capturing all preliminary information provided by user with 1 incident place, 3 different user locations and fire types (building fire, high rise

- building fire, rural area fire, public entertainment venue fire etc. except **chimney fire**). This scenario requires only review activity scenario;
- Capturing current user activity and reflection learning for **chimney fire** situation1 using PORML prototype. This scenario requires both actual activity scenario and review activity scenario;
 - Capturing current user activity and reflection for **chimney fire** situation2 using PORML prototype. This scenario requires both actual activity scenario and review activity scenario.
- Explain methodology
 - Activity-based scenarios

Resources required for the evaluation

- Equipment to run the PORML prototype
- Documentation
 - Script for detailed scenarios

Scenario1: Capturing all contextual information providing by user for different user locations and fire types (building fire, high rise building fire, rural area fire, public entertainment venue fire etc. except chimney fire)

This activity scenario is to examine the PORML prototype can be provided by the preliminary contextual information about the specified place and fire type as the following goal:

Goal:

- Check the flow of dialogue – is the flow of dialogue adequate for exploring and collecting relevant context parameters in fire risk assessment activity. In particular, are the dialogue contents coherent for focusing on relevant context parameters which are collected during stage I and stage II for specific fire type at the specified incident place, can the user understand and follow the dialogue easily, is the sequence of dialogue move suitable for collecting context parameters.
- Check the context parameters – are collected context parameters adequate for risk assessment activity on the scenario. Specifically, are there any missing context parameters which are relevant to risk assessment activity on this scenario, are there any redundant context parameters provided in the dialogue, and which parameters provided in the dialogue are actually important.
- Check the dialogue template – is dialogue template suitable for questions and answers. Especially, are there any questions in the dialogue of stage I and II the user does not understand, are there any questions in the dialogue of stage I and II that should be rephrased and how to do that, are there anything in the options that should be changed (e.g. another value could be provided, an existing value should be deleted or rephrased).

This scenario contains two stages of PORML prototype dialogue stages

Stage I: Collect basic information

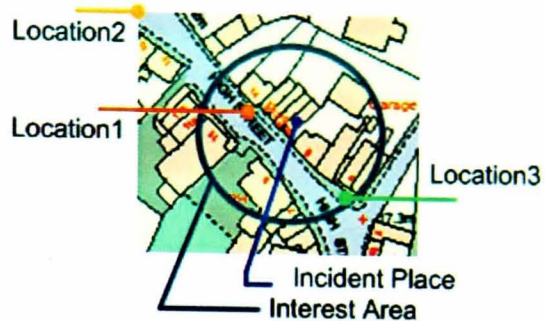
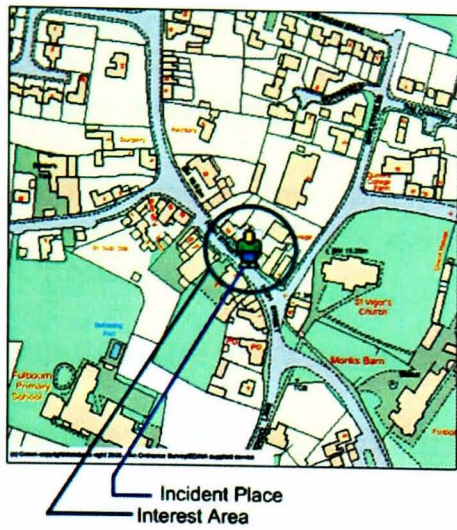
Stage II: Collect specific information

Three different locations closing to incident place or interest area (see picture below) are assumed for a user (a crew commander) who uses a mobile device at these locations to explore and capture context parameters about location context surrounding the selected incident place. The locations in this scenario will be represented in **Great Britain National Grid** – Easting and Northing (in metre scale) to identify the position (Easting, Northing) on the map. The map was produced from **Ordnance Survey MasterMap** in UK. When user selects the location, the PORML agent will calculate the possible places surrounding in range 250 metres radius in order to be the incident place options for user selection. When user selects the incident place from the options, the PORML agent will calculate the places surrounding in range 30 metres radius called **interest area**. The contextual information (represented with context parameters in the scenario) in this area which is assumed may impact to risk assessment activity.

Assume location1 – position (Easting, Northing) = (551985, 256251)

Assume location2 – position (Easting, Northing) = (551800, 256400)

Assume location3 – position (Easting, Northing) = (552225, 256200)



Review Activity Scenario for Capturing the Context Parameters

Paul uses his smart phone or netbook to explore and capture the context parameters about location context and fire risk assessment context. He opens the PORML address URL using the browser. The PORML agent prompts for entering login name and password. He provides his login name “paul” and password “password”, then the agent issues the assumption of his current location on location selection page (three locations). He chooses location1 and explores on stage I (collect basic information) for selecting the incident place, fire risk assessment type (except **chimney fire** for this scenario case), incident date, start and end time of incident, weather conditions, and then follow the stage II (collect specific information) until the starting page of stage III. After finished exploration using location1, he chooses a location selection button at starting page of stage III to go back to location selection page, and repeat exploring stage I and II again by using location2 and location3 respectively. Finally, the end page has to be at the starting page of entering to stage III in order that the latest dialogue history (dialogue script), which you explore from stage I and II, will be recorded for helping you to review the dialogue statements that can be used to answer the questions in the questionnaire.

Description about initial context parameters (appear in stage I)

Incident place – place name of the incident place which fire takes place

Fire type – type of fire which fire crews have to deal with at the incident

Date – date of the incident

Start and end time – the time duration of fire incident which may impact to risk assessment and fighting the fire e.g. the rush hour may have traffic jam surrounding the incident place which obstructs or detains crews and equipment transportation etc.

Weather conditions – conditions of the weather may have impact to risk assessment and fighting the fire e.g. bad visibility, freezing, high wind etc.

Others context parameters (appear in stage II)

It depends on particular place and/or fire type, example below

Place and/or Fire Type	Context Parameters
Public house	crowd of people surrounding, drunk people, hazardous substance nearby
Farm fire	additional rescue of persons from agricultural silos, sufficient water supply for fighting fire, hazardous substance nearby
Secure accommodation fire	a prison building, additional secure area for evacuation, hazardous substance nearby

Scenario1 Evaluation Script

Review Activity Scenario for Capturing the Context Parameters

The following questionnaire is to investigate if we have identified a suitable dialogue for collecting the preliminary contextual information in fire risk assessment activity using PORML prototype.

Questionnaire for review activity scenario1

Questions about the flow of dialogue

1. Was the dialogue used to collect context information coherent for focusing on relevant context parameters for specific fire type at the specified incident place? Please circle below:
- Yes No

Could you please explain the reasons for your answer:

2. Could you understand and easily follow the dialogue contents capturing context parameters? Please circle below:
- Yes No

Could you suggest any improvements?

3. Was the sequence of dialogue moves suitable for collecting context parameters?
- Yes No

What changes of the sequence would you like to see in dialogue stage I and II?

