# Generative techniques in composition: Commentary on audio pieces

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**0.1 – Abstract**

In this project, I used generative and algorithmic processes to produce raw material for further development, acting as both composer and curator, and eventually producing a series of compositions that combine random elements with human embellishment. Building on techniques and approaches pioneered by indeterministic composers such as John Cage and his contemporaries (as well as the later generative artists, beginning with Brian Eno), I applied the perspective of indeterminate music in the context of more mainstream or dance-oriented music.

The first piece I produced was stylistically rooted in modern electronic music but consists of note events whose timings derived from mathematical games. Following this, using a polysynth made with Max/MSP, I pastiched the use of short, timbrally contrasting samples in electronic music, without using existing sound sources, resulting in a piece that uses randomly selected timbres and pitch content.

The process and presentation of these pieces considered altogether positions the role of the creator as an entity beside the work, rather than preceding it, and posits that the role of the listener is inherently creative.

The final submission of this project is a collection of audio pieces, a collection of Max/MSP patches, and this written commentary. The audio pieces are numbered according to their status, with the whole numbers 1 and 2 being the two main pieces, each unique in concept, and pieces with decimal numbers being compositions that explore related concepts to those, either as a tangent, an alternate take on the idea, or just a demonstration of the processes involved.

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### 0.4 – Author's declaration

I declare that this thesis is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as references.

### 0.5 – Context and Background

The idea of 'generative' music was first defined 1996, by Brian Eno, with *Generative Music 1*, a piece released on a 3½ inch floppy disk[1], and which required the 'Koan' media player to play its randomly altered tracks[2]. Unusually for a genre, it was introduced with a clear definition and purpose – generative music would be music produced with software, that is never set in stone, and different every time it's played[3] – but use of the term has varied since then, with a greater emphasis on recording the result of generative processes emerging[4], and the general field of stochastic and non-deterministic music has seen much more activity and a range of approaches.

Today, in general, generative music is produced by algorithmic processes, which may involve an element of chance, and after being produced it is then fixed and determinate, whereas 'aleatoric' music is a written score that specifies indeterminacy, and is therefore different every time it is played. Somewhat confusingly, Brian Eno in *Generative Music 1* used the word 'generative' to mean music that is different each time it's played, and John Cage's *Music of Changes* is usually called aleatoric, despite being a set composition that was guided by chance, and which was considered determinate by its author. In any case, in this project I have focused on composition guided by algorithms that result in finished, determinate pieces of audio.

While the term 'generative music' was coined in the twentieth century, the practises of producing and transforming indeterminacy in music are much older, as are ideas of

1 Brian Eno, *Generative Music 1*, SSEYO, 1996, Floppy Disk.
2 SSEYO. 'Generative Music 1 by Brian Eno.' http://web.archive.org/web/20060323154716/www.sseyo.com/products/koancontent/genmus1.html
3 Intermorphic. 'Generative Music 1 and Brian Eno.' http://intermorphic.com/tools/noatikl/generative_music.html
4 In Motion Magazine. 'Generative Music — Brian Eno.' http://www.inmotionmagazine.com/eno1.html

musical 'automatons' and games. Generative music that uses a computer is in a sense only automating the reasonably common practise of observing self-made rules while writing music, and there is conceptually nothing a generative system could do that couldn't be done 'manually' by a human being, given enough time. Applying your compositional skills to an algorithmic system is the art of elevating musical choices to the level of rules, and in that process interrogating the validity of the choice from a new perspective-- asking whether that choice is truly sound enough to become a rule.

However, Brian Eno was astute in describing generative music as a separate new category, distinct from live and recorded music, as the creation of generative music puts the creator into a role entirely unlike that seen in other forms of composition, and the act of consuming it is unlike most other music. In the process of making algorithmic music, the idea of the composer as compositional authority is deliberately erased – even if the designer of the system is the only human being to have had any input into the piece. From the perspective of the romantic ideal of the artist/author, generative and indeterminate music could be said to be certifiably non-existent music, verifiably written by no one.

John Cage, for example, is well-known for works that prompt the listener to consider the definition of music, such as the well-known *4'33*, but his work leading up to that landmark piece was also based around interrogating the definition of the role of creator, and attempting to produce works that elide the traditional dynamics of self-expression. As he put it, 'I had a goal, that of erasing all will and the very idea of success.'[5]

Locating the human element in the works that came out of this approach is a complex task. Cage's *Music of Changes* uses stochastic, uncontrolled elements to provide the impetus of the piece – taking randomisation as a starting point and a source of inspiration.[6] The piece, like many of Cage's from the same period (beginning with *Concerto for Prepared Piano and Chamber Orchestra* in 1950-52[7]), presents the performers with a series of charts of musical instructions to follow, rather than a traditional score. It is divided into four 'books', each of which is a separate 'realization' of the concept, a separate result of the process of interpreting the I Ching through Cage's system of charts.[8] It represents part of Cage's ongoing

5 John Cage.org. 'Imaginary Landscape No. 4 (March No. 2)' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=104

6 John Cage.org 'Music of Changes' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=134

7 John Cage.org 'Concerto for Prepared Piano and Chamber Orchestra' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=49

8 John Cage.org 'Music of Changes' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=134

(at that time) aim to remove 'personal preference' from his music, as well as 'memory', which he saw as the natural next step in the evolution of music and composition. However, *Music of Changes* was only composed using methods that surrendered authorial control. Randomness was only employed during its creation, and the resulting piece is fixed and determinate. Cage would later take the extra step of preserving indeterminacy in the final piece, instructing performers to incorporate improvisation or truly uncontrolled elements[9]

*Imaginary Landscape No. 4* is instructed to be performed on two radios, with instructions for changes in volume and the frequency the radios are tuned to, but naturally no control over what sound the stations they pick up are broadcasting.[10] Although instructed improvisations had been in Cage's works before, this shift to the entirety of the piece being uncontrolled was a distinct step towards his goal of erasing the expressed self in his work.

In a similar vein, *In C*, by Cage's contemporary Terry Riley[11], preserves the random element until the moment each note of the piece is played, as it is essentially a piece that gives minimal instructions and allows the actions of the performers to shape the piece.[12] Indeterminate written scores of this kind arguably approximate a jazz musician's approach to performance, with improvisation around the core guidelines of the piece, but seem to emphasise the chaos produced by multiple actors acting separately rather than the dynamic between musicians who consciously act in a way that coheres with each other and works within their group dynamic.

Cage's method of using I Ching was employed again with *Seven Haiku* (1951-52), which was actually composed using the same charts used in *Music of Changes*[13] and then again with *Williams Mix*, in which Cage produced something akin to Musique Concrete, using a variety of sound sources such as radio broadcasts and tone generators, all cut up and rearranged on tape using again the guidance of the I Ching according to charts Cage had designed.[14] The finished piece surrenders musical control as thoroughly as any before it, but is in its final form a determinate piece, even more so than the score of *Music of Changes*, since it is an audio recording. A parallel could be drawn between this approach and the way

9 John Cage.org 'Water Music' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=241
10 John Cage.org. 'Imaginary Landscape No. 4 (March No. 2)' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=104
11 Terry Riley, *In C*, (New York : Associated Music Publishers, 2015).
12 Intermorphic. 'Generative Music 1 and Brian Eno.' http://intermorphic.com/tools/noatikl/generative_music.html
13 John Cage.org 'Seven Haiku' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=173
14 John Cage.org 'Williams Mix' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=246

in which an improvised jazz piece is elevated to composition by the process of recording it, intent (in the compositional sense) being produced retroactively.

