Processes and Potentials

Composing through objects, networks and interactions

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Abstract

This dissertation is concerned with strategies for composing computer music. It is moti&ated b an interest in problems concerning the interaction and relationships between materials and processes and their influence on de&elopment and form. The main objecti&e is to create a framework of ideas and technical solutions that could lead to no&el possibilities when creating computer music and e'periencing the compositional process. (ifferent processes create musical compositions and an associati&e approach will be presented where the aim is to relate these &arious aspects. The relations occur b binding operati&e objects, control polarities, sound processes and networks together. These relations are interacti&e and d namic where compositional focus is put on forming and manipulating these relationships.) compositional en&ironment implementing these ideas will be introduced, along with a discussion of musical compositions inspired b them.

Acknowledgments

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1. Introduction

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When I direct my attention inward to contemplate my own self […] I perceive at first, as a crust solidified on the surface, all the perceptions which come to it from the material world. These perceptions are clear, distinct, juxtaposed or juxtaposable one with another; they tend to group themselves into objects […] But if I draw myself in from the periphery towards the center […] I find an altogether different thing. There is beneath these sharply cut crystals and this frozen surface, a continuous flux, which is not comparable to any flux I have even seen. There is a succession of states each of which announces that which follows and contains that which precedes it. […] I could not have said where any one of them finished or where another commenced. In reality no one begins or ends, but all extend into each other.

;Bergson, "#$", Chapter $, para. 3<

This thesis is the result of an e'plorator process which was initiall concerned with possibilities. The main moti&ations concerned finding new and creati&e approaches for making computer music. Composing this kind of music was alread something I had been occupied with for some time. !owe&er, the applied methods of creating the music seemed to e'cite me increasingl less. The wa I approached a piece of music was purel goal=orientated. The final result was all that mattered. It should be interesting, powerful, compact but also beautiful and original. !ow I got there was not important and just something that had to be done. 6f course creati&e situations and inspiring moments occurred, but somehow I felt the creati&e process should be made more interesting. This is what I wanted to e'plore and make fundamental to m project. The choice was made to concentrate on processes, relations and the creation of compositionall interesting situations. These could be unified b considering e&ents such as the compositional process, the listening process, the temporal process or sound processes as sharing general attributes. B associating these, potentials emerge of connecting different elements of their totalit in no&el wa s.

) theoretical framework which unites &arious aspects of musical composition is clearl attracti&e for a composer to de&elop. I will tr to do this in the following discussion, but I will howe&er not constrain all discussed topics to m proposed &iew. The important dri&e behind all this is to disco&er how &arious compositional acti&ities can relate in new and original wa s. This means to >uestion them, e'pand their functions and tr to de&elop no&el associations.

In order to combine working modes and to compose on se&eral le&els simultaneousl , I sense the need for an approach that addresses the possible relationships between musical processes on a fundamental le&el. I feel that new and e'citing electronic music should challenge the notions of linearit , interactions between elements and organi-ation of musical materials. I think this is best achie&ed b e'ploring how different elements in a musical composition or a compositional process can interact and form relationships. I will tr to approach this problem concerning the wa music is produced, but the scope will also be e'panded b including the compositional process itself as a ke factor.

!opefull foundations can be created for a process=based theoretical framework in terms of composing computer music. This should be able to stand on its own but it has also concrete implementations. Both a compositional en&ironment and musical compositions will be discussed and an attempt will be made to unif these aspects as a whole.

?er briefl I would like to introduce a few ke concepts behind these ideas. The aim of the implementation has been to create a compositional en&ironment which fa&ors interacti&it , d namic relations and structural hierarch among its elements. This en&ironment should be generati&e in nature but highl fle'ible in its response to the composer@s compositional desires. The operational base should be the process.) relati&el open term, a process can mean different things depending on its applications. !ere it will be used partl as a unif ing element for &arious technical and musical features.

The compositional en&ironment that has been implemented is based on hierarchal processes and functions &er much b combining and nesting different processes. Bridges between actual sound processes and their specification is found in structures called *objects*.)n object is in control of a sound process and can also be subject to other structural processes or direct interacti&it from somebod using the en&ironment. This user can in &arious wa s create configurations for how objects will beha&e and interact. !owe&er, once the s stem is running, the main wa of communication will be pro&ided b the object and its *polarities*. The polarities pro&ide a common language that all objects understand and respond to. The polarities control the beha&ior of a sound process &ia the object which is responsible for that sound process. The state of these polarities ;which are 3 in total< is what becomes the primal material to compose for when using the s stem.

)nother important factor is the definition of these objects and how the occur and interact. Their combination is found in *states*.) state defines how se&eral objects are combined on higher structural le&els. It also specifies the temporal order of objects. These states interact and create the music b connecting in a *network*. The network determines how a state will be approached and how it interacts with other states. These issues will be e'plained in more detail later but it is important at this point in time to be familiar with the basic concepts of this en&ironment.) process=based composition en&ironment represented in terms of objects and networks is rele&ant as a technical solution as well as proposing a new aesthetic from a compositional point of &iew.

This thesis contains si' chapters. The first one consists of this introduction and the last one contains conclusions. The second one introduces concepts that ha&e inspired the technical, creati&e and musical solutions that form part of this research. The third chapter e'amines in details important components of these solutions. The fourth chapter deals with the compositional en&ironment that has been de&eloped to implement the topics presented in this te't. The en&ironment is called 5+6C ;5n&ironment for +rocess and 6bject Composition<. Its &arious aspect will be co&ered mostl in the light of its underl ing moti&es where technical jargon is kept to a minimum. *inall the fifth chapter is concerned with musical issues. Compositions will be discussed that ha&e been reali-ed as part of this project and how the connect with other ideas co&ered in this te't.)ll *rench language sources ha&e been translated b the author.