Questions about the context parameters

After you read activity design scenario1 for capturing the context parameters, please use them to clarify your responses. Table below is the description about these context parameters

Context parameters	Description
Incident place	Place name of the incident place which fire takes place
Fire type	Type of fire risk assessment which fire fighters have to deal with at the incident place
Date	Date of incident

Start and end time	The time duration of fire incident which may impact to risk assessment and fighting the fire e.g. the rush hour may have traffic jam surrounding the incident place which obstructs or detains crews and equipment transportation etc.
Weather conditions (weather, wind, visibility)	Conditions of the weather may have impact to risk assessment and fighting the fire e.g. dark (bad visibility) may lose sight during fire activity, high wind may accelerate fire and sometime endanger to fire fighters etc.
Others contexts	It depends on particular place and/or fire type (appear in stage II)

4. Do you think there are any **missing** context parameters which are relevant to risk assessment in scenario 1? Please circle below:

Yes No

If yes, could you please provide which context parameters should be included and why:

5. Do you think there are any **redundant** context parameters which are not relevant for this scenario 1? Please circle below:

Yes No

If yes, could you please provide which context parameters should not be included and why:

6. For each context parameter, please indicate its **importance** for risk assessment activity in scenario 1? Please tick left hand side if the parameter is important and give reason for this (You can tick more than one):

Context Parameters	Reason
<input type="checkbox"/> Incident Place	<hr/>
<input type="checkbox"/> Fire Type	<hr/>
<input type="checkbox"/> Date	<hr/>
<input type="checkbox"/> Start and End Time	<hr/>
<input type="checkbox"/> Weather	<hr/>
<input type="checkbox"/> Wind	<hr/>
<input type="checkbox"/> Visibility	<hr/>
<input type="checkbox"/> Others (please specify)	<hr/>

Questions about suitability of dialogue template for questions and answers

After you have finished the dialogue stage I and II, the system will record the dialogue interaction which you interacted. Please **use the recorded dialogue script** to answer the following questions:

7. Are there any questions from the dialogue agent which you **do not understand**? Please tick the questions on the left hand side and provide the reason below:

Question:	Reason:
<input type="checkbox"/> Q1	_____
<input type="checkbox"/> Q2	_____
<input type="checkbox"/> Q3	_____
<input type="checkbox"/> Q4	_____
<input type="checkbox"/> Q5	_____
<input type="checkbox"/> Q6	_____
<input type="checkbox"/> Q7	_____
<input type="checkbox"/> Nothing	_____

8. Are there any questions from the dialogue agent which **should be rephrase** and how? Please tick the questions on the left hand side and rephrase below:

Question:	Rephrase:
<input type="checkbox"/> Q1	_____
<input type="checkbox"/> Q2	_____
<input type="checkbox"/> Q3	_____
<input type="checkbox"/> Q4	_____
<input type="checkbox"/> Q5	_____
<input type="checkbox"/> Q6	_____
<input type="checkbox"/> Q7	_____
<input type="checkbox"/> Nothing	_____

9. With every question, the system gives **possible options to choose**. Is there anything in the options that should be changed (e.g. another value could be provided, an existing value should be deleted or rephrased)? Please tick on the left hand side and provide which option and how change below:

Question:	Option:	Change (provided, deleted, rephrased):
<input type="checkbox"/> Q1	_____	_____
<input type="checkbox"/> Q2	_____	_____
<input type="checkbox"/> Q3	_____	_____
<input type="checkbox"/> Q4	_____	_____
<input type="checkbox"/> Q5	_____	_____
<input type="checkbox"/> Q6	_____	_____
<input type="checkbox"/> Q7	_____	_____
<input type="checkbox"/> Nothing	_____	_____

Scenario 2 and 3 Capturing user current activity and reflection learning

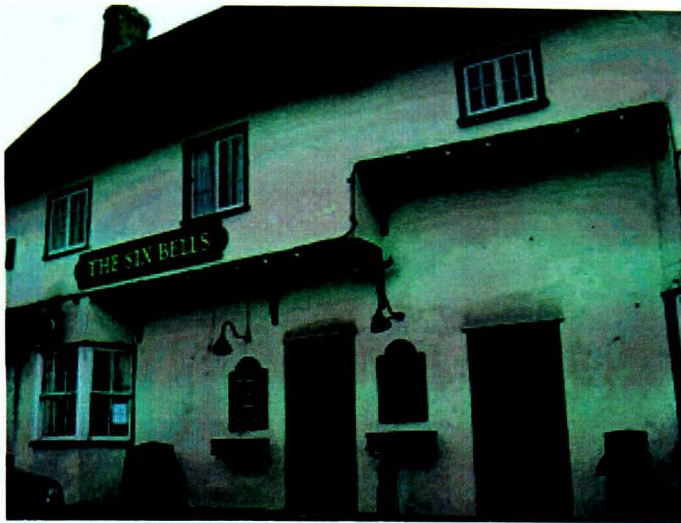
Goal:

- Capture user knowledge about fire risk assessment activity – What is the user's knowledge about dialogue, reflective learning and fire risk assessment activity. Particularly, do you have any knowledge about tutorial dialogue and interaction dialogue, do you have any knowledge about reflective learning, do you have any knowledge about fire risk assessment activity.
- Check the use of the communication medium – is the communication medium adequate for examining the review of risk assessment activity. Especially, can the dialogue agent provide the expressive power to utter the communicative act, do the users have any problem with understanding what the agent convey to them.
- Check the characteristics of the dialogue – are the characteristics of dialogue for presentation to user provided by the dialogue agent adequate for reflective learning in the review of risk assessment activity. In particular, are you satisfied the features of the dialogue (form template, functions of buttons, position of contents, the dialogue presentation layout e.g. text colour, background colour, text size, font style, or others), do you find the features of input selection provided by the dialogue agent sufficient for helping you answer the dialogue question, is the dialogue presentation suitable and convenient for usage on small screen in smart phone browser and bigger screen in netbook or notebook browser, are there impressive in the aim of the interaction provided by characteristic of dialogue presentation, are you satisfied the way the system maintains the dialogue, is the presentation style of reflection appropriate for reflective learning.
- Check the flow of dialogue - is the flow of dialogue suitable for reviewing the fire risk assessment activity. In particular, are the presented dialogue coherent for focusing on selected fire type at the specified incident place, can the user understand and follow the dialogue easily, is the sequence of dialogue move suitable for reviewing the fire risk assessment activity.
- Check general feedback – do you have any general comments about using program. In particular, are there any changes you would like to see in the overall of dialogue, can you rate the overall quality of the dialogue, is there anything you would like to say about the performance of the system that has not been included in the questions.

Scenario 2: Capturing user current activity and reflection learning for chimney fire situation case 1

Actual Activity Scenario for Risk Assessment Activity

(Adapted from real accident in 28 March 2008, 7.37pm)



At the incident: 30 June 2009

The fire occurred from the chimney accident near the foyer of the building at the Six Bells public house on the 29 High Street, Fulbourn, Cambridge, Cambridgeshire, CB21 5DH. A servant in charge tried to extinguish the fire but it spread to others parts in the building. The customers and staffs were evacuated from the building. At the same time, a receptionist called 999 to FRS. And then, a few minutes two crews (one became a crew commander or an incident commander for this case) from Cambridgeshire FRS (Fire and Rescue Services) and a turntable ladder from Cambridgeshire were called to the incident, a chimney fire. The fire starts at 6:00 p.m., the weather is sunny, the wind is low, the light is light, the traffic is medium jam, customers and staffs have about 40 persons, no drunk of people, no hazardous material for place surrounding in 30 metres radius.

The crew commander (and become an incident commander), Paul, and his colleague arrived at Six Bells public house at 6:25 p.m. They spent a few minutes to perform some initial actions:

- Obtained information from fire control station during driving vehicle before arrived at incident site – the chimney at Six Bells pub has never occurred any fire accident and it is not quite old one;
- Using the hose reel and applied a small amount of water into the grate of chimney;
- Checked which flue was fired.

He assessed the risk (first situation) from his experiences and knowledge for another few minutes to perform the fire actions. He assessed that this was a low risk rating. Then, he decided to take fire actions by sending his colleague to extinguish fire on chimney rod on the roof using a hose reel, thermal imaging camera (T.I.C.), eye protection, mirror and a roof ladder, and he went inside the building on the ground floor to extinguish fire in the grate and the other fire parts inside the building. This decision was an offensive mode. Fifteen minutes later, all fires were able to be wiped out at 6:45 pm. No more risk assessment activity for next situation was required.

The following information clues (control measures) were the reasons why he assessed the risk result as low risk rating and decided to take fire actions in the first situation:

- The traffic jams in medium level but the weather tends to the good conditions;
- Cordon off;
- Provision use and maintenance of roof ladders;
- He and His colleague has attended the chimney fire training of gaining access to and working on the roof activity (falling masonry and roof conditions), working in roof space and cutting away activity (hazardous substances), applying extinguishing media activity (fire spread and blow back);

- Provision use of safe systems of work for the risk activities in chimney fire (attack on the roof, attack on the grate, asbestos and MMMF hazardous material, and extinguish media);
- Provision use of hearth kit, thermal imaging camera, eye protection and mirror;
- Provision use of work positioning and fall arrest systems.