Following these various experiments, Cage arrived of course at his famous *4'33*, where intentional sound is absent.[15] The only instructions to the performer are to open and close the lid of the piano (an idea explored earlier in Cage's *A Flower* and in *Music of Changes*, where a closed piano lid is used as a percussive instrument[16]). In a piece such as this, the role of the author could uncharitably be said to be meaningless, but to take the commonplace reading of *4'33*, that the composition itself is the uncontrolled sounds that are heard, it follows that the composer here is entirely absent, but the composition itself is present.

For another illuminating contrast. compare Stockhausen's one-time insistence on all elements of a piece mathematically relating to each other (or to an overall principle) to Matthew Herbert's similar guiding principle of using significant numbers to guide the composition of his pieces, down to using coffee consumption statistics to dictate the structure of the song *An Empire of Coffee*[17] [18]. Contrarily to Stockhausen's approach, Herbert seems to merely use this logic as a jumping off point for his composition, or raw grist for the mill of creativity. Despite the stubbornness with which he applies them, the implementation and interpretation of his guidelines are entirely in the hands of the creator, and could not, for instance, be automated.

### 0.6 – Aims & Objectives

My approach has been to build generative systems and tools, and use them as both the source of finished work and as the source of inspiration and raw material for further work. A couple of my pieces are not so much generative as indeterminate, in that they involve constructing a system where there is one optimal solution, and using Max to find that solution. It's my belief that my approach to constructing algorithmic musical systems is related to the field of combinatorics, the field of mathematics that considers optimal

15 John Cage.org '4'33' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=17
16 John Cage.org 'A Flower' https://www.johncage.org/pp/John-Cage-Work-Detail.cfm?work_ID=23
17 Matthew Herbert, 'An Empire of Coffee,' *Plat du Jour*, Accidental, 2005, CD.
18 Herbert, Matthew. 'Plat du Jour: The Making of' https://matthewherbert.com/plat-du-jour-the-making-of/

solutions to logical puzzles, and structural approaches to finding them, in terms of graph theory.[19]

While there is not necessarily a random element in an 'indeterminate' piece, the control of the creator is ceded in the same areas. What's more interesting about a non-random indeterminate piece or process is it can be seen as illustrative of an objective mathematical principle -- albeit often in a counter-intuitive away.

Making and solving puzzles is both a 'hard', mathematical pursuit and a 'soft', creative one, and this is, I think, where the human element of generative music is. Here, as with many rule-based composition systems of the past, the creativity and the hand of the author is mostly found in the design of the system, not the shaping of the piece itself. Further editing was done after the fact, and in some cases I have leaned on the scale to a greater degree than in others.

The end result is a collection of randomised musical ideas towards which I have acted as a sort of curator -- the curator of a museum of accidents. This project offers cherry-picked results of the processes I have been dealing with, attempting to offer a selection of audio pieces that are both rewarding to listen to devoid of context, and interesting from a theoretical perspective offering a similar experience to mine as I approached these ideas and discovered their results.

This role is analogous to the role of the artist in many other art forms, such as theatre or film. The elements of the work that they have no control over have a different scale, but it is a difference of kind, not a difference of quality. Indeed, to enjoy art is itself a creative act, because the art you perceive and enjoy is inaccurate, inevitably adapted and changed slightly by the process of perceiving it.

19 Gullberg, Jan. 1997. *Mathematics From the Birth of Numbers*. New York: Norton.

**Piece 1 - *Planets***

The initial concept of *Planets* was an idea that applied concepts of periodicity found in nature to a piece of procedural music – a piece where the concept is that several notes play repeatedly, each repeating at a different rate – that is to say, the note event being repeatedly triggered, like a musician pressing a key repeatedly. Each note has an independent rhythm, and the resulting effect is like a fluttering arpeggio with a strange rhythm. For simplicity's sake, from here on I will refer to the speed that each note repeats as its recurrence, to differentiate it from frequency.

This concept vaguely echoes Brian Eno's approach when making *Music for Airports*[20], wherein he played several looping tapes of different lengths and recorded the result.[21] *Planets* has this approach, but as if each tape had only contained one note.

The piece is so-called because I considered the principle of several cycles that rarely coincide and create a continuously original state to be roughly analogous to the common orbits of planets in one solar system. The length of time for each 'orbit' doesn't change, and indeed one orbit on its own seems monotonous, but the overall system produces what seems like endless change, or an evolving piece. The original inspiration for this piece was the sound of church bells ringing, which produces shifting random melodies as the individual bells naturally repeat but go in and out of sync with each other.

Using this starting point, I then applied this principle to a series of harmonies, almost like using an arpeggiator, and this was the basis of 'Piece 1'. The drum patterns were later added as part of another experiment.

A similar concept to this automatic arpeggiation is used in Arvo Pärt's *Tabula Rasa*, particularly it's second part, 'Silentium'[22], which methodically disassembles/explores a scale in two voices, at two different speeds, over the course of fifteen minutes.[23] This method of exploring the harmonies of a scale was the first use of a technique Pärt called 'Tintinnabuli', which was drawn from his experiences with religious chants, and uses great simplicity and exactitude to draw out the harmonic warmth of a scale.[24] Pärt later compared this form of

20 Brian Eno, *Music for Airports,* Polydor, 1978, CD.
21 In Motion Magazine. 'Generative Music — Brian Eno.' http://www.inmotionmagazine.com/eno1.html
22 Arvo Pärt, 'Silentium,' *Tabula Rasa*, ECM Records, 1984, CD.
23 Marvelly, Paula. 'Arvo Pärt: Silentium' https://www.theculturium.com/arvo-part-silentium/
24 Marvelly, Paula. 'Arvo Pärt: Silentium' https://www.theculturium.com/arvo-part-silentium/

composition to a prism splitting white light into colours. The semi-procedural nature of the technique belies its plainly apparent emotion.

### 1.1 – Optimal timing derived from roughness

In the earliest incarnation of this piece, the idea was that the recurrence speed of the notes would be derived from the pitches of the notes themselves, specifically in the sense that the timing of the notes would be programmed to 'maximise' the consonance of the resulting arrangement, so that intervals with more dissonance (or 'roughness', to be more specific) would be less likely to occur than others – effectively finding the 'optimal' way to play the selected notes.

In this project I have differentiated dissonance from roughness (and the closely related concept of amplitude fluctuation), using roughness only to refer to the quantifiable effect of multiple differently-pitched waveforms 'beating' as they interfere with each other. The concept of dissonance (and the general idea of different intervals being more or less pleasant than others) is where I have drawn my inspiration for this piece, but it is a subjective quality, and impossible to measure. For expediency's sake, I chose to focus on roughness, which is closely linked to dissonance, but possible to measure – the fact that it can be evaluated means I can use it as a value in a program.

The assessments of roughness I have referred to comes from the late 90s work of William Sethares,[25] who built upon work by Plomp & Levelt in the 60s[26], and produced a system of measuring the roughness of a given signal produced by a pair of sine waves (the roughness of a signal containing more than two sine waves can be calculated by adding the roughness of each pair of the constituent sines, but whereas phasing is not an issue for this system in a signal made up of two sines, becomes more of an issue in a signal made up of three or more -- and moreover this is irrelevant to my aim of assessing the roughness of intervals. However, the complexity of analysing a signal containing more than two sines actually relates conceptually to the theoretical underpinning of *Planets*, since it shows chaos

25 Sethares, W. A. (1998). *Tuning, Timbre, Spectrum, Scale*. London: Springer-Verlag.
26 Plomp, R. and Levelt, W. J. M. (1965). *Tonal consonance and critical bandwidth*. JASA, Vol. 38: 548-560.

and disproportionately varying results coming from a system of repeating events if they happen to be timed in a certain way).