2. Bringing Forward

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Composers are concerned with the creation of musical situations emerging concretely out of a critical interaction with their materials, including their algorithms. This task cannot be exhausted by a linear (a priori, non-interactive) problem-solving approach. Interaction is here matching an important feature of musical composition processes, giving room for the emergence of irreducible situations through non-linear interaction.
;?aggione, "##$, p% 14<

This chapter will start b discussing the compositional process and what elements of it could be subject to change and compositional choices% This will lead to a discussion of the different le&els a composer is concerned with during the creati&e process% The aim is to e'plore wa s to e'tend the traditional &iews of these le&els and how the are seen as an important factor in composition% *rom e'amining the time and structural le&els the focus will shift to the materials which are used when creating a musical composition% (ifferent, points will be e'amined concerning what material is, how the definition of material can be e'tended and what is the relationship between material and form% (uring the discussion on material, a focus will be put on how materials can be seen as processes and how these processes are characteri-ed b certain beha&iors% +rocesses in interaction will bring forth the topic of emergence, how it can be useful for a process=based wa of composing and how it relates to temporal issues% *rom emergence, the issues of causalit and comple' beha&ior will be looked at% This will lead to the final section of the first chapter, the one of time and how it ser&es as an important factor in the framework of compositional ideas proposed in this te't%

2.1 The Creative Process

) fundamental concept in this thesis will be the one of process% +rocesses themsel&es are temporal phenomena and as such ha&e man common attributes with music, which could be seen as a temporal art ;Collins, "##1<% The term AprocessB in music is often associated with minimal composers such as Ste&e .eich or +hilip Glass, e'perimentalists such as Cohn Cage or e&en serial composers from Schoenberg to Stockhausen ;M att, "#$$%< 6ften the term is used for music that emphasi-es process as its theme or mode of creation% In the case of Stockhausen it is seen as helpful for *"navigating in a multidimensional musical space"* ;Maconie, "##1, p% "1#<% A+rocessB has conse>uentl been used e'tensi&el in connection to music and the applications can &ar greatl as the abo&e e'amples demonstrate%

In the following discussion the term AprocessB will be used for acti&ities ranging from the higher le&el composition process to the lower le&el sound process, with se&eral intermediate steps% The usage here will for sure o&erlap with, and borrow from, what the abo&e mentioned people ;and others< ha&e made of it% Still it is important for the following discussion to tr to keep the definition open and not restricted to its historical representations%

Man important issues can often be accuratel described in terms of process, of acti&it , of change% 6ne definition of processes is to think about an actual process as something that comes into being from a set of possible processes ;.escher, "###<% +rocess as an actualit rising from se&eral possibilities% +rocesses can also be anal -ed in terms of their doings and beha&iors% *or a process=based s stem of thought, becoming is no less important than being, >uite the contrar %

In the musical conte't of this te't, process=based ideas are especiall rele&ant for works that put into foreground beha&iors, changes and actions% *or e'ample fluid sound structures, fu-- materials or forms% Music without sharp boundaries%

> *THAT 'all things flow' is the first vague generalization which the unsystematized, barely analyzed, intuition of men has produced [...] Without doubt, if we are to go back to that ultimate, integral experience, unwarped by the sophistication of theory, that experience whose elucidation is the final aim of philosophy, the flux of things is one ultimate generalization around which we must weave our philosophical system.* ;Dhitehead, $323, Chapter $#, para% $<

If things flow or if the simpl e'ist% *or processes the flu' of things is of primal importance% !ow do processes then flowE !ow do the e'ist in general and what is it that defines themE !ow and when do the occur and what happens during the lifetime of a processE Dhat elements constitute a process and how are their relationshipsE Dhat is the scale or magnitude of a processE)re the nested and then how do the interactE

The starting point here will be to reflect on the compositional process% The creati&e acti&it of making music% This means to tr to reali-e what units or phases define the de&elopment of a piece of music and how the relate% Can these relationships be changed, automated or become subjects of compositional choicesE

It is interesting to think about what happens during the course of creation% The computer is an ideal tool for inspecting different aspects at multiple stages of the creation process% This kind of anal sis does of course not onl appl to electronic or computer music, helpful reformations of the composition process could indeed be seen as something interesting for all kinds of creati&e acti&it % Computer music still has a uni>ue position since much of its operations happen inside the computer which has high capacities in anal sis and s mbolic processing% The stud of what happens during the e&olution of a musical composition made with a computer can gi&e birth to new methods and wa s of making music% This can lead to what)gostino (i Scipio calls Amodel of compositional designB ;(i Scipio, $331<% !is model represents a holistic &iew of the composer's creation process and shows possible relationships between &arious elements that are created during the process and their link to the composition which is its product%

The &iewpoint that will be taken here is that the elements that form the process and how the are designed is a &er important factor% It is, howe&er, not the intention to argue that a formali-ation of these elements is necessar the most important thing% Dhat is important is to reali-e what steps are taken during the process and which of them could be ameliorated and be subject to compositional choices% The aim is to in&estigate the relationships between what happens during the &arious phases of composing and the composition that is created during the process% Dhat is the definition of the materials used and how are the representedE !ow the &arious aspects during the de&elopment of a piece of music can possibl be made more accessible and e'pressi&e to the composer b use of speciali-ed software or customi-ation%

Phases

The >uestion of what constitutes the compositional process is of course ambiguous and &aries between composers% To arri&e at a clear formulation about what e'actl defines the compositional process and a musical composition is difficult and could lead into reductionist traps where important aspects are e'cluded% Such a definition would ha&e to be built on some a'ioms that generali-e the elements of the definition% This kind of formali-ation can be dangerous since in music it is often hard to find such constants or uni&ersal truths% The compositional process should rather be seen as something creati&e, open and d namic, possibl changing e&er time it is repeated% *or now, a useful starting point would be to sa that the *compositional process* is e&er action taken b the composer during the creation of a *musical composition* which is the final outcome of this process%