Review Activity Scenario of Risk Assessment Activity

This scenario contains all stages of PORML prototype dialogue stages.

Stage I: Collect basic information

Stage II: Collect specific information

Stage III: Review of dynamic risk assessment activity

A crew commander, Paul, uses a mobile device (smart phone or netbook with assigned location provided by prototype) to review the risk assessment activity for the recent chimney fire activity near the incident place (Six Bells Pub, chimney fire type) – in range radius 250 metres, and assume his current location (East, North) is location1 (551985, 256251).

He opens the PORML address URL using the browser. The PORML agent prompts for entering login name and password. He provides his login name “paul” and password “password”, then the agent issues the assumption of his current location on location selection page. He chooses location1 (551985, 256251) and the following selection in stage I and II: SixBells Pub for incident place, chimney fire type, 30 June 2009 for date, 18:00 – 18:45 for fire start and end, sunny, low wind, good visibility, No - for crowd of people (less than 50 persons from setting), No - for drunk people, and No - for hazardous material surrounding. Then, he enters to stage III to review dynamic risk assessment activity.

He spends around 10 – 15 minutes to interact with the dialogue agent in stage III. The first part of stage III is collection of initial fire actions, for example, “DialogGameAgent: Did you perform identifying of the correct flue in initial actions for chimney fire?, Paul: Yes, I did.”. At the end of first part, the agent will prompt you the reflection questions in free text reflection answering, and move to the second part of stage III, initial control measures – start with situation 1.

The second part of stage III (situation 1) is asking you to examine the control measures you provided, for example, “DialogGameAgent: Did you provide cordoning off an unsafe area in control measure for chimney fire? Paul: Yes, I did.”. At the end of second part, the agent will prompt you the reflection questions in free text reflection answering, and move to the third part of stage III, identify hazards in risk assessment activity and situation risk assessment.

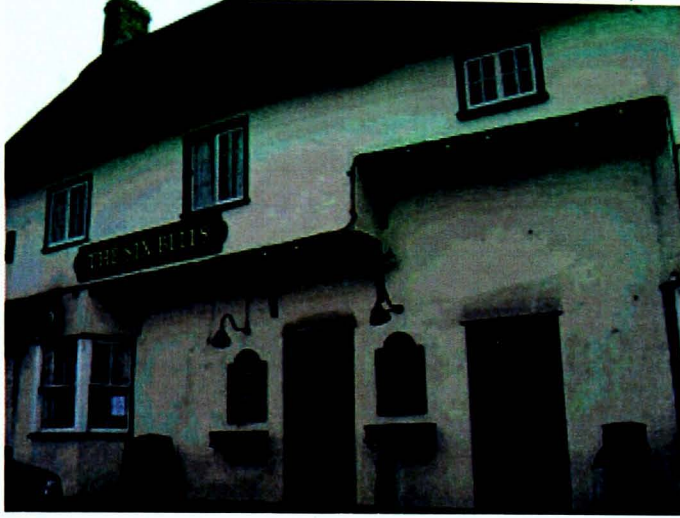
The third part of stage III (situation 1) is the review of dynamic risk assessment activity; identify hazard and risk, identify who were harmed (risk group), risk assessment result (risk rating). At the end of third part, the agent will prompt you the reflection questions in free text reflection answering, and move to the fourth part of stage III, mode and system. On this scenario, you could answer “offensive mode”, and “accessing to the grate for attack from below in risk assessment (RA) activities for chimney fire.”. And then the agent will move to the fifth part of stage III, additional control measures actions. This part will inform you from the risk result that any additional control measures actions are required, and then prompt you the last reflection question, and end of dialogue.

(You can see an example of the whole dialogue script in an example of PORML prototype for chimney fire RA scenario script)

Scenario3: Capturing user current activity and reflection for chimney fire situation case 2 using PORML prototype

Actual Activity Scenario of Risk Assessment Activity

(Adapted from real accident in 28 March 2008, 7.37pm)



At the incident: 10 February 2009

The fire occurred from the chimney accident near the foyer of the building at the Six Bells public house on the 29 High Street, Fulbourn, Cambridge, Cambridgeshire, CB21 5DH. A servant in charge tried to extinguish the fire but it spread to others parts in the building. The customers and staffs were evacuated from the building. At the same time, a receptionist called 999 to FRS. And then, a few minutes two crews (one became a crew commander or an incident commander for this case) from Cambridgeshire FRS (Fire and Rescue Services) and a turntable ladder from Cambridgeshire were called to the incident, a chimney fire. The fire starts at 9:30 p.m., the weather is snow, the wind is high, the light is dark, the traffic is quite low or no jam, customers and staffs have about 60 persons, a few people have drunk, no hazardous material for place surrounding in 30 metres radius.

The crew commander (and become an incident commander), Paul, and his colleague arrived at Six Bells public house at 9:40 p.m. They spent a few minutes to perform some initial actions:

- Obtained information from fire control station during driving vehicle before arrived at incident site – the chimney at Six Bells pub has never occurred any fire accident but it is quite old one;
- Checked which flue was fired;

He assessed the risk (first situation) from his experiences and knowledge for another few minutes to perform the fire actions. He assessed that this was a medium risk rating. Then, he decided to take some control actions for additional control measures and assessed that this result could become a low risk rating. He provides the use of work positioning and fall arrest systems, which is a control measure, to prevent persons who may fall from the roof. And then, he sent his colleague to extinguish fire on chimney rod on the roof using a hose reel, thermal imaging camera (T.I.C.), eye protection, mirror and a roof ladder, and he went inside the building on the ground floor to extinguish fire in the grate and the other fire parts inside the building. This decision was an offensive mode. Thirty minutes later, all fires were able to be wiped out at 10:30 pm. No more risk assessment activity for next situation was required.

The following information clues (control measures) were the reasons why he assessed the risk result as medium risk rating and decided to take some control actions in the first situation:

- Although the time period is good for the traffic condition, the weather tend to bad conditions;
- Cordon off;
- Provision use and maintenance of roof ladder;
- He and His colleague has attended the chimney fire training of gaining access to and working on the roof activity (falling masonry and roof conditions), working in roof space and cutting away activity (hazardous substances), applying extinguishing media activity (fire spread and blow back);
- Provision use of safe systems of work for the risk activities in chimney fire (attack on the roof, attack on the grate, asbestos and MMMF hazardous material, and extinguish media);
- Provision use of hearth kit, thermal imaging camera, eye protection and mirror;

The following control actions he decided were added for additional control measures:

- Provision use of work positioning and fall arrest systems

Review Activity Scenario of Risk Assessment Activity

This scenario contains all stages of PORML prototype dialogue stages.

Stage I: Collect basic information

Stage II: Collect specific information

Stage III: Review of dynamic risk assessment activity

A crew commander, Paul, uses a mobile device (smart phone or netbook with assigned location provided by prototype) to review the risk assessment activity for the recent chimney fire activity near the incident place (Six Bells Pub, chimney fire type) – in range radius 250 metres, and assume his current location (East, North) is location1 (551985, 256251).

He opens the PORML address URL using the browser. The PORML agent prompts for entering login name and password. He provides his login name “paul” and password “password”, then the agent issues the assumption of his current location on location selection page. He chooses location1 (551985, 256251) and the following selection in stage I and II: SixBells Pub for incident place, chimney fire type, 30 June 2009 for date, 21:30 – 22:30 for fire start and end, snow, high wind, bad visibility, Yes - for crowd of people (more than 50 persons from setting), Yes - for drunk people, and No - for hazardous material surrounding. Then, he enters to stage III to review dynamic risk assessment activity.

He spends around 10 – 15 minutes to interact with the dialogue agent in stage III. The first part of stage III is collection of initial fire actions, for example, “DialogGameAgent: Did you perform identifying of the correct flue in initial actions for chimney fire?, Paul: Yes, I did.”. At the end of first part, the agent will prompt you the reflection questions for free text reflection answering, and move to the second part of stage III, situation state inquiry – start with situation 1 (in scenario3).