An important concept in this piece, and in a couple of other short pieces in this project, is the idea of timing multiple systems to either maximize or minimize coincidence between them, which is related to the mathematical concept of periodicity. In this piece it's used to time the individual notes of the piece, and later used to decide the frequencies of the various oscillators in 'piece 1.3'. In this way, the two pieces become like observing the same phenomenon at different time domains – at the scale where frequencies are perceived as musical pitch, and at the scale where they are perceived as discrete repeating events.

Use of this principle actually occurs in nature, as a couple of species of cicada have prime numbered life cycles, which helps avoid a predator's life cycle syncing up with theirs, while retaining the advantages of a synchronized hatching period.[27]

### 1.2 – The *Planets* drum arrangements

A while before the creation of this piece, I was interested in whether I could create a beat (specifically an arrangement of drum sounds) that the listener doesn't hear as a rhythm. IE, a beat that's as irregular as possible, that cannot (easily) be heard as having an underlying beat. Any potential arrangement can be heard as 'rhythmic' in this sense if the times at which each note event occurs have at least one common factor, so that the ear can resolve it as an arrangement with that common factor as the tempo, essentially. It is essentially impossible to completely avoid this effect, since any two numbers have at least one common factor if you accept fractions, but can be effectively minimised. With this in mind, the logical way to create a beat that is as 'non-rhythmic' as possible is to assign the timing of each beat based on a system of prime numbers, which is conceptually related to the methods involved in other offshoots of the 'planets' concept. These drum pattern ideas formed the basis of the minor offshoot 'Piece 1.2' and the drums for the main *Planets* track, 'Piece 1'.

This avenue of exploration was inspired by the drum patterns of the group Autechre, particularly the first half of the song 'LCC'[28] and the track 'Fold4, Wrap5'[29]. Autechre seem to

27 Ito, H. et al. Evolution of periodicity in periodical cicadas. Sci. Rep. 5, 14094; doi: 10.1038/srep14094 (2015)
28 Autechre, 'LCC,' *Untilted*, Warp, 2005, CD.
29 Autechre, 'Fold4 Wrap5,' *LP5*, Warp, 1998, CD.

approach polyrhythms from a procedural perspective, producing interesting patterns with exploration in theory preceding the actual creation of sound. An example of this would be the aforementioned 'Fold4, Wrap5', which is based on a loop where the tempo falls continuously, but seamlessly doubles (or switches to double-time, to look at it from another perspective) at a certain point in the loop, resulting in a fluid sounding beat that defies conventional timing and the instinctive expectations of the listener. Such a rhythm could essentially only be conceived as the result of playful experimentation with theory and procedural systems, rather than 'normal' composition.

### 1.3 – Further production

One of the main sounds you hear in *Planets* is from a polysynth patch made in Max/MSP, which uses the matrixctrl UI object to control the signal routing between a set of oscillators, thereby offering a robust range of possibilities for modulation, especially as oscillators that are already modulated can in turn act as the modulator for another oscillator.

During the creation of this patch I ran into a problem with Max's interpretation of event scheduling, and redesigned the synth to work around it. Because Max/MSP allows you to set out patches so freely, you can end up designing something that causes a stack overflow, and something that can cause this in the audio domain is an arrangement of oscillators connected in a way that allows the signal path to become too circuitous or self referential – creating a situation where Max's DSP engine is stuck attempting to evaluate one sample of audio that calls for infinitely recurring processes. The upshot of this is that a patch where an oscillator can potentially modulate something that will later modulate it in return will automatically disable the audio in Max without an error message. The standard way to prevent this issue is to make sure there is a delay of at least one sample at some point in the hypothetical loop, which can be done either with tapin~ and tapout~ objects (a simple delay effect) or by using the Gen environment to specify the delay explicitly.

The synth setting heard at the start of the track was produced by three sine wave oscillators: the first ring modulated by the second (which is at the same pitch) and frequency modulated by the third, which is at 0.25 times the pitch of the other two. To accentuate the warm lower tones of this instrument, a low shelf filter was applied at around 71Hz.

Eight bars into the piece, a second polysynth can be heard, which is simply a sine wave oscillator with a unison setting that produces nine voices for each note event, resulting in a very airy sound. The unison effect also spreads the panning of these voices across the stereo image.

Sixteen bars into the piece, a bass monosynth and a melodic polysynth enter. The bass synth consists of two sine waves, one of which is ring modulated by another sine wave at its own pitch, and the other of which is unmodulated and an octave lower; a setting which results in a fairly rich timbre while still retaining a powerful low-end. This synth also applies unison to the notes, producing two voices which are hard panned to the left and right, the result of which seems quite similar to one voice in the centre, but without occupying that space in the mix. A subtle distortion effect was applied to the bass, at a level which essentially equates to a slight addition of 'warmth' to its timbre.

The melodic polysynth is a simple sine wave with FM from a sine wave at the same pitch, but the depth of this arrangement comes from its subtle delay effect, which is mixed low enough that it isn't immediately noticeable, and hard to pick out of the mix, but it adds harmonic warmth to the overall piece at that point. This synth also has no unison effects, allowing it to cleanly occupy the centre of the stereo image and remain more coherent than it might otherwise have been, which was the purpose of hard panning the voices of the bass synth.

At 32 bars in, another polysynth enters (with no other backing), with similar settings to the one heard 8 bars in, but this time with unison settings that vary the pitch of the produced notes, and a strong reverb effect, the dry/wet setting of which is set at 53%, which, in terms of reverb, is very prominent, and results in a warmer, more saturated sound, while also abrading the sound to an extent, and making this arrangement easily lost in the mix when the other arrangements return.

### 1.4 – Nested oscillators

Partly conceived to be the opposite of the original *Planets* itself, the third permutation of the planets concept is a piece that consists of a sustained drone whose properties vary very slowly over time, as if every setting of a synth patch were connected to

an LFO. The speed of the changes itself changes over time, and over time we hear very different timbres and patterns of pitch content introduced to the piece.

The piece is, therefore, essentially a large net of interconnected oscillators which act as controllers and modulators to each other. There is no mesostructural control happening in the piece – the changes you hear over time are the result of oscillators operating outside the frequencies that the human ear perceives as pitch, in the domain of rhythm and discrete sounds.

The principle of optimal timing returns here, now dictating the frequencies of all of these oscillators, designed to produce the longest possible time before the same combination of settings is heard again. Despite the difference in timescale, this piece explores the same principles as *Planets* – the frequency of waves mirroring the playing of notes – and the same maths as before is employed to select the frequencies of the oscillators, which were then manually edited slightly, as I attempted to find something pleasant to hear and perhaps harmonically interesting. Similar to earlier in the project, this is an arrangement where there is one perfect solution to the 'problem' being posed, whereby the elements of the piece combine to create an optimal effect.