The 7ew Fealand@s)rts 6nline offer the following definition of a compositional processG

> *Composition processes: a process which is unique to every individual when creating music. It usually involves the development of a concept initially, and requires exploring, experimenting and improvising with musical ideas. Ideas are then developed, extended, manipulated and structured into a complete piece of music. The complete piece is often represented in a form appropriate to the genre, such as a traditionally notated score, a lead sheet or a graphic score.*
> ;)rts 6nline, Sound)rtsG Glossar , "##2<

)n interesting aspect of this definition is hoe an initial concept usuall pla s an important role% This implies that the process is carried out in order to fulfill some intentions% It has the purpose of ser&ing the initial concept, but wh should the process of making music be conditioned b a conceptE Is it actuall as useful as the initial inspiration might suggestE In the conte't of this thesis, it is the process itself that is the most important as well as that what is created during the process% The process itself should not need to be constrained b e'ternal influences% If the emphasis is on the process itself, it seems contradictor that it is to ser&e a preconcei&ed idea%)lso of interest in the definition abo&e is that the process is being thought of as something highl indi&idual% Dhich it perhaps is, but there also e'ist common elements between music making acti&ities that in the end form a compositional process%

) compositional process can be seen as a se>uence of steps which might or might not be iterated in &arious wa s in order to produce a musical result% Some of these steps might be automated or carried out b a software program which re>uires a certain kind of clarification of what happens in each of the steps% Searching for the minimum of logical constraints necessar for the construction of a musical process, Iannis Henakis presented in his book *Formalized music* eight steps which he calls the I*undamental +hases of a Musical DorkJ ; ! arle , "##4<

$ **Initial conceptions** ;intuitions, pro&isional or definiti&e data<K

" **Definition of the sonic entities** and of their s mbolism communicable with the limits of possible means ;sounds of musical instruments, electronic sounds, noises, sets of ordered sonic elements, granular or continuous formations, etc< K

/ **Definition of the transformations** which these sonic entities must undergo in the course of the composition ;macrocomposition G general choice of logical framework, ie, of the elementar algebraic operations and the setting up of relations between entities, sets, and their s mbols as defined in "< K and the arrangement of these operations in le'icographic time with the aid of succession and simultaneit < K

4 **Microcomposition** ;choice and detailed fi'ing of the functional or stochastic relations of the elements of "<, ie, algebra outside=time, and algebra in=timeK

1 **Sequential programming of 3. and 4.** ;the schema and pattern of the work in its entiret < K

: **Implementation of calculations**, &erifications, feedbacks, and definiti&e modifications of the se>uential program K

2 **Final symbolic result** of the programming ;setting out the music on paper in traditional notation, numerical e'pressions, graphs, or other means of solfeggio< K

9 **Sonic realization** of the program ;direct orchestral performance, manipulations of the t pe of electromagnetic music, computeri-ed construction of the sonic entities and their transformations<

Henakis also comments that order is not rigid, that permutations are possible and that most of these phases are happening unconsciousl ;Henakis, $33"< It does seem, howe&er, that these phases are somewhat dependent on each other and that their order in time can not so easil be altered The are presented in a numbered list and this does seem to clearl ha&e to happen in a linear succession in time Henakis speaks of feedback and that the order is not important but this is not e'plained further Taking the &iewpoint of the compositional process as being something d namic and perhaps non=linear then the list does seem >uite conser&ati&e The phases are in perfect harmon with the classical idea of the composer ha&ing an initial inspiration and then working his wa up from the definition of the material to the final sonic reali-ation of a score or tape) n e'tension of these phases could include how the could easil be reordered and their elements combined ! ow could one possibl start at element / then go to : which would lead to phase "E AIntuitionB is here clearl a starting idea which others are based upon ! ow could one change his intuition at a later stage in the process which should be reflected in other phases without repeating them entirel E) lso of interest here is his comment about these phases being unconscious If feedback and change of order are possible then how do the affect the resulting musicE It is probabl true what Henakis sa s, that in man cases composers tra&el somehow unconsciousl through the compositional process This raises the >uestion that if the would proceed differentl through the process then how would their music be affectedE Can this process be configured in a different and ma be more non=linear wa E

The main point here is not to critici-e or anal -e the phases Henakis has defined Dhat is important to point out, is the linear nature of how these steps are put forward, that the seem to succeed each other and that the first phase is where the intuition occurs so that the following steps seem to be highl conditioned b the first one In an inter&iew with Brigitte .obindore the)merican composer Curtis .oads defines three phases of his own creati&e process

$ **Creation of sound source material** ;pla ful<
" **The important phase of classifying and editing the source material** ;t pes and time=scales<
/ **Make the macroform puzzle.** *"It is as if each piece in the puzzle is a sound object with a potentially unique morphology. As I assemble the puzzle, certain objects appear to be natural matches: they fit in sequence or in parallel."* ;.oads, "##4, p $:<

It is likel that these / phases reflect a commonl used approach in computer music It also recalls the different perspecti&e on the creati&e process

> *It's a process, a cycle that starts with certain sounds that stimulate an emotional response: shortwave, the sounds of places that are unique, sounds in nature. What I feel in these sources determines choices for details or for the structure, which again become another influence. At a certain moment the music itself makes clear the compositional choices and it becomes irrelevant to separate the maker from the work itself. I'm just another part of the process, no more and no less than the other elements, rather than a 'controller'.*
>
> ; (uncan, $332, p $<