The second part of stage III (situation 1) is asking you the dynamic risk assessment situation state, for example, “DialogGameAgent: What was the tactical mode in risk assessment (RA) activities for chimney fire? Paul: That was offensive mode in risk assessment (RA) activities for chimney fire.”. At the end of second part, the agent will prompt you the reflection questions for free text reflection answering, and move to the third part of stage III, situation risk assessment.

The third part of stage III (situation 1) is the review of dynamic risk assessment activity; identify hazard and risk, identify who were harmed, risk assessment result (risk rating), and the next actions could do. At the end of third part, the agent will prompt you the

reflection questions for free text reflection answering, and move to the end of dialogue or situation 2. He chooses no more situations and the agent navigates to the end of dialogue.

(You can see an example of the whole dialogue script in PORML prototype for chimney fire risk assessment scenario3 in provided an example of scenario2 and 3 script)

This section will be provided before using PORML**Preliminary questionnaire**

1. Indicate your gender

Male

Female

2. How old are you?

21 – 30

31 – 40

41 – 50

> 50

3. What is your occupation?

 Student (post graduate non-computer science) Student (post graduate computer science) Programmer Teacher/Lecturer/ProfessorQuestions about capturing your knowledge

4. Please rate your knowledge of dialogue-based interaction

Very good 1 2 3 4 5 6 7 No knowledge at all

5. Please rate your knowledge about reflective learning

Very good 1 2 3 4 5 6 7 No knowledge at all

6. Please rate your knowledge about fire risk assessment activity

Very good 1 2 3 4 5 6 7 No knowledge at all

Scenario Evaluation Script

Actual Activity Scenario of Risk Assessment Activity

The following questionnaire for actual activity scenario is to investigate if we have captured the actual or current risk assessment working practices.

Questionnaire for actual activity scenario

1. Please rate the detail of description of actual activity scenario provided above?

Very good detail 1 2 3 4 5 6 7 Very bad detail, I can't understand that

Could you justify your answer?

2. Is there anything that could be changed or clarified the description of the actual activity scenario?

Review Activity Scenario of Risk Assessment Activity

The following questionnaire for review activity scenario is to investigate if we have identified a suitable dialogue for reviewing the recent risk assessment activity and recording the user activity using PORML prototype.

Questionnaire for review activity scenario

Questions about the communication medium

1. How would you classify the expressive power you have been provided with to utter your communicative acts?

Extremely good 1 2 3 4 5 6 7 Not at all good
(I managed to construct every communicative act which I wanted) (I couldn't construct any communicative act using PORML)

If you have experienced problems with uttering your communicative acts, could you please describe them?

2. Did you have problems with understanding what the system conveyed to you?
 Didn't have any problems at all 1 2 3 4 5 6 7 Couldn't understand anything about what the system was trying to say

If you have experienced problem with understanding what the system uttered, could you please specify?

Questions about the characteristics of dialogue

You have been given the review activity scenario mentioned above and an example of dialogue transcripts (An Example of PORML Prototype for Chimney Fire RA Scenario), please use them to clarify your responses.

3. The following is a set of statements about the features of the dialogue in PORML prototype. For each statement please say whether you agree strongly, agree, disagree, or disagree strongly. Tick the appropriate box.

Statement	Strongly agree	Agree	Disagree	Strongly disagree
I could understand the information in form template provided by dialogue agent				
I am confusing the functions of buttons provided by dialogue agent				
I am satisfied the position of each content on the form template provided by dialogue agent				
I could not comprehend the purpose of dialogue questions presented to me				
I am satisfied with the length of overall dialogue				

4. Are you satisfied the dialogue presentation layout about form e.g. text colour, background colour, text size, font style, or others (please specify)? Please circle below:

Definitely, I am very satisfied 1 2 3 4 5 6 7 I am very disappointed

Could you please provide suggestion?

5. Do you find the features of input selection provided by the dialogue agent sufficient for helping you answer the dialogue questions?

Definitely, 1 2 3 4 5 6 7 I am very disappointed,
all input the input selections were
selections not helpful at all
were very helpful

Could you please provide suggestion?

6. Would you say that the dialogue with PORML was frustrating for interaction dialogue with the presentation on the screen?

(The PORML prototype is designed to use for mobile device both the small screen on smart phone and bigger screen on netbook or notebook. Thoroughly, this testing will be demonstrated on netbook or notebook for easier capturing the video on screen; however, you will be seen a part of testing demonstrated on smart phone, an example on iPhone mobile, for answering this question)

For bigger screen, netbook or notebook
Not at all, 1 2 3 4 5 6 7 Definitely,
it was a pleasure I am very
to navigate the disappointed
sequence of interaction

Could you please provide suggestion?

7. The same as question 6

For small screen, smart phone (iPhone)
Not at all, 1 2 3 4 5 6 7 Definitely,
it was a pleasure I am very
to navigate the disappointed
sequence of interaction

Could you please provide suggestion?

8. What was the impression you had about the aim of the interaction with PORML? (You may tick more than one option)

This was a basic review about the recent user activity.

This was a review about my knowledge in fire risk assessment activity and I could influence the system's diagnosis.

This was a conversation with an agent which tried to help me to understand some fire risk assessment terms.

Others (please specify)

9. PORML has also a planning mechanism that analyses each of you turns which system may continue the sequence of communicative acts in the current dialogue episode for the system turn, or constructs the new communicative acts in the other dialogue episode until finished and come back to the current dialogue episode again for the system turn. In these terms, how would you assess the way the system was maintaining the dialogue?

Very well 1 2 3 4 5 6 7 Not well maintained at all
maintained

We would appreciate if you could describe the problems.

10. In the dialogue interaction, dialogues are divided into dialogue game episodes. The main dialogue game episodes, e.g. initial actions DG (dialogue game), initial control measures DG, identify risk assessment DG, situation assessment DG, mode and system DG, additional control measures DG, are executed in sequence. Do you think the position of reflective questions (from reflection DG) is suitable for reflection the review of each main dialogue game episode? Please circle below:

Yes

No

If no, which position could be in each main the dialogue game episode? Please tick on the left hand side:

at beginning

in the middle

depend on previous dialogue question: if select this option, please explain how?

11. Is the presented style of reflection question and answer appropriate for reflective learning? Please circle below:

Yes

No

Could you please explain the reasons for your answer?

Question about the flow of dialogue

12. Was the presented dialogue coherent for focusing on selected fire type at the specified incident place? Please circle below:

Yes

No

Could you please explain the reasons for your answer?

13. Could you understand and easily follow the dialogue contents capturing user activity and reflection by review the risk assessment activity? Please circle below:

Yes

No

Could you suggest any improvements?

14. Was the sequence of dialogue move suitable for reviewing the fire risk assessment activity and capturing user activity? Please circle below:

Yes

No

Could you suggest any improvements?

Questions in general comments

15. What changes would you like to see in the overall of dialogue?

16. How would you rate the overall quality of the dialogue? Please circle below:

High quality, very engaging and easy to follow 1 2 3 4 5 6 7 Low quality, confusing and frustrating

17. Is there anything you would like to say about the performance of the system that has not been included in the questions/answers above? Please write it here:

Appendix - D

Summative Evaluation Materials

This appendix contains summative evaluation materials provided to a group of firefighters at a fire station, Avon FRS, Bristol, UK during the experimental study presented in Chapter 7, Section 7.4. The materials consist of D1 – Information Sheet (D-2), D2 – Model Participant Consent Form (D-3), D3 – A Chimney Fire Scenario (D-4), D4 – Questions for Interview (D-5), D5 – PORML Summative Evaluation User Feedback Questionnaire (D-6 – D-7).

D1. Information Sheet

Personalised On-the-job Reflective Mobile Learning (PORML) Evaluation

You are being invited to provide feedback on a computer program developed in a PhD research project at the University of Leeds. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time without it affecting any benefits that you are entitled to in any way. You do not have to give a reason.