My use of generative principles to create a drone piece was partly inspired by Brian Whitman's *A Singular Christmas*[30], an album of music that used statistical analysis techniques to create procedurally generated Christmas music[31] – an approach that is mathematically perfect but compositionally hands-off, receiving no input from the creator but for a small amount of editing and the selection of the tracks itself.[32] Being a PhD student of music at the time,[33] the project is unsurprisingly rooted in a theoretical approach, following on from Whitman's previous 'Eigenradio' project, which performed a similar analysis/resynthesis process on radio broadcasts and streamed the results in real-time[34] – which itself underlines the automatic, absent-creator nature of this approach. However, despite his later insistence that 'the computer made it, not me!'[35], the whole project represents a unique creative

30 Brian Whitman, *A Singular Christmas*, 2004, Digital Download.

31 Whitman, Brian 'A Singular Christmas (2004)' http://notes.variogr.am/post/262976984/a-singular-christmas-2004

32 Ibid.

33 Ibid.

34 Recht, Ben and Brian Whitman, 2003. *Musically Expressive Sound Textures from Generalized Audio. In Proceedings of the 2003 Digital Audio Effects (DAFX03)*. [pdf] Available at: <http://alumni.media.mit.edu/~bwhitman/recht_whitman_dafx03.pdf>

35 Whitman, Brian 'A Singular Christmas (2004)' http://notes.variogr.am/post/262976984/a-singular-christmas-2004

statement, and a vision of what music and composition means to one person. And in fact, the mix of a methodical, preset approach and the composers input provides a unique balance between mathematical elegance and musical passion.

**Piece 2 – *Plethora***

The goal of my second piece, *Plethora* was to mimic, procedurally, the effect of sampling multiple different songs to create a new arrangement – a technique emblematic of French House (in which re-contextualised samples of 70s music became a key feature of the style), which produces a harmonic and melodic effect unlike any single instrument, I would argue. In the case of this project, this effect was achieved with a polysynth made in Max/MSP and the end result was a single piece of music that explores its sound.

To expand on the reasoning behind making a piece in this style: when an arrangement is played in this form, with periodically changing timbre, the impression of distinct melodic voices within it is obscured. Not only do voices and directionality in the arrangement become ambiguous, the very octave each note is played can do as well, since the changing partials/pitch content of the notes can make them impossible to contextualise. An example of this sampling technique is 'Face to Face', by Daft Punk[36], which features a rapid-fire assortment of samples at various points throughout the song.

Although originating in the technique of sampling, the general practise of combining contained bursts of timbrally distinct arrangements has since been used in other styles of music. For example, the band Meatbingo use a similar technique in several of their songs (notably throughout the track 'Smug Resistor'[37]) wherein many synths and original sound sources are each used (usually once) to create an arrangement. Although these snippets of sound are mostly synthesised rather than sampled, the resulting decontextualised moments of harmony is calculated to achieve the same effect of obscuring the presence of melodic voices as with the rapid-fire sampling of earlier electronic music, and is stylistically descended from that approach that only became possible beginning in the 80s with the appearance of consumer-targetted samplers.

The way I approached this task was to create a polysynth patch whose individual voices were 'desynced' from one another, each having a different timbre and independent settings. The effect of this in theory is that playing a chord in this synth results in what sounds like a snapshot of a complete song with multiple arrangements of different timbre – IE, one instrument playing the bass part, another playing sustained chords, and another the

36 Daft Punk, 'Face to Face,' *Discovery*, Virgin, 2001, CD.
37 Meatbingo, 'Smug Resistor,' *Trendy Robots*, Skam, 2013, Cassette.

lead melody. Single notes played into the patch don’t create the impression of a 'snapshot', but they do sound melodically independent of each other.

For the desired effect of an arrangement made of distinct samples, it’s necessary for it to appear that certain 'samples' are being played more than once, rather than every sound being entirely unique. For this reason, in this version of the patch, each note remains at the same settings rather than being randomised every time a note event is played, which may have been a sonically interesting approach, but would not fit the style I was aiming for.

Another way of preserving the impression of 'reused' samples would have been to use the 'thresh' object in Max to join closely timed note events into a list, and then use that list (or some derivation of it) as the random seed for the settings of the synth patch, so that playing the same chord would always produce the same effect, but the notes in that chord would sound different if they were played in another context. However, I chose not to use this method, because of the slight loss of responsiveness/timing fidelity, but also because this method doesn’t work well for melodies and single notes.

The patches used for this piece are 'plethtest-new2edit2', the main patch that receives MIDI input from a given source; 'plethprotob', the synth patch itself, 36 instances of which are instantiated as the synth’s voices when it is in use (one for each note in 3 octaves, one voice for one note and none other); and 'oscbase3'/'oscbase3b', which is one oscillator of the synth.

To create different timbres, the 'plethprotob' patch uses (for each voice) a set of three oscillators that are connected in a way that allows for many different types of modulation or combination, while still being relatively lightweight and undemanding in terms of system resources. Frequency modulation, amplitude modulation and additive synthesis are all possible within each voice of the synth.

Using Max/MSP’s implementation of polyphony, it’s actually easier to let each voice have different settings than regulate them and keep them in sync, with the same settings, since each voice is a separate instance of the synth subpatch, and hence messages that change the settings need to be sent to all instances – but until now I hadn’t seen any particular use for this quirk of the language. The independence, or lack thereof, is a useful feature in Max, because it allows for various effects to be achieved when using 'unison'. In Max, unison is achieved simply by sending duplicate note-on messages to a poly~ object, so that multiple instances of each note are played, with slight variations in the parameters if

need be. I find unison effects particularly useful for imaging and panning effects, allowing you to control not only how wide the stereo image of this one sound is, but how the stereo spread is achieved.

Nearly as important as the timbre, to achieve the desired effect, is the volume envelope of the sounds produced, which needs to create the impression of a sample repurposed from a longer piece – a snippet of sound that wasn't intended to be heard in this context. To achieve this, I decided that the end of the volume envelope should always be an abrupt silence when the note off event occurs, which is also in keeping with the style of sampling I'm aiming to pastiche. Essentially, it should seem like you can hear the envelope of the 'original' sound *and* the envelope of the sampler that contains it. The attack and sustain of each voice are random and fairly varied, and the panning of each voice varies, but tends strongly towards the centre of the stereo image, for the sake of overall neatness. The distinct voices of plethora do not have their own effects chains but it would have been simple to add delay and phasor effects using tapin~/tapout~. In the end it was just simpler to mix and apply effects afterwards, since the composition style I ended up moving towards was fairly minimal.

Besides the patches that handle audio, the minor patches 'randomtend' and 'randompitchmod3' handle the maths determining the synth's settings. 'Randomtend' fills the useful role of generating numbers that tend towards the middle of the given range, which makes extreme results less likely, and thereby help keep the audible results from sounding too outlandish. The amount to which numbers tend towards the middle of the range can also be specified using the patch's arguments.

Having completed the patch, I set about creating the track, using two strong bass notes as my starting point, and constructing additional harmonies around them. The random settings of the patch sometimes forced me to avoid certain notes, since their timbre had ended up unsuitable for use, and my solutions to this issue resulted in a piece that I wouldn't have composed without such an intrusion – random elements provoking the composition of the track, but ultimately being filtered through my own creative decisions.

As this piece began by drawing inspiration from House music, I thought it would be appropriate for the structure of the piece to be quite conventional from a pop/dancefloor standpoint, with a decisive intro, something approaching a verse/chorus structure in the first half of the song, and a drawn out climax. Therefore, the first 2 minutes of the track quickly

introduce a version of the main theme, using an ABAB structure, while the remainder of the track is stripped back to just drums and then builds up to an ending that that recapitulates the full theme of the piece and introduces more harmonies. Being reduced to only a couple of patterns and then building back up to a full mix is a very well established, almost cliché, approach in dance music.