(uncan sees himself as being **part of the process**, just an element among others The entities that make up the phases of creation can be seen as distinct parts with composable relationships The composer or IcontrollerJ might then just as well be a distinct part himself This is a &er open wa of seeing things It is the act of creation that is put into focus and this act will bring forth new disco&eries (uncan@s &iew also implies an encouragement with the process Be part of the process (o not see it as a se>uence of steps that are to fulfill something e'terior to the process 5ngage ourself in the making and interact with other elements of the process) lso of interest is (uncan@s Icertain momentI where the compositional choices become clear and the maker becomes part of the work itself Is he referring to the moment when the process takes o&erE ! ow and when does this occurE *or sure not initiall since the nested IinfluencesJ must need some duration before emerging This suggests that the &alue things ha&e for the final result are increased as the process unfolds The process gi&es more substance to its own products than the ones that are outside it or belong to a pla ful first phase

Possibilities

) lso from) merica is the soundLinstallation artist and graphic designer . ichard Chartier ! e is mostl known for his work in reductionist microsound , which is a sort of e'treme minimalism where the music is often &er >uiet or &er sparse Chartier has an interesting proposal concerning the act of deleting

> *My work is really a process of removal. Sometimes a piece will be based on one [looped] sound with things layered over it, and then eventually I will take the original linking element out. So it's this ghost element that's not really there. That absence continues to exert a pressure on the work, lurking as an implied presence in the tracks and compounding the obscure impression that something is missing.*
>
> ;Chartier, "##", p $<

Chartier has re&ersed the importance of steps b establishing a collection of sounds composed around a core sound, which he then remo&es from the track, so its organi-ing principle is absent The choices made after the core sound has been selected, gain attention b the remo&al of this core sound This is an original solution to the problem of putting sounds together where sometimes earl choices condition later ones To delete what was started with also highlights the later choices This emphasi-es the emerging products of the compositional process 6ne could imagine repeating this remo&al process se&eral times, perhaps re= introducing the core sound at later stages in order to arri&e at something which becomes more and more the aftermath of its creation principle) nother wa of using the process of deleting as a creati&e solution is to delete entire phrases or section that ha&e been created b putting pre=made materials together% This could be an e'tension to three steps proposed b Curtis .oads% Instead of completing the pu--le it could simpl be remo&ed% This could result in all the steps being repeated, but now with a heuristic obtained from higher le&el decision making which would influence the material generation% Met interaction with all musical materials emerge from the compositional process% (elete and repeat%

B deleting elements from a composed set of elements the relationships between the remaining ones come to the foreground% This raises the >uestion of how certain materials condition others% The German composer Bernhard GNnter describes his &iew of how possibilities are brought forward b the selection of materialsG

> *The way I usually start work is with some material that I've treated to a certain degree. That's the starting point. One thing leads to a huge field of possibilities. I add a second thing and the field shrinks, immediately. You have a relationship between the two and there are consequences. Then I add a third thing, and.. you see what I mean? When I have that I may repeat one or introduce a new one, and that also has its own consequences. Some people say composing is creating problems and then solving them, but for me it's more like creating possibilities and choosing between them.*
> ;GNnter, "##/, p% "<

GNnter describes something fundamental about the discussion so far% The fact that each choice that is made redefines the set of other possible choices a&ailable at an gi&en point in time% So that if different choices would ha&e been taken the composer would be confronted with a different set of possibilities for each of his choices% This unfolding is se>uential in nature and if properl documented could be used to create a map of the whole compositional process% B creating such a map ;or network<, its e'ploration can be repeated with different na&igational strategies% This implies a possible hierarch of choices that can later be e'plored on different le&els of time or structure% The choices made can be linked together and become themsel&es materials to compose with% The choices are of course products of the compositional process% So that what in the end is composed for, is an outcome of the process, and where the material is perhaps one of its most interesting aspects, the compositional choices%

This section started b >uoting ?aggione emphasi-ing the power of interaction between the composer and his materials% This is &er &alid point to reflect on for the current conte't% !e also mentioned that a linear problem sol&ing mode can lead to certain pitfalls% 6ne of the dangers of adopting a black bo' approach to computer music is that the algorithm becomes a fi'ed entit which can be hard to control% Much use of generati&e methods suffers from the fact that if the results of a certain algorithm do not satisf the composers needs, the onl wa for him to react is to interfere with the output% This seems contradictor to a d namic situation where the order of the steps taken is fle'ible, adapted to the needs of the composer and could perhaps lead to what ?aggione calls the *"emergence of irreducible situations through non-linear interaction."* This contradiction is indeed fundamental to the moti&ation behind the solutions that will be presented later in this te't and perhaps e&en to algorithmic music in general%

It is crucial to reali-e how a compositional process can be anal -ed in a wa where it is seen as both relational and non=linear% It is clearl seducti&e to imagine discrete steps that constitute the process and could easil be modeled% In man cases howe&er the process is more comple' and steps are re=iterated and their order unknown before the process begins% This should be part of the compositional model and perhaps its most important component%

> *A (musical) system of symbols can be formally structured (i.e., built as a system including functions manifesting diverse degrees of abstraction) without being completely formalized, the last case arising, strictly speaking, when all non- defined symbols present in the system are properly enumerated (or, if preferred, when nothing is hidden).*
>
> ;?aggione, "##$, p% 1:<