About this project

PhD student: Wichai Eamsinvattana, School of Computing, University of Leeds (wichai@comp.leeds.ac.uk)

Supervisors: Dr. Vania Dimitrova, School of Computing, University of Leeds (V.G.Dimitrova@leeds.ac.uk)

Dr. David Allen, Leeds University Business School, University of Leeds

(D.Allen@lubs.leeds.ac.uk)

This is a PhD project conducted at the **University of Leeds** between two departments – the **School of Computing** and the **Leeds University Business School**. The goal is to **design, implement and evaluate a mobile application which assists with training of risk assessment skills at fire and rescue services**.

About this demonstration

This demonstration will show a **computer program on an i-phone 3G** aimed to promoting reflection by reviewing the activity a user has been involved in. The intended users are fire fighters, in general, and fire crew commanders, in particular. The user is taken through a text-based dialogue which corresponds to the general risk assessment procedure. At some steps, the dialogue is interrupted with reflective questions. The program is 'smart' as it 'knows' about both the risk assessment activity (using a knowledge model of a generic risk assessment activity) and the physical context of the accident (using a knowledge model that simulates a smart map relating buildings and places in the physical world to fire hazards and procedures). Based on this, it plans what to say to the user, generates model answers for the user to choose from, and decides what reflection questions to include.

This demonstration is built around a **fictitious scenario of a chimney fire accident** which is adapted from fire records available online¹. We assume that after everything has finished, the fire crew commander would use the PORML program on their i-phone 3G to review the risk assessment activity.

The demonstration will include:

- Reading the fictitious scenario (about 2-5min).
- Demonstration by the PhD student (Wichai) of the dialogue (10 min).
- Hands-on-experience with the program (10 min).
- Feedback (10 min) – interview (individual or in a group, as appropriate); including open style questions about the usefulness of the PORML program.
- Questionnaire (5 min) – including open and closed style questions to get your feedback how easy it is to use the PORML program.

Thank you very much for taking part in this study. As a small gesture of gratitude, you will be given an electronic Amazon voucher of £20 pounds.

If you would like more information about this research or would like to know the results of this study, please do not hesitate to contact the researchers at their email addresses above, or phone **Dr. Vania Dimitrova** at **0113 343 1674**.

¹ <http://www.cambsfire.gov.uk/>

D2. Model Participant Consent Form

Title of Research Project: **PORMLL - Personalised On-the-job Reflective Mobile Learning. Evaluation Study**

Name of Researchers: **Mr. Wichai Eamsinvattana**, School of Computing, University of Leeds
(wichai@comp.leeds.ac.uk)

Dr. Vania Dimitrova, School of Computing, University of Leeds
(V.G.Dimitrova@leeds.ac.uk); telephone: 0113 343 1674

Please initial box

1. I confirm that I have read and understand the **information sheet** dated *27 April 2010* explaining the above research project and I have had the opportunity to ask questions about the project.

2. I understand that my participation is **voluntary** and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. If you have any concerns, please *contact the lead researcher: Dr. Vania Dimitrova (0113 3431674)*.

3. I understand that my responses will be kept **strictly confidential**. I give permission for members of the research team to have access to my **anonymous responses**. I understand that my name will not be linked with the research materials, and neither I nor my organisation will be identified or identifiable in the report or reports that result from the research.

4. I agree for the data collected from me to be used in future research

5. I agree to take part in the above research project.

Name of Participant
(or legal representative)

Date

Signature

Name of person taking consent
(if different from lead researcher)

Date

Signature

To be signed and dated in presence of the participant

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

D3. A Chimney Fire Scenario

The fire occurred from the chimney accident near the foyer of the building at the Six Bells public house on the 29 High Street, Fulbourn, Cambridge, Cambridgeshire, CB21 5DH. An employee in charge tried to extinguish the fire but it spread to others parts in the building. The customers and staffs were evacuated from the building. At the same time, a receptionist called 999 to FRS. And then, a few minutes two crews (one became a crew commander or an incident commander for this case) from Cambridgeshire FRS (Fire and Rescue Services) and a turntable ladder from Cambridgeshire were called to the incident, a chimney fire. The fire starts at 6:00 p.m., the weather condition is sunny, low wind, good visibility, the traffic is normal traffic, customers and staffs have about 40 persons, no drunk of people, no hazardous material for place surrounding in 30 metres radius.

The crew commander (and become an incident commander), Paul, and his colleague arrived at Six Bells public house at 6:25 p.m. They spent a few minutes to perform some initial actions:

- Obtained information from fire control station during driving vehicle before arrived at incident site – the chimney at Six Bells pub has never occurred any fire accident and it is not quite old one;
- Using the hose reel and applied a small amount of water into the grate of chimney;
- Checked which flue on fire.
- Considered attack from the grate as first firefighting option.

Paul assessed the risk (first situation) from his experiences and knowledge for another few minutes to perform the fire actions. He assessed that all hazards were low risk. Then, he decided to take actions by sending his colleague to extinguish fire in the chimney rod on the roof using a hose reel, thermal imaging camera (T.I.C.), eye protection, mirror and a roof ladder, and he went inside the building on the ground floor to extinguish fire in the grate and the other fire inside the building. Crew commander made decision in offensive mode. Fifteen minutes later, all fires were able to be extinguished at 6:45 pm. No more risk assessment activity for next situation was required.

The following **factors** affected the risk assessment decisions:

Environment conditions	<ul style="list-style-type: none"> • Normal traffic; Weather tends to the good conditions
Training	<ul style="list-style-type: none"> • Training of gaining access to and working on the roof activity • Training of working in roof space and cutting away activity • Training of applying extinguishing media activity
Activity	<ul style="list-style-type: none"> • Cordoned off • Safe system of work in accessing to and working on the roof for attack from above • Safe system of work in extinguishing media
Tools	<ul style="list-style-type: none"> • Used roof ladder; Used hearth kit; Used thermal imaging camera (TIC); • Used eye protection and mirror; Used work positioning and fall arrest systems

D4. Questions for Interview

1. The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

2.

a. If YES to q1: How can this program be used for training, e.g.

- for chimney fire
- what other fire types/situations can this be used for
- who can benefit (novices/crew commanders, etc.)

b. If NO to q1: What else may be needed to make this program useful for training?

3. If a program like this was available, could you use it in your practice and how?

- what activities would you use it in?
- whom with?
- how would you use it (e.g. as complementary to your current training, as a new form of training, ???)

4. If this program is used in practice, what difference could this make, e.g.

- affect training (effectiveness, efficiency)
- address any existing problems (e.g. recording experience, capturing best practice, automate capturing and search through records,...)

D5. PORML Summative Evaluation User Feedback Questionnaire

This questionnaire will gather your feedback about how easy it is to use the PORML program that was demonstrated to you. Can you please answer quickly the following questions. Your answers are anonymous and will be used solely for the purpose of evaluating the PORML program.

Your name or your institution will not be linked with the research materials or the responses, and will not be identified or identifiable in the report or reports that result from this research.

BRIEF QUESTIONS ABOUT YOUR PROFILE

1. How long have you been in Fire and Rescue services? years

2. What fire type have you been involved?
.....
.....

3. What roles have you been involved in (e.g. crew member, crew commander, other?)
.....
.....

4. What is the level of your experience with chimney fire (please select one)

- extensive experience of dealing with chimney fire
- good experience of dealing with chimney fire
- some experience if dealing with chimney fire
- no experience with chimney fire

5. What has been your role in dealing with chimney fire (e.g. crew member, crew commander, other?)?

.....
.....

6. Have you used any computer programs for training (please select)?

..... YES NO
.....
.....

7. What is your experience with i-phone 3G (please select)?

- I own i-phone 3G and use it on a regular basis
- I have used i-phone 3G but not on a regular basis
- I have never used i-phone 3G

8. What is your experience with using a touch screen on a mobile device (please select)?

- I have a touch screen mobile device and use it on a regular basis
- I have used a touch screen mobile device but not on a regular basis
- I have never used a touch screen mobile device

QUESTIONS ABOUT THE SYSTEM

9. The following is a set of statements about the PORML prototype. For each statement please say whether you agree strongly, agree, disagree, or disagree strongly. Tick the appropriate box.