I thought several of the samples really shone when used as if they were drum samples with unusual pitch content, so I devoted a short portion of the track to essentially nothing but rhythm, before the end of the track. These samples not only worked well with the drum arrangements, but allowed me to bring harmonies into the piece in a surreptitious way, which is an effect I enjoy in music. Buried or imperceptible pitch content in (mostly) rhythmic samples (or drum synths, even) is a fairly common feature of electronic music, which allows composers an unusual amount of freedom to do this. An example of this effect is ‘Revolution 909' by Daft Punk[38], in which quiet sustained harmonies throughout the song can easily slip by unnoticed unless you pause and resume the song, but nonetheless contribute to the overall harmonic motion of the song.

Towards the end of the track, I brought in a couple of the notes from the plethora patch that had ended up with noisier, less obviously 'musical' timbres, to create a sort of 'cloud' of ambiguous timbre around the sparse pitched instrumentation of that section, similar to having an instrument in the mix with a lot of reverb (or a similar effect), so that it begins to fill the mix and lose its impression of pitch content, becoming something like a background element that contextualises the rest. I also found this provided a pleasant contrast with the crisp, controlled style of sampling used at the start of the song, and which also returns in the last few seconds, to bookend the piece.

At various points of the song (starting at 0:24), a polysynth plays long sustained harmonies backing the sounds of produced by the plethora patch. This synth uses a unison setting that produces two voices per note, panned noticeably but not dramatically apart from each other, and being nearly 90 degrees apart in phase. This setting helps to make it sound both richer and more indistinct, without applying reverb or delay, which would make it murkier and detract from the clarity of the piece. A unison setting of more voices would produce an even airier, more indistinct sound, but again at the cost of clarity. To further sink

38 Daft Punk, 'Revolution 909,' *Homework*, Virgin, 1997, CD.

this sound into the mix, a fairly wide high shelf filter was applied at around 655Hz to attenuate higher frequencies, making the arrangement less bright

Finally, the piece was mastered in Reaper, mostly using the included VSTs ReaEQ and ReaComp, which are impressively transparent while also offering a great deal of control, but also the commercial VST 'Sausage Fattener', which is predicated as a sort of one-stop mastering plugin,[39] but which is more useful as a kind of distortion or tone control effect.

*Plethora*, in the end, diverged quite far from its generative beginnings, becoming almost a track divorced from the generative concept entirely, lying on the extreme end of the spectrum of approaches to generative content I've taken in this project.

### 2.1 – *Plethora* 'dubstep'

Relating to the core concept of *Plethora*, as a minor aside exploring similar concepts, I was interested in seeing if I could use the timbre-randomisation system to pastiche the characteristic use of multiple bass timbres in the 2010s EDM offshoot usually called 'dubstep'. I would define this style as the use of multiple quite extreme bass timbres in one arrangement, often changing very quickly, and underpinned by a relatively simple dance beat. Hence, the *Plethora* patch could fairly easily be adapted to mimic this style by converting it to mono, increasing the amount of variation, and optimising the the settings for lower notes (trying to avoid settings where the impression of the note's pitch itself gets lost because of a prominent oscillation or modulation at too low a frequency), and allowing for more situations where the note seems to bend in pitch (which in plethora is just achieved by having frequency modulation with a low pitched oscillator as the controller).

To bring more warmth to the bass part, I added a series of gated chords that expanded on the harmonies they implied, and this in turn suggested a simple song structure wherein the chords gradually fade in and become the focus on the track. A reverb effect (with a long decay time, but with a reasonably low dry/wet setting) was applied before the gate effect, and a delay effect (with the same timing as the gate, meaning the echoes overlaps with the bursts of sound when the gate is open) was applied afterwards, to add richness to the arrangement.

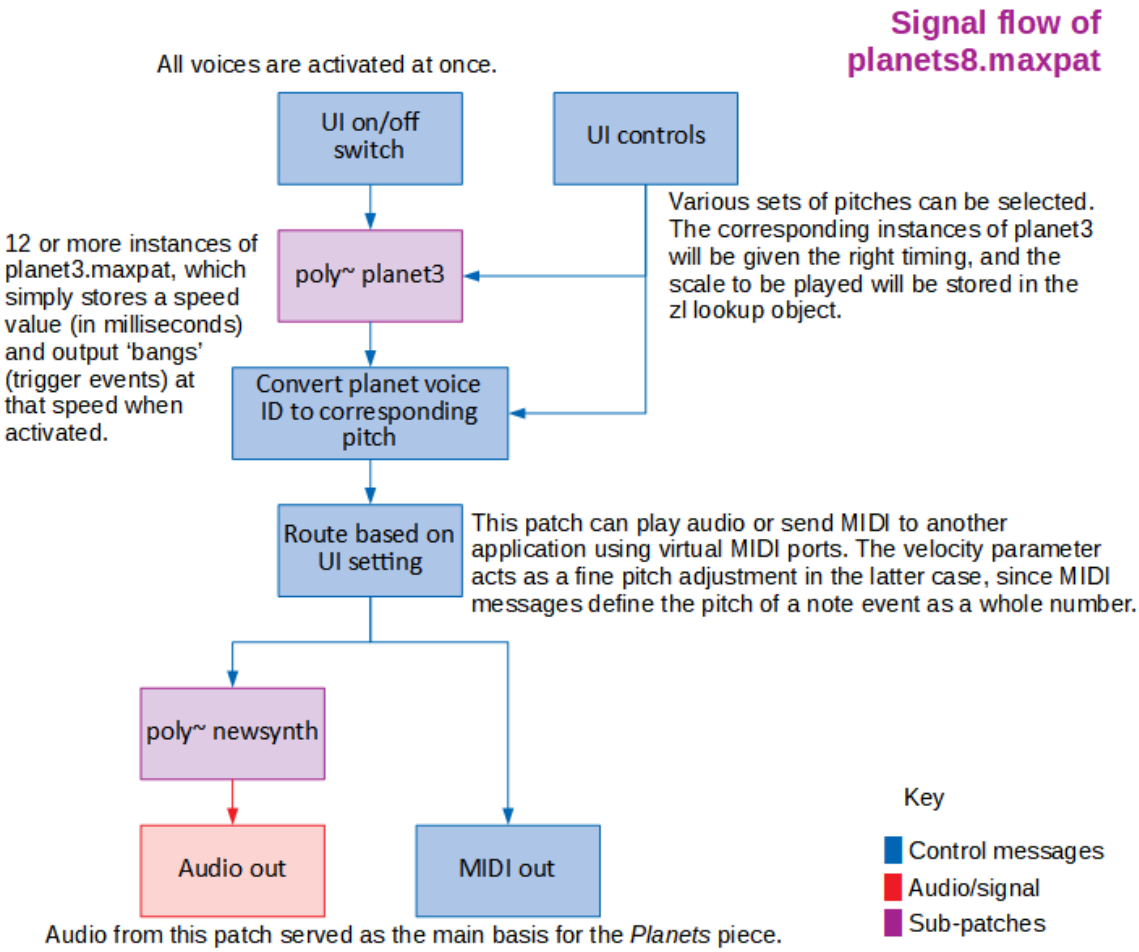
39 Dada Life, 'Sausage Fattener' http://www.dadalife.com/sausage-fattener/