Intensions should lead to methods that help one fulfill those intentions% This should include feedback so that both the methods and intentions could &ar and their relationship be d namic% In chapter three of this te't, networks will be e'amined and how the can be useful for the compositional process% 7etworks can pro&ide a useful solution to the problems addressed so far% 6ne can imagine relations between &arious phases of the process where the order is determined b the connections between them% 6f course some phases in the construction of a piece of music are alwa s dependent on others% *or e'ample in the case of the Henakis phases it is not possible to Areali-e sonicall B a piece without ha&ing at least some Asonic entitiesB% It is howe&er possible to &iew the se>uences of steps performed during the act of composing as something that could be subject to d namic choices% In order to be able to get there, it is necessar to define on what scales different operations occur and what is the material used for the different operations reali-ed during the process% This will be discussed in the ne't two sections%

For much of the twentieth century, all sciences, including biology, were obsessed with reductionism: viewing the world at all levels, from the smallest to the largest, as merely a machine made of parts. Take the machine apart, examine the individual pieces, and we would understand how the world works. […] But some scientists admin that reductionism falls short of its ultimate goal: understanding how the world works. It falls short because it fails to recognize the connectedness, the unity, that is the deep essence of nature in all realms. […] There is a oneness in nature in the sense of interdependence.
;+epperberg, "##9, p. ""/<

2.2 Scales and States

)n important propert in the definition of a compositional process or en&ironment it to decide on the operational le&el. 6n what le&el are operations to be conducted. Is it about creating sounds, phrases, sections, or piecesE In his book *Microsound*, Curtis .oads defines nine time scales of music ranging from infinite long to infinite small ;.oads, "##$<. The most useful for our discussion are the ones occurring in the middleG the micro, sound object, meso and macro le&els. .oads admits that the boundaries between these scales are not alwa s clear but still e'plains in detail the difference between them and their function in music. These time scales ha&e become an almost fundamental part of the language emplo ed when discussing computer music and are often used as starting points for describing sounds or musical elements. These scales can be seen as related to traditional music theor where notes form moti&es which form phrases which form sections and so on. *or e'ample, when talking about the micro=time scale it is common to refer to what is Aunder the noteB ;?aggione, "#$#<.

,arlhein- Stockhausen ga&e attention to low=le&el time scales b stating that pitch and rh thm are to be considered as being the same phenomenon, differing onl in time scale ;.oads, "##$<. This &iew implies a sort of generali-ation and reductionism which is not alwa s useful. Indeed, one of the possibilities of computer music is to blur these boundaries and create materials that escape this definition. The solutions that ha&e been de&eloped during this research as well as the music the ha&e created are not concerned with notes. It is therefore not &er useful to reflect on some time=scale that lies Aunder the noteB.

> *Electroacoustic gestures and textures cannot be reduced either to note or pulse; the music is not necessarily composed of discrete elements; nor can we find that (consistent) measure of minimum movement density.* ;Smalle , $332, p. $$4<

In music made with computers the difference between composing sounds and composing pieces is not necessar &er big or an important distinction to make. ?aggione belie&es that time scales and their interaction are one of the most important aspect of his music. !owe&er, he also belie&es that the time scales and their definition is &er much a compositional decision.

> *All compositional manipulations articulating relations between different temporal levels depend essentially on the paradigm adopted by the composer. Evidently, a decision has to be made concerning the status and the nature of these interactions: to consider them as taking place in a continuum organized as a fixed hierarchy […] or to assume the existence of discontinuities, of nonlinearities, considering (in the last case) microtime, macrotime, and all intermediate dimensions as disjoint (or relative) realms.* ;?aggione, "###, p. $/<

In other te'ts ?aggione emphasi-es the importance of a non=linearit between these time scales which sometimes makes it complicated to understand what the refer to% In ?aggione@s music much importance is gi&en to it functioning on se&eral time scales simultaneousl % It is one of the highl interesting aspects of his works and it is not the intention here to critici-e this% It remains uncertain howe&er if his &iew of non=linear time scales can indeed alwa s be useful in the general field of discussion% If the focus is on creating practical structural units for process=based sound material, then perhaps restricting these anatomic elements to temporal representations is misleading% Could structural le&els or containers be introduced in the conte't of process=based composition which are not necessar temporal in natureE

Blocks

Some useful ideas come from , oenig in his article *Composition processes*. ! e starts b proposing three different methods which he labels Ainterpolation B, Ae'trapolationB and Achronological=associati&eB ; , oenig, $329<% B interpolation , oenig means going from the outer limits of form to the smallest detail of a sound% 5'trapolation signifies the opposite, to start from the indi&idual sound and proceed towards the larger form% The third method, named chronological=associati&e, implies a method that unfolds along the time a'is where e&er e&ent is graduall gi&en its order in time which can not be changed later in the process% This method also has an e'tension where feedback is used in order to continuall compare local e&ents to other objecti&es% This e'tension is what , oenig finds closest to the *real process of composition* and in some wa again recalls ?aggioneG

> *On every level, everything depends on the precise definition of the time scale where one fixes (temporarily) his << window >>, the operational reference frame. Thus, we jump from one scale to another, in every direction [...] often passing by points that are very close to each other. A process of multi-scale oriented composition is always << multilocal >>. This applies to composing as well as listening.* ;?aggione, "#$#, p%1$<

The most rele&ant proposition in , oenig@s paper, at least for the discussion at the moment, is his idea of blocks% 5&en though his ideas regarding these three pre&iousl mentioned methods in&ol&e a certain relationship to time scales the are thought of as compositional methods% This is actuall somehow more useful than simpl defining where the boundaries of some time scales reside% ! owe&er, , oenig's abo&e mentioned methods propose a rather uniform wa of a compositional approach, one chooses one direction as opposed to another one% The aim of the current direction of this te't is to embrace d namic, comple' and non=linear approaches to musical composition% This relates to the fourth method proposed in , oenig@s paper, his idea of blocks% ! e proposes a notion of blocks that seem to encapsulate a more comple' structural entit and are defined asG