Statement	Strongly agree	Agree	Disagree	Strongly disagree
(1) I could follow the dialogue with the agent				
(2) I was confused about the statements made by the dialogue agent				
(3) I found the reflection questions helpful				
(4) I could not comprehend the purpose of dialogue questions presented to me				
(5) The dialogue was frustrating				
(6) The review could help people learn about risk assessment				
(7) I would use the system if it is available				
(8) I would recommend this system to other people from my unit				
(9) I would never use this system				

10. What do you see as the strongest points of the PORML program?

.....

11. What do you see as the weakest points of the PORML program?

.....

12. Did anything in the interaction with the PORML program surprise you (please specify)?

.....

Thank you very much for taking part in this study. As a small gesture of gratitude, you will be given an electronic Amazon voucher of £20 pounds.

If you would like more information about this research or the results of this study, please do not hesitate to contact the researchers at the **School of Computing, University of Leeds:**

Mr. Wichai Eamsinwattana (wichai@comp.leeds.ac.uk) or
Dr. Vania Dimitrova (V.G.Dimitrova@leeds.ac.uk).
 You can also call **Dr. Vania Dimitrova** directly at **0113 343 1674**.

Appendix - E

Transcripts of Interview with Firefighters

This appendix provides interview transcripts with a group of firefighters at Avon FRS, Bristol, UK during their work time at the fire station starting from 6pm. This interview transcripts are used for the experimental study in summative evaluation to acquire information for applicability of the PORML prototype. There are 6 participants (S1 – S6) for this experiment.

User S1
<p>Question #1 <i>Interviewer:</i> The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment? <i>SI:</i> Yes, not in term that. It will need more. It would be suitable RCM (I guess Risk Control Management) in risk assessment training too, it would be at all but not any at all <i>Interviewer:</i> Do you mean, no <i>SI:</i> No, I mean, yes, it is useful <i>Interviewer:</i> Is it suitable? <i>SI:</i> Yes <i>Interviewer:</i> but it needs more? <i>SI:</i> It needs other training together with as well, practical training <i>Interviewer:</i> practical training? <i>SI:</i> Yes</p> <p>Question #2 <i>Interviewer:</i> How can this program be used for training e.g. for chimney fire or other fires? <i>SI:</i> I would say if you had a I will use this for training in chimney fire, is that a question? <i>Interviewer:</i> Yes <i>SI:</i> Then I would say when I went to a chimney fire as watch manager. Then I would get my crew manager to checking me and make the same, so I make the real position. So I would get him to make fault decision and I would compare to see how we have done it. <i>Interviewer:</i> Because I use the simple scenario, I don't need to use more complicate. It's just started the research. If it is suitable for training, so we can expand, or we can use other scenarios to clear more <i>SI:</i> Yeah! Yeah! No, No, I think it suits, but I will see for a new crew manager that how I use it. <i>Interviewer:</i> What other fire type or situation can be used for? <i>SI:</i> Road traffic learning, because of that, anything normally the same thing I will do over again. So a road rescue from high, a fire in high rise building <i>Interviewer:</i> And also other fires? <i>SI:</i> Yes. <i>Interviewer:</i> I think from the generic risk assessment, so it has 8 or 9 fire types. Do you think these fire types can be used in this program? <i>SI:</i> Yes <i>Interviewer:</i> Who can benefit, let say a novice, a crew commander, or a new firefighter? <i>SI:</i> Yeah! a new crew manager, a firefighter who want to become a crew manager, a firefighter who shows potential to become a crew manager. Then, I think they would benefit for that training. Therefore, they start a job as a crew manager, and they want Sen. Cog happy with that. Then, they become a crew manager.</p> <p>Question #3 <i>Interviewer:</i> If a program like this was available, could you use in your practice and how? <i>SI:</i> I don't think I would use it all the time but I would use it sometime <i>Interviewer:</i> Can use all the time? <i>SI:</i> No <i>Interviewer:</i> Not only after the accident <i>SI:</i> I wouldn't do that all the time after the accident, it is too long to do. I have got to compute the thing I have to do for every accident, so I can get that every time that I will get them for something. That is unusual. Then, I will go in check mine how well perform but there is something I would do a lot, then I will do. <i>Interviewer:</i> OK. What activities would you use it in? <i>SI:</i> Operational activity. I will use the thing that is quite generic e.g. high rise fire, chimney fire, car fire, train refuse, the generic incident. <i>Interviewer:</i> and who, crew commander?</p>

S1: Yes, I would say a crew commander and potential crew commander.

Interviewer: How would you use it?

S1: in a debrief, debrief at all

Question #4

Interviewer: If this program is used in practice, what difference could this make, e.g. affect training, address any existing problem?

S1: It can be used in reflective, so we can assess how well perform as long as a log somewhere. So you can collect information see how many time would strength you or incident where shouldn't be used and how many time wasn't used and when shouldn't be used. And then, at the training department, we will put a part of training into the work strength causes a crews are using strength where it should be used as strength. So I will use in debrief at all. So I will decide which area for training would be concentrated at all. So if 100 people have done that chimney fire and 7 of them didn't use work strength on the roof, then, I would say the trainer I need to concentrate that all training crew in work strength because I obviously nothing in my work strength of at all.

Interviewer: OK, thank you very much.

User S2

Question #1

Interviewer: The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

S2: It can play part, however; main problem would be when people come back from the incident and they have time to reflect. They may change some of the answer, so this appears that a word to better of system they actually did in practice.

Interviewer: Sometime you mean, sometime the commander forgot something, but actually the purpose of this project is to review and protect you forget it. Because normally in practice you spend two weeks, one month or more than that, you fill the form to review but it takes a time. But this is an immediate action after you did or may be an hour later which you can remember.

S2: It is just for a personal training, then, I think it could be open an honest. If this information goes up to manager, high manager, then, I think people manipulate this to make them look better.

Interviewer: OK. This is a drawback

S2: Yes, that is a drawback. In the personal reflection, it fantastic but if this information is related to high management and they will look how well you did, then, I think people would manipulate the answer after reflection.

Interviewer: It means cheat.

S2: Yes, I think they may cheat.

Interviewer: I assume you say yes. It is suitable for training.

S2: Oh! Yes, it is good.

Question #2

Interviewer: How can this program be used for training e.g. for chimney fire or any fires? How do you think?

S2: Yes, for the reflection afterward. It can be anything, hazardous materials, rescue. You can suit it in any situation I think.

Interviewer: Who can benefit, the novices or new crew commander?

S2: I think mainly new crew commander, however; I think anyone who sense that in the role could benefit, case of something you forget

Question #3

Interviewer: If a program like this was available, could you use in your practice and how?

S2: It is what activity use, I think post incident and with the whole crews or everyone who are attendant.

Interviewer: How would you use it, for example as complementary to you current training?

S2: Because it is to use with debrief, so you come back station afterward. You come back here, put the opener screen, and then you could the whole crews talk about what action they did, what action the crew commander did, what risk assessment state they came up with, so you can use it for the whole team. The debrief in talk.

Question #4

Interviewer: If this program is used in practice, what difference could this make e.g. affect training, address any existing problem?

S2: I think it would make it less personal, so any training needs could be addressed without identify an individual

Interviewer: Any affect the effectiveness?

S2: Yes, I think it works very well, it affects the future training. If you came up and the system was used in traffic light system where you did very well or you did OK or you fail measurably, and you can use that in the future training, maybe.

Interviewer: OK, thank you.

User S3

Question #1

Interviewer: The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

S3: I think yes, it is. It is good for that training for reflection on your action and that ask pertinent question in the right sequence, I think it is that a good idea.

Question #2

Interviewer: How can this program be used for training e.g. the chimney fire or the other fires? Because this program is an example in the chimney fire, how about the other fires or any other rescue services?

S3: I think the highlight suppose that you go to risk assessment about the steps of the incident, so I think that those skill in generic in that sense.

Interviewer: Do you think these steps are OK.

S3: Yes, general speaking yes. Some questions were particular clear but that would the part of language you use in the question it isn't clear what you are asking for. I think the idea of thinking through the incident in the reflective way I think it would learn other incident easy in different nature, and you understand the process about gathering information designing what to do, designing options to do, and designing which option is a choice. I think it is quite good in that sense. I think maybe you do that anyway. It just may be realised the process they go to their mind to do it.