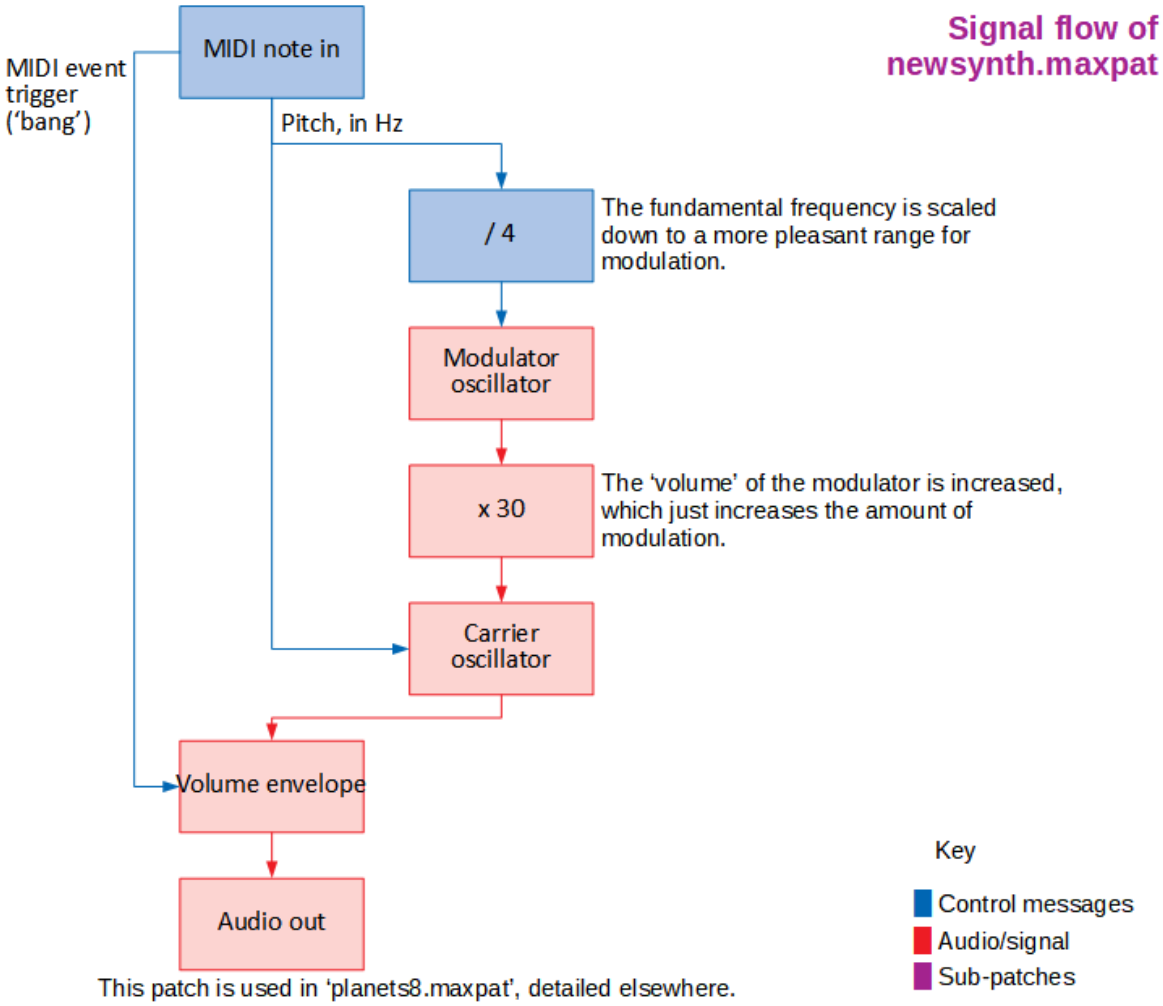
### 2.2 – Minor generated pieces

Included along with *Plethora* are a handful of recordings from a related set of patches that were used to create simple arrangements, using lists in Max to create harmonic arrangements based on parallel harmony, and feeding the results into four polysynths. They are named 'minor piece' 1-3.