> *A combination of methods more oriented towards time or space can be found in the composition of blocks; by a block I mean a part of a structure which requires complementing by other blocks but which is still complete in itself.* ; , oenig, $329, p% :<

Dhat is interesting is that what , oenig finds more oriented towards time actuall allows for more freedom in temporal organi-ation% 6ne can create such blocks b one of the three methods he pre&iousl mentioned and then work towards a complete composition b defining their interaction%) lso of interest is the fact that these blocks should be complemented b other blocks but still be complete in themsel&es% This raises the >uestion of when a block could be seen as complete and in which wa complementing occurs% Dhat kind of interaction emerges from this complementation and how can these be composed% 6f course it is possible to discuss interactions between time scales as well% In music where the boundaries of the time scales are fluid this interaction becomes a &er interesting point of the music% ! owe&er it does seem hard to de&elop well defined strategies to compose directl for these interactions% It seems more appropriate to define structural le&els which are fle'ible and do not necessar emphasi-e temporal >ualities%

+artiall inspired b , oenig@s blocks, the concept of *states* will be used in this te't% Briefl e'plained, a state is a fle'ible container of sound processes that facilitates interaction between these processes as well as with other states% States can be seen as building blocks for a musical composition and can for e'ample become sections% States can howe&er e'ist on &arious time=scales and the might just as well become short sound objects or phrases% Dhat is important is the interaction between them, how the complement each other, how the differ or succeed each other%

Susceptibility

In the article 'Comple' sounds', , oenig discusses how the differences or similarit of simultaneous structures can be dealt with in compositional wa % ! e labels structures that easil blend with others 0permeable0 structures and stresses that the wa structures o&erlap and coalescing occurs should be treated with care, and choices be made regarding whether similarit or difference should be emphasi-ed% This is useful also when discussing blocks or states% , oenig then mentions another interesting propert regarding relationships between structures which he calls susceptibilit %

> *Susceptibility means that two structures complement each other, interpret each other, that the one structure articulates the other in a characteristic manner.*J Mater he addsG *"Structures which are to be susceptible to one another do not have to be incomplete, or as it were musically half-finished[…] The penetration of two susceptible structures could result in a kind of coalescence (and dealt with under the aspect of permeability) […] The fact that two events are in a tension-relationship to each other is presupposed by their distinguishability, their difference. It is these differences that prevent coalescence. Of course, if they do not, the structures are not susceptible.*
> ; , oenig, $3:1, p%$1<

The relational properties of two or more structures, their completeness, similarit or difference is something that can be of great use for hierarchical le&els of compositional structure% It is useful to imagine how structural elements can be concei&ed that incorporate , oenig@s ideas of both blocks and comple' sounds% ! ow the beha&ior of states can benefit from the methods of interaction as proposed b , oenig%

The concepts of complementation, coalescing, susceptibilit and permeabilit are used here with regards to the relationships between things instead of describing the things themsel&es% This is e'tremel important since a compositional practice that fa&ors processes on &arious le&els must embrace the &arious relationships between these processes%

The english mathematician, scientist and philosopher,)lfred 7orth Dhitehead , spoke of the set of processes and their relationships as a *nexus*.) ne'us is defined as a *"a particular fact of togetherness among actual entities"* ;Dhitehead, "#$#, Chapter ", para% :<%)n actual occasion is where a process becomes actual from the set of possible processes% Dhen the elements of a ne'us are reunited the become self=sustaining and form what Dhitehead calls IsocietiesJ ;Dhitehead, "#$#, Chapter /, para% $/< It is the wa elements connect and form relationships in the societies that is important% Members of a ne'us relate in the form of inheritance and their totalit is what makes enduring objects% Besides being contiguous, a ne'us also Asustains a characterB whose meaning is close to the latin word ApersonaB which can be understood as being its identit %

Dhitehead@s ne'us of relations can be applied to states as being collections of objects and processes% These states could be treated as compositional units and what constitutes their particularit , AcharacterB or ApersonaB becomes important when the are used in a compositional conte't% Dhat is also important is how these relationships are defined in a state and how interaction can be understood as emerging from them% Before discussing further how emergence can be useful, it is necessar to tr and define more precisel what elemental parts are re>uired to create higher le&el structures that inherit these concepts of interaction%

In architecture, what is more important than the material itself? Like the Taj Mahal – which was made with marble and things like that, very expensive material – I don't think it's a very important architectural piece. There are other things that are done with cheaper materials. They are much more interesting. Why? Because in architecture [it] is the problem of shapes, of proportions and the sizes, of course. These are features, kind of abstract, much more than the material itself. And if the proportions are OK, then this enlightens the materials; they become much more important, interesting. If not, then you might add gold or whatever and fail anyway. In music, I think it's the same thing; it's the same problem.
;Henakis, $33", p. "<

2.3 Materials, Processes and Behavior

*ollowing the discussion on le&els of operation, the >uestion of material in music and how it manifests itself becomes important. (uring the co&erage of composition processes in section ".$, se&eral e'amples were introduced which re&ealed how material is related in different wa s to the process and its final product. .oads pla ful initial phase resulted in a comple' pu--le that remained restricted b his initiall created material. Chartier@s deleting of earl materials shifted focus to their relationships to later choices.