Interviewer: If I provide the review of your answer for reflection, you can view the previous your answer the reflection. It could be useful, couldn't you?

S3: Yes it is useful.

Interviewer: Who can benefit? Do you think?

S3: I think everybody can benefit.

Interviewer: Especially, the novice or the new crew commander.

S3: Yes even beyond that they can desire get to reflect on your actions

Question #3

Interviewer: If a program like this was available, could you use in your practice and how?

S3: I think it can be used. I don't how, how part could, it would be used all the time. Because at the time...

Interviewer: In term of activity

S3: Yes, perhaps to use once a month, maybe, to run into incident. I think you try to use after every incident if you have time to do that with your available time would not be here where other thing to do. Certainly, I think using from time to time that once a month periodically.

Question #4

Interviewer: If this program is used in practice, what difference could this make e.g. affect training, address any existing problems?

S3: I think you could practice use to collate across organisation how people response to it and see there are any area where general speech and some training record. I think individuals can practice reflect themselves. I think the organisation they could collate all the answers and perhaps look at demonstrator that people are thinking in this way about this type of incident. So I think some value on that individual is useful to go to and perhaps reflect your answers that you gave what you get on them.

Interviewer: OK, thank you.

User S4

Question #1

Interviewer: The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

S4: Yes, definitely.

Question #2

Interviewer: How can this program be used for training, for chimney fire or others?

S4: Because I go into that system and I identify the correct way the system should be done a correct working procedure that should be used and also it would help the individual to work through the scenario and the actions were taken to be able to receive picture themselves that should not be done. The program help direct you in the right way in that sense. So, it is very useful.

Interviewer: Do you think who can benefit for this program?

S4: firefighters, crew manager, everyone, definitely. Because as well as crew manager making decision what actions could be taken. Firefighters need to know the actions to take as well. You know at the reason why.

Interviewer: Do you think this is more benefit for the new crew manager, not the experience crew manager?

S4: I think it very benefit for new crew managers to help involved their decision making

Question #3

Interviewer: If a program like this was available, could you use in your practice and how?

S4: I think if it is available, it should be very good to use when you get back to station after incident. If it had a generic risk in different type of accident we go to and we then come back and log on, then input that information and I think that will help direct your decision making.

Interviewer: Do you think it more benefit after you complete the fire incident near the incident site and you use this program? Does it make sense in your practice?

S4: Yes, I think some situations might be difficult to do it straight after incident because of the nature having get

back call being call other incident or something like that, if this something can be filled in completely to back to the station when nothing else is going on. The crew manager are returning back to station after an incident you still have something to do because the time take to fill in and it might be something would be better to be done back in the station rather than still actually apply at the scene because you want to be made available for any other fire crews.

Interviewer: is this for availability to everyone?

S4: Yes

Interviewer: How would you use it e.g. as complementary to your current training?

S4: I guess you could use after real scenario, after training exercise, you could have this after you've done an exercise, you could use after as well. So you could use a part of the exercise and a part of the training scenario. It is when you finish that their all training guy. You come back in the classroom more the lecture room and use it for everybody.

Interviewer: We can use in 2 situation.

S4: Yes

Interviewer: For example after the real scenario and anytime or training scenario

S4: Yes Yes, after training scenario, you can use in both ways, in real life for operational incident or in just a normal training incident. So I think in action fact there are space you got more time, it might be more beneficial after training incident. You can think about it takes more time to do it, so I think it could be used both.

Question #4

Interviewer: If this program is used in practice, what difference could this make e.g. affect the training in term of effectiveness or efficiency, and address any existing problems?

S4: If a lot of questions and answers with highlight incorrect responsive, I nothing practice responsive are highlight too from a number of people using in, then that were highlight its training need in that circumspect. So I think it is very good for highlight in training need, yes definitely.

Interviewer: Do you think it is effectiveness?

S4: Yes, yes because it is you give everybody the same scenario, the same thing you feel in, so the same possible for who are feeling in that. So the answer could be more accurate if you interview somebody, 5 people interview, 5 different people they can do it in different ways, so they act it different for this one particular way, so you can accept the answer. It's like a control measure, isn't it? It's like the experiment as be controlled and done the same way everywhere, so the result can be used accurately and I think that what this task they give you accurately response from a large number of people which will even give you a good way of determining training need.

Interviewer: OK, thank you.

User S5

Question #1

Interviewer: The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

S5: Yes, definitely

Question #2

Interviewer: How can this program be used for training e.g. for chimney fire? And about the other fires or any rescue services?

S5: It can be used. I think in two ways for training. One is using it in order to identify thing you will need to train, for example, if you went to chimney fire and you will be shown by this program that you had not done important thing. Then, it will help you to identify the thing the extra thing you need to train, and I think also it would be good for training and in situation where you may not actually had to go to chimney fire. But you could gather and what people you work with and you can say right. Let potent to go to the chimney fire what will we do and get everybody to say what will we do, and then want everybody said what we want to do. You can use this program say right "Did you do this?" "No, we didn't" "Did we do that?" "No, we didn't". And it can identify the thing the people are forgetting and the thing people need to do.

Interviewer: And just to reminds for the next time.

S5: Yes, that is right

Interviewer: Do you think who can benefit from this program? The novice or new crew commander or every firefighter?

S5: Mainly, crew commander and watch commander, and I think it is possible it would be more work, may be possible to ah no. I think most benefit is crew commander and watch commander because although most firefighters should know all information on here and it is not necessary their responsibility. But it will search in not any harm for firefighters to do it and even, and specially if you want to become a crew commander and you can use it as part of your training, so yes.

Interviewer: If you are not a crew commander, you are a normal crew. You should use this because you..?

S5: Yes, if you want to become a crew commander ever be very useful and you've never known even if you say at the moment I don't want to be a crew commander. I think there is not any harm in getting more knowledge, so you can, in the future, know what you would need to do with you did decide to go a motion. So I think it could be yes. I think it could be good for everybody. I think the short term benefit would be for the officers and the long term benefit would be the firefighters.

Question #3

Interviewer: If a program like this was available, could you use in your practice and how?

In term of what activities, whom with?, How would you use it?

S5: Well, you can use it, most you come back from situation after fire complete. When you come back to the station, I think it would be best. I think outside work would be more difficult.

Interviewer: Is it possible if you complete the fire and then you still stay around the incident place and use this program?

S5: I think it, yes, possible actually. I think it is possible but I'm not necessary know whether it might be used instead of a book. I think it would be less useful at the incident. It can still be used but I don't, I think it strength so in training and identify and for useful analysis that it's why its strength should be.

Question #4

Interviewer: If this program is used in practice, what difference could this make, for example, affect the training in term of effectiveness, efficiency, or address any existing problem?

S5: Right, yes, it is interesting recording experience for. I think it would be very good to be able to record the experience, for example, from a legal point of view because it sometime happen where firefighter will go to an incident like a fire or chimney fire where somebody heard. And somebody afterward remember public mine criticize what firefighter have done. And if the person can write down shortly what I have done and it can be shown very issue and they can make sure they have done thing that need to be done and some record then not any well. It help them to see anything it should have done, also help them to remember what they should do next some have it, but also would be something record down and what they could refer to do it later day that somebody complain that you are very good on that fire. They can say well actually I did this, this and this, and although I didn't do that I did have a reason first, so I refer to it by that.

Interviewer: OK, thank you.

User S6

Question #1

Interviewer: The main goal of this program is to help with reflection by asking a person to review their risk assessment activity. Do you think that this program will be suitable for training risk assessment?

S6: Yes, definitely it benefit in have to be shall remember what they did well, what they didn't do.

Question #2

Interviewer: How can this program be used for training e.g. for chimney fire or other fires, or the others rescue services?

S6: It is useful for us to shall remember how we perform the incident, how we can approve most of us.

Interviewer: Do you think who can benefit directly or indirectly from this program?

S6: Most of these questions are in for crew manager, incident commander but I think it is useful for new firefighters too.

Interviewer: Maybe every firefighter.