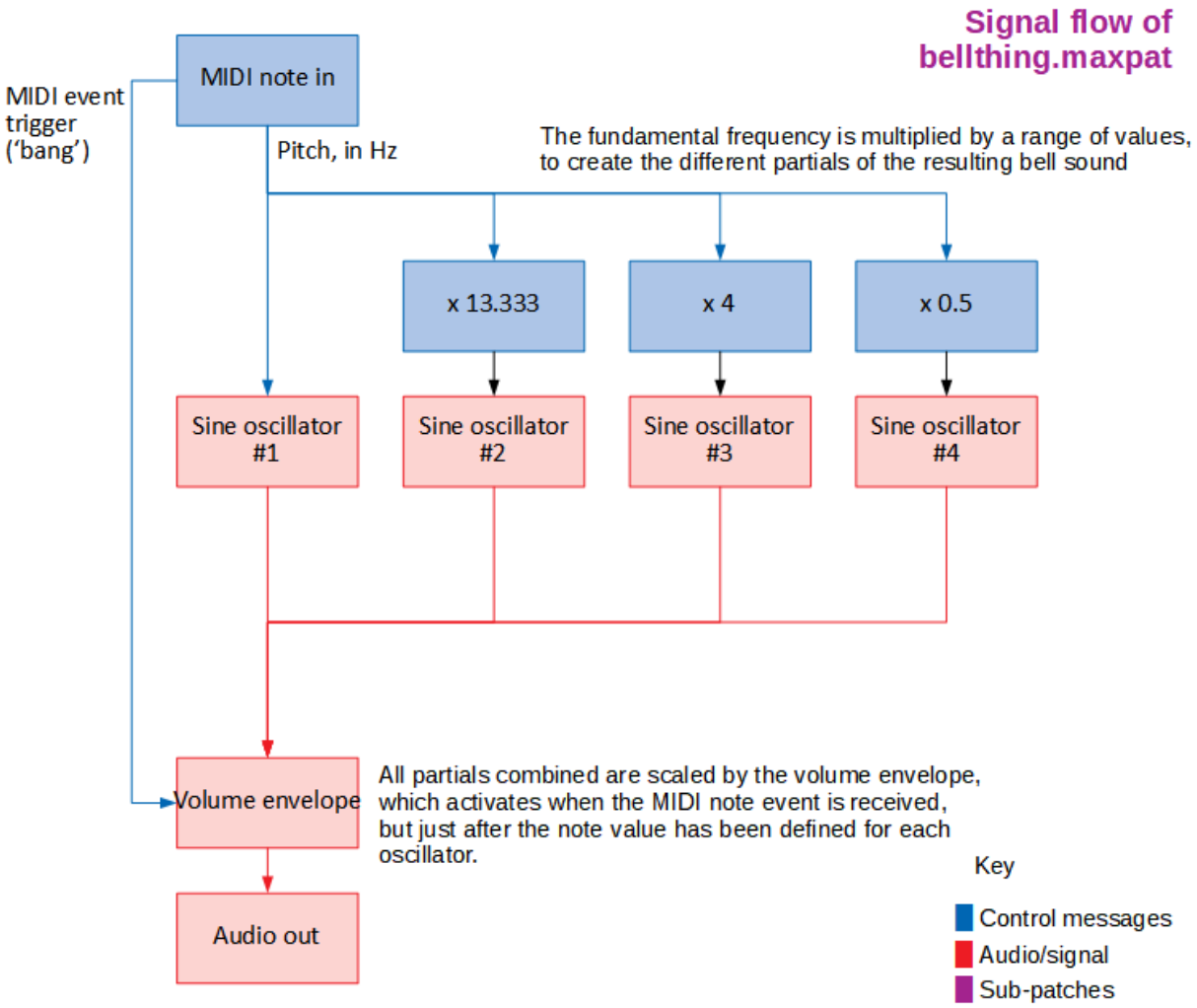
### 3.0 -- Signal Flow Diagrams

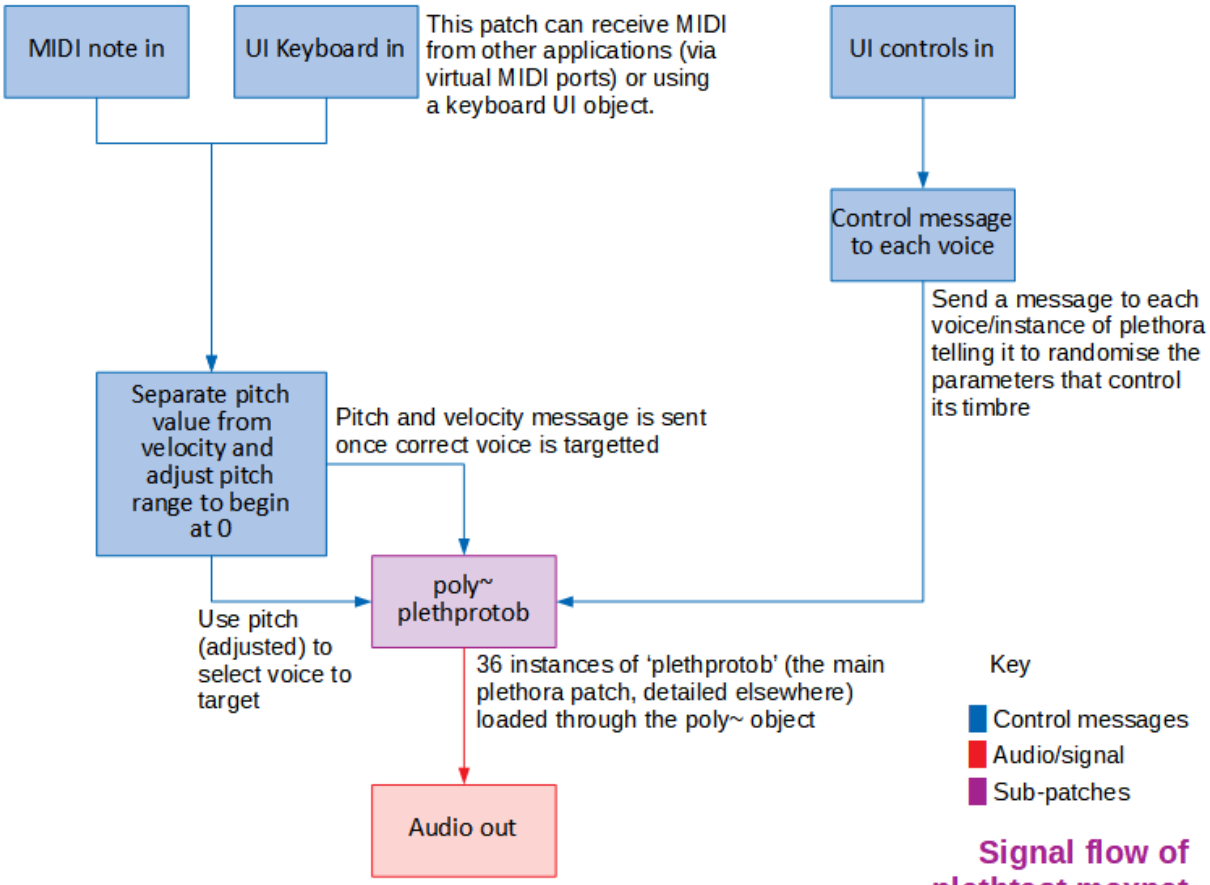
In these diagrams,  blue lines represent MIDI or control messages, and red lines represent audio signal. The operation of these patches has been simplified a little for these diagrams, but they can be seen in full detail in the included patches themselves, since a Max patch is ultimately just a complex signal flow diagram.



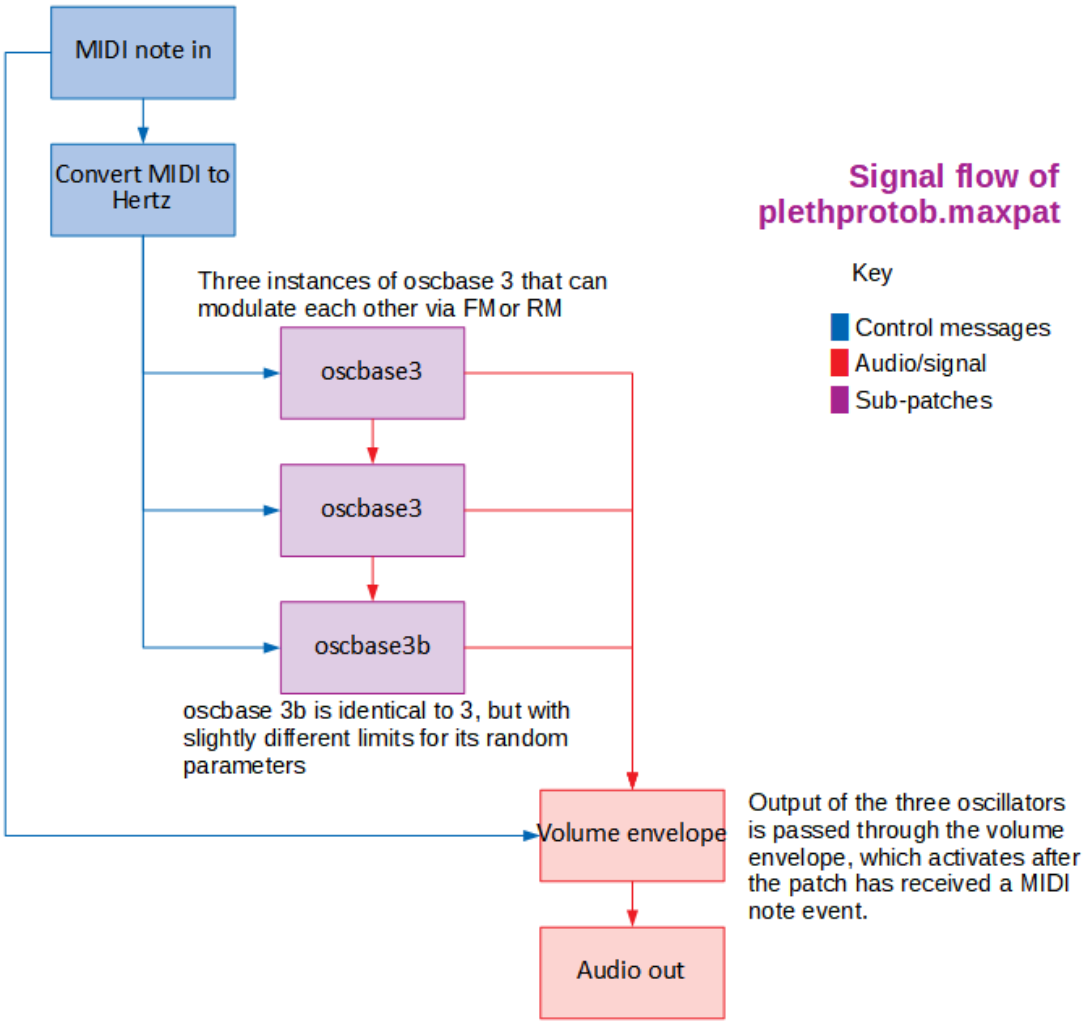



This patch is used in 'planets8.maxpat', detailed elsewhere.