Synthesis and composition

)n e'tension to the importance gi&en to material b the people working at the Cologne studio in the 1#@s are the non=standardB s nthesis approaches of the $32#% ! ere compositional methods are applied to the process of sound generation% Changes in the compositional methods that happen on a &er low le&el can ha&e big impact on higher time scales% +hil Thomson has suggested that the non standard approach can be seen as microsoundBs digital beginnings ;Thomson, "##4< Microsound can be understood as an approach to music that emphasi-es composition on e'tremel brief time scales% The possibilit of composing the sound as part of the compositional process is a &er interesting one and special to the medium% (i Scipio speaks of *Micro-time Sonic Design* and how this can be helpful to blur the distinction between material and formG

> *What is obtained by processes of sonic design, though we may still want to call it sound material, is a formed sound-object. Clearly, as far as timbre is the form of the sound material and sound materials are themselves the object of the composer's knowledge-level strategies, this perspective on composition confounds the classical distinction between material and form.* ; (i Scipio, $334, p% $41<

 ! e adds that richness in sonic results can be obtained b methods that are created for compositional needs instead of prescribing an particular acoustic model% This is similar to the idea behind the non=standard approach although (i Scipio prefers working on a slightl higher time le&el, which he labels being based on the *micro-time behavior of sound.*

Dhat (i Scipio has e'plored in his &entures through micro=time is mainl the use of granular s nthesis% The granular approach is an interesting techni>ue and useful not onl because it proposes a new wa of describing sonic e&ents, but more importantl because this description can be transferred from the categor of ph sical signals to the le&el of the s mbolicLoperational which is &er fruitful from the &iewpoint of composition% It also in&ol&es a process% The process of arranging grains in time% ! ow these grains are distributed in time, what is their duration, fre>uenc and so on% 6n a lower le&el, the non=standard approaches, with their often strong relationship between material and form, can also be understood as processes% The process of distributing the sample &alues that form the created sound or wa&eform% 6f course it is possible to sa that with this logic all sound generation methods could be understood as processes% Dhich ma be is hard to den , but does not fit the current &iew of processes as suggested here%

Granular and non=standard s nthesis are generall not based on acoustic models% ! owe&er, there are some granular s nthesis methods that are used to anal -e and represent sound based on acoustic models% 5'amples are (ictionar =based methods, (BMs, which pro&ide an no&el approach to sound representation and manipulation ;McMeran, .oads, Sturm, and Sh nk, "##9<, and pitch s nchronous *6* s nthesis which are used to simulate the human singing &oice ;Clark and .odet, "##/<% *or the current purpose, howe&er, granular s nthesis is seen as an as nchronous method of scattering small sound >uanta that, like the non=standard method, is not based on acoustic models%

.esulting from this is the somehow absent causalit principle found in man composed sound processes There is nothing that tells us how these sound processes start or stop The process of generating the sound could go on fore&er or be influenced b another process The unfolding of the process can be influenced b its constituting elements *or e'ample how certain grains or calculations of sample &alues affect the generation of other grains or &alues where causalit is internal to the process These methods also appear ideal for e'perimentation with compositional methods This is due to the fact that the their models do not necessar re>uire acoustical=based parameters but can easil interpret more compositional ones

B creating sound processes that are controlled b a small common set of parameters, the nature of these parameters becomes &er important +arameters should encapsulate control of beha&ior that is fle'ible to compose for and adapt to compositional ideas If parameters are common for &arious processes the should optimall be as few as possible In practice this is a difficult task to achie&e and brings forward the few=to=man relationship mapping problem ; ! unt and Danderle , "##"<

Sound processes and mapping will be discussed later and it is not the intention here to e'plore or compare these two abo&e mentioned methods an further It should be stressed howe&er that the are an e'ample of musical materials that ha&e strong relationship with form and lend themsel&es well to compositional ideas .egardless of what s nthesis method is emplo ed, the compositional desires that influence the de&elopment of a sound process will ha&e a great effect on its final design There is a big difference between designing s nthesis modules that pro&ide parameters simpl for ma'imum control o&er sound generation, and processes with parameters which alread are designed with compositional ideas in mind This can lead to restrictions but also to more creati&e solutions

Processes and textures

Being process=based is a restricti&e >ualification that can also lead to inno&ati&e outcomes The sound generation methods dealt with in this te't all share the fact that the can be understood as being process=based Dhen describing processes 7icholas .escher states that

> *Processes, events, occurrences - items better indicated by verbs than by nouns. Clearly, storms and heat waves are every bit as real as dogs and oranges […] Moreover, processes are not in general a matter of the doings of things. The fire's heat causes the water to boil. But it is clearly not a thing. To be sure, some events and processes relate to the doings or undergoings of things (the collapse of the bridge)* ; .escher, "###, p 4<

Sound processes, ha&ing internal causalities and blurred differences between beginning and end, fit well this description +rocesses are defined b the wa the do things instead of what the are The can therefore be anal -ed in terms of beha&ior The most important parameters in granular s nthesis for e'ample, usuall control some global beha&ior of how grains are organi-ed If a sound process is isolated and its go&erning principles remain constant, the focus shifts to its internal beha&ior In his theor of Spectromorpholog , (ennis Smalle describes te'tural music as being something that I*concentrates on internal activity at the expense of forward impetus'* This is different from gestural music which he labels as being *“governed by a sense of forward motion, of linearity, of narrativity.”* ;Smalle , $332, p% $$4<

Compositionall designed sound processes as proposed abo&e and described in detail later in this te't share common attributes with Smalle @s te'ture% Their internal acti&it is what remains important and when actuali-ed, a goal=oriented motion does not e'ist% This does howe&er not e'clude gestural or narrati&e de&elopment which can be created b interacting with the process and its polarities% Indeed what Smalle defines as Abeha&iorB, or the *“relationships among the varied spectromorphologies acting within a musical context”* ;Smalle , $332, p% $$2< will be dealt with as **interaction** in the following discussion%

Some words or phrases are evocative, even provocative. So it is with the word emergent. Commonly, we express this idea with the sentence, The whole is greater than the sum of its parts. The sentence is provocative, for what extra can be in the whole that is not in the parts? I believe life itself is an emergent phenomenon, but I mean nothing mystical by this. […] Life in this view, is not to be located in its parts, but in the collective emergent properties of the whole they create.
; , auffman, $331, p. "4<

2.4 Emergence and Causality

B embracing the comple' relationship between the process of making music, its &arious phases, operations and elements, music can be understood as consisting of emergent properties. 5mergence is defined b the wa comple' s stems and patterns arise out of a multiplicit of relati&el simple interactions. It is the *"case where a joint effect of several causes cannot be reduced, or traced back, to its component causes"* ;Dhitlaw, $339, p. /29<. +erhaps all goal=oriented artistic e'plorations would like the fact that the final product is greater than the sum of its parts. This does howe&er not mean that e&er compositional process is emergent. 5mergent compositional processes are the ones that emphasi-e interaction and manifold relations.) musical work made of lower=le&el interacting elements, nested operations and hierarchical relationships can be seen as emerging out of the interaction between factors of the compositional process.

+re&iousl in this te't, the importance of creati&e processes, relational s stems and fluid materials has been stressed.)n approach that fa&ors the process instead of prior intensions. 8ncertaint , une'pected outcomes and surprises are conse>uentl &er interesting properties of emergence to e'plore. 5mergence still remains a slipper term and its application to music is not alwa s ob&ious. *"Different accounts often disagree on whether an entity is emergent; and when they agree, there is often no clear basis for this agreement."* ;Dilson, "#$#.< The pre&ious definition of emergence also contains one of its main problems, the magical *getting something from nothing*, which suggests that no&el e'planations are needed to full e'plain emergent phenomena ;Chalmers, "##:<. Mark Bedau defines two main principles of emergence:

;$< 5mergent phenomena are somehow constituted b , and generated from, underl ing processes.
;"< 5mergent phenomena are somehow autonomous from underl ing processes.

!ere, the problematic nature of emergence becomes clear.)t worst this seems to make emergent phenomena inconsistent, at best it still raises the Agetting something from nothingB problem ;Bedau, $332<. In music with emergent properties it is also >uite hard to state that the outcome ;musical work< is autonomous from the underl ing processes ;operations of the compositional acti&ities.<) more narrow definition is needed in order for emergence to be useful.

5mergence can be subdi&ided into two perspecti&es, that of *weak emergence* and *strong emergence*. Strong emergence is when the whole is reall greater than the sum of its parts and when the *"truths concerning that phenomenon are not deducible even in principle from truths in the low-level domain."* ;Chalmers, "##:< Deak emergence leads to no&el properties in s stems as the result of interactions at elemental le&els where the *"truths* *concerning that phenomenon are unexpected given the principles governing the low-level domain."* 5mergence is then onl a part of the model describing the s stem@s beha&ior, but creates une'pected deri&ati&es which can still be deduced from the underl ing processes. The wa emergence applies to both the music and en&ironment discussed in the ne't two chapters is &ia the weak &ersion.

5mergence is often said to occur from &er simple micro=le&el operations. It is also fre>uentl used in relation to adapti&e or self=organi-ing s stems. !owe&er, in phenomena occurring from weak emergence it is not re>uired to possess these >ualities in order >ualif as emergent. 5mergence can indeed be understood as comping purel from interaction and thus *"stating certain logical facts about formal relations between statements rather than any experimental or even 'metaphysical' facts allegedly inherent traits of properties of objects"* ;.outledge and ,egan as cited in Dhitlaw, $339<. The relations between the elements of the creati&e process and the compositional en&ironment, are the ones to be e'plored to bring forth no&el outcomes. B creating simple connections on &arious le&els between different elements, for e'ample nodes in a network, emergent properties become interesting to e'amine.

Emergent sonorities

In his book *Formalized music* Henakis proposes the h pothesis of granular construction of all possible sounds ;Henakis, $33", p42<. !is idea of sonorities of second, third or higher order could be discussed as being a form of emergent beha&ior. Granular s nthesis can in fact be understood as wa s of dealing with emergence ;(i Scipio, "##"<. !ow can the distribution of grains be organi-ed so that emergent and original sounds can be heardE Dith regards to process=based approaches the >uestion becomes how the relationships between elements of a process are to be defined for no&elt to emerge.

> *The conceptual separation of composition (or, responsibility on premises and conditions, in my wording) and music (sonic features arising from premises and conditions) perhaps attests to a shared perspective. The implication is that sound is the epiphenomenon of a lower-level process: you design a low-level process, and the interactions and interferences among particle components taking part in the process are heard as a dynamic shape of sound, a process of sonological emergence.* ;(i Scipio, "##1, p. $9<

(i Scipio is >uoted here because of the importance he is gi&ing to the process as well as its result, and that their relationship is fundamental to understand. It is not to be hold that a piece of music should alwa s be connected with the process of its making but rather that the piece of music could be seen as emerging from the process of its making. (i Scipio has taken this to an e'treme le&el in his music where all higher=le&el structures emerge from simple interactions at the micro le&el. +erhaps a pure bottom=up approachE !e also states that *"decisions, choices, and the evaluation of temporary results determines the general outlook as well as the details in the designed object"* ;(i Scipio, $331, p. /:#<. This implies d namic decisions and local choices as fruitful possibilities. 6pposed to organic emergence the focus should be on the interacti&e or computational one. *"Computational emergence arises through the interaction of elements, regardless of their relationship to the observer's model"* ;Dhitlaw, $339<.

Dhat is important here is not to engage in (i Scipio@s bottom up approach. It is rather to reflect on how relationships between materials can be created that will result in something that is bigger then the sum of its part. !ow b using a well=defined s stem which has focus on interaction can one create emergent beha&iors due to these interactions.)lso, if the focus is on the compositional process in a s stem that contains a hierarch of processes, then emergent beha&iors should be desirable.

> *A musical composition constitutes an