S6: Yes, initially, if we have new procedure in term of change the procedure, they want to choose new procedure. They could assess us and follow the new procedure.

Question #3

Interviewer: If a program like this was available, could you use in your practice and how in term of what activity, whom with?

S6: Be useful mine all of them I think. So you are asking me can be used on operational incident

Interviewer: I mean what activities which you use in?

S6: What do you mean?

Interviewer: For example, debrief or others.

S6: I think it issues for your own development, your training, personal training.

Interviewer: Training development

S6: Yes, your personal performance because they tailor their own responsible for our own performance for the standard, so that is a good way to check our personal performance.

Interviewer: Is it possible for, because normally you have a debrief after complete the fire?

S6: Yes

Interviewer: And you debrief to the manager, and then this program can be used like this for debrief

S6: Yes, definitely

Question #4

Interviewer: If this program is used in practice, what difference could this make, e.g. affect the training in term of effectiveness, efficiency?

S6: I think it will help

Interviewer: Or address any existing problems, for example recording experience, capturing best practice etc.

S6: If you identify training areas, area that willing to train like an our discuss area, and I didn't put in place anything for place start, for safe system of work in risk for it. So it demonstrated to me that I forgot something about risk assessment. So next then I get to incident my back what I forget the next step, make sure any weakness in your risk assessment.

Interviewer: OK, thank you.

Appendix - F

Questionnaire with Firefighters

This appendix presents the firefighters' answers in questionnaire including open and closed style questions to get feedback about their profile and usability of the PORML prototype during the experimental study in summative evaluation at the fire station, Avon FRS, Bristol, UK. Questions 1 – 8 are used to ask them about profiles with some experiences while questions 9 – 12 are used to ask them about usability of PORML prototype.

Questions 1 – 4

Participant	Q1:How long have you been in Fire and Rescue Services?	Q2:What fire type have you been involved?	Q3:What roles have you been involved in (e.g. crew member, crew commander, others)?	Q4:What is the level of your experience with chimney fire?
S1	17	All fires	Firefighter, crew manager, watch manager	Some experiences of dealing with chimney fire
S2	12	All fires, house, cars etc.	Crew member, crew commander	Good experience of dealing with chimney fire (4 or 5 times)
S3	21	Many	Crew member	Good experience of dealing with chimney fire
S4	6	House fires, chimney fires, warehouse fires, car fires	Crew member	Some experiences of dealing with chimney fire
S5	7	Fire affecting gas cylinders, bin fire, car fire, house fire, skipfire, RTC (car crash), rope rescue, person in water, chemical incidents, removing objects (rings/locks) from people, rescuing people/cat from trees, making dangerous structure safe, grass	Crew member, officer in charge of (small) special appliance	Some experiences of dealing with chimney fire
S6	9	Almost every type of fire	Crew manager, firefighter, urban search and rescue	Extensive experience of dealing with chimney fire

Questions 5 – 8

Participant	Q5:What has been your role in dealing with chimney fire (e.g. crew member, crew commander, others)?	Q6:Have you used any computer programs for training?	Q7:What is your experience with i-Phone3G?	Q8:What is your experience with using a touch screen on a mobile device?
S1	Firefighter, crew manager	Yes, MINERVA	I have used i-Phone3G but not on a regular basis	I have a touch screen mobile device and use it on a regular basis
S2	Crew member, crew commander	Yes, equality training	I have never used i-Phone3G	I have a touch screen mobile device and use it on a regular basis (at work only)
S3	Crew member	Yes	I have never used i-Phone3G	I have a touch screen mobile device and use it on a regular basis
S4	Crew member	No	I own i-Phone3G and use it on a regular basis	I have a touch screen mobile device and use it on a regular basis
S5	Crew member	No	I have never used i-Phone3G	I have never used a touch screen mobile device
S6	Firefighter	Yes	I own i-Phone3G and use it on a regular basis	I have a touch screen mobile device and use it on a regular basis

Questions 9(1) – 9(9)

Participant	Q9(1): I could follow the dialogue with the agent.	Q9(2): I was confused the statements made by the dialogue agent.	Q9(3): I found the reflection question helpful.	Q9(4): I could not comprehend the purpose of dialogue questions presented to me.	Q9(5): The dialogue was frustrating.
S1	2	3	2	2	3
S2	3	2	2	3	3
S3	2	2	2	3	3
S4	1	3	1	3	4
S5	3	2	2	3	3
S6	2	2	2	3	3
1 – Strongly agree, 2 – Agree, 3 – Disagree, 4 – Strongly disagree					

Participant	Q9(6): The review could help people learn about risk assessment.	Q9(7): I would use the system if it is available.	Q9(8): I would recommend this system to other people from my unit.	Q9(9): I would never use this system.
S1	2	2	2	4
S2	2	2	2	3
S3	1	2	2	3
S4	1	1	1	4
S5	1	1	1	3
S6	1	1	1	3
1 – Strongly agree, 2 – Agree, 3 – Disagree, 4 – Strongly disagree				

Questions 10 – 12

Participant	Q10:What do you see as the strongest points of the PORML program?	Q11:What do you see as the weakest points of the PORML program?	Q12:Did anything in the interaction with the PORML program surprise you?
S1	The mobile unit so that it can be used as part of a hot debrief.	The dialogue is a little confusing.	It responded to my answers.
S2	As a reflective tool – post incident for debriefing crews and self reflection.	The language	No.
S3	The reflective nature of the questions help the user to understand their actions (or inactions) and can help them to perform better at further incidents.	The language used in the questions is not very good and their seems not to be an opportunity to really explain why decisions were made if those decisions are outside of the normal answers.	I expected a summary at the end – something that could be printed off or saved as a text file.
S4	It helps you to evaluate your decision analysing process and review your actions.	I think the structure of the questions need to be thought about so that they can be read and understood very easily.	I thought the interaction was very intuitive.
S5	It is a way to learn and remember important safety considerations. It can be done in confidence, so senior officers will not be able to criticise when you make mistakes.	It can make general statements (such as “I think the situation was high risk”) – which may upset some people, since every situation is different and can not always be put in a box. The English sentences are not yet 100% perfect.	Yes, I was impressed by how the program was able to explain so many risk points. I wonder if it may be useful to have a reference for the risks (i.e. a reference page in fire service manual / risk manual), so person can do further research if/when they identify things they need to refresh.
S6	The program would encourage personal to assess their actions and thought processes which would lead to a better understanding of training needs. Brigade could identify patterns.	(1) Fire service technology would help. (2) Multiple choice questions – perhaps the opportunity to add notes for personal reflection (3) Possible fear of investigation should there be an accident where a firefighter was injured and correct risk assessment was not carried out.	The system is very logical and intuitive.

Appendix - G

Copy of Ethical Approval Letter

This appendix is to show that the project was reviewed and accepted by the University Research Ethics Committee to do the experimental study of the research involving firefighters with the proposed methodology and related documents.

Research Support

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MEEC Faculty Research Ethics Committee
University of Leeds

10 May 2010

Mr. Wichai Eamsinwattana
School of Computing
University of Leeds

Dear Mr. Eamsinwattana

Title of study: PORML - Personalised On-the-job Reflective Mobile Learning
Ethics Reference Number: MEEC 09-023

The above project was reviewed by the MEEC Faculty Research Ethics Committee at its virtual meeting of 7th May 2010.

The following documentation was considered:

Document	Version	Date
MEEC 09-023 PORML-Ethical Review Form V3.doc	1	27/04/10
MEEC 09-023 PORML-study-concent-form.doc	1	27/04/10
MEEC 09-023 PORML-study-information-sheet.doc	1	27/04/10
MEEC 09-023 PORML-study-questionnaire-usability.doc	1	27/04/10
MEEC 09-023 PORML-study-chimney-fire-scenario.doc	1	27/04/10
MEEC 09-023 PORML-Questions to ask after the demo.doc	1	27/04/10

On the basis of the information provided, the Committee is approves the project.

Yours sincerely

Jennifer Blaikie
Research Ethics Administrator, Research Support
On Behalf of Professor Richard Hall, Chair, MEEC FREC.

Cc: Vania Dimitrova, Supervisor