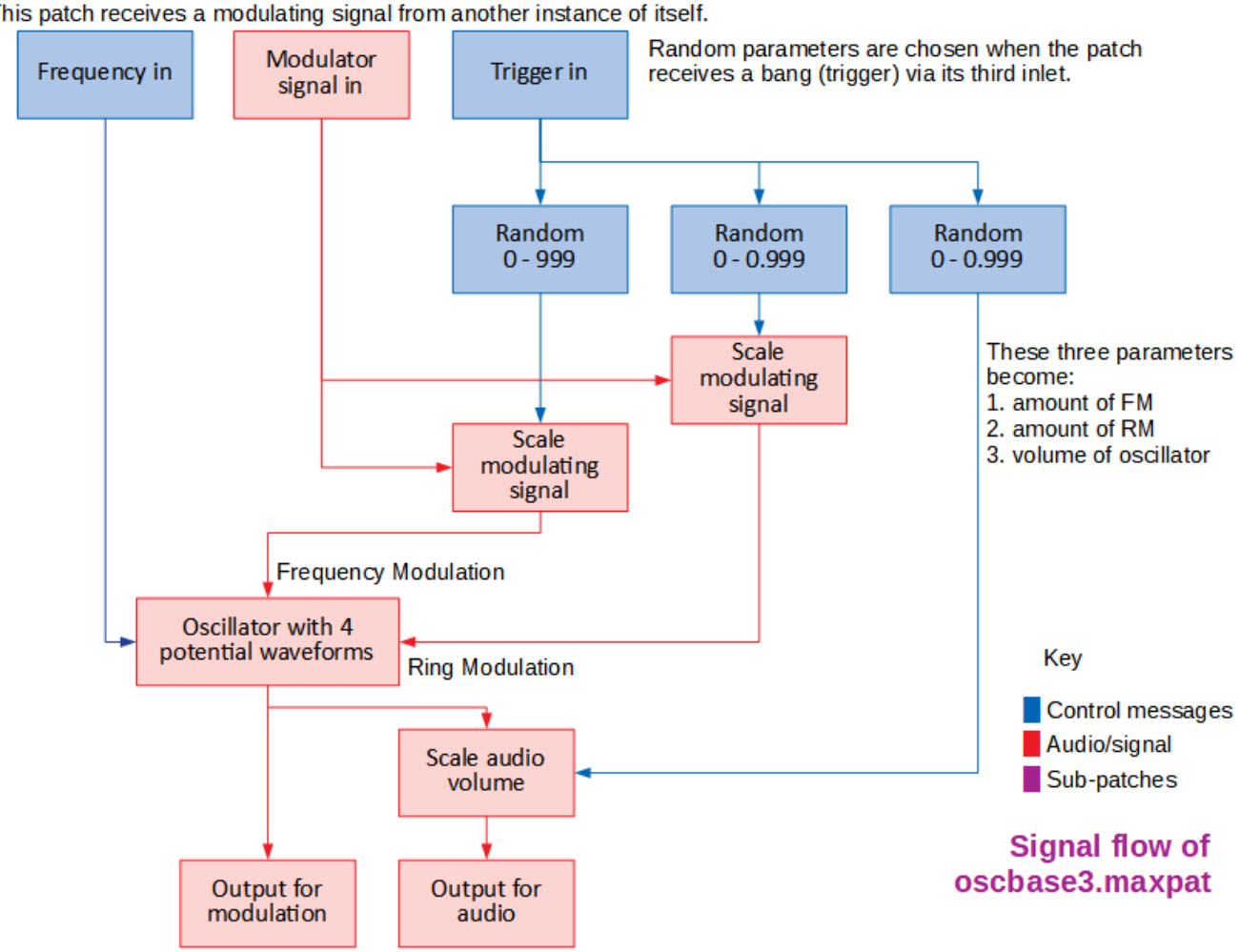

Signal flow of bellthing.maxpat
MIDI note in
MIDI event trigger ('bang')
Pitch, in Hz
The fundamental frequency is multiplied by a range of values, to create the different partials of the resulting bell sound
x 13.333
x 4
x 0.5
Sine oscillator #1
Sine oscillator #2
Sine oscillator #3
Sine oscillator #4
Volume envelope
All partials combined are scaled by the volume envelope, which activates when the MIDI note event is received, but just after the note value has been defined for each oscillator.
Audio out
Key
Control messages
Audio/signal
Sub-patches




Audio from this patch served as the basis for the piece *Plethora*.


MIDI note in
Convert MIDI to Hertz
Three instances of oscbase 3 that can modulate each other via FM or RM
oscbase3
oscbase3
oscbase3b
oscbase 3b is identical to 3, but with slightly different limits for its random parameters
Volume envelope
Output of the three oscillators is passed through the volume envelope, which activates after the patch has received a MIDI note event.
Audio out
This patch is used in plethtest.maxpat, detailed elsewhere
Signal flow of plethprotob.maxpat
Key
Control messages
Audio/signal
Sub-patches

This patch receives a modulating signal from another instance of itself.




**Signal flow of oscbase3.maxpat**

Three instances of this patch are used in plethprotob.maxpat, detailed elsewhere.

**4.0 -- Conclusion**

Following on from works by John Cage, Brian Eno and many of their contemporaries, I've composed a collection of pieces that explore the concepts of authorial will, and its presence or absence in a complete piece of music, and furthermore the concept of the listener's role in the piece.

Similarly to Cage's work with indeterminacy, but with the advantage of digital processes to automate certain things, I've used generated arrangements and settings both to augment or prompt my compositional decisions and to replace them entirely. In the piece *Planets,* I used generative systems of my design to dictate the timing and horizontal aspects of the arrangements, whereas in *Plethora*, I used generative systems to determine the timbre of most elements of the piece -- or in other words, the pitch content. In both cases, the will of the composer was ruled out, and replaced by automated decisions following a system of rules constructed beforehand.

Indeterminacy is a tool that allow the composer to erase their 'preference', as Cage put it, from the piece, and in so doing to approach a more rarefied form of composition; a creation that expresses more than the self of the creator. Moreover, in absenting themselves (to an extent), the composer of an indeterminate work casts new light on the act of listening to music, as piece can no longer be understood in the Romantic sense of being the expression of one self conveyed to another.

Brian Eno's notes on Generative Music 1 describe the role of the listener in terms of their expectations of a piece, comparing the experience of hearing recorded music to hearing a generative piece reconstructed in realtime, however the concepts behind generative and indeterminate music suggest several more insights on this subject. One goal of my work in this project was locating the role of the listener, as compared to the composer, and my conclusion is that listening is an inevitably creative act, both in terms of the context in which you process a piece, and the content it offers you. Eno likens the preserved unpredictability of his generative process to the act of an architect allowing the eventual owners of a living space to make it their own (to 'finish it'), an interesting simile which foregrounds what I feel is one of the main revelations of the indeterminate mode of working -- the human element in deciphering and discovering music.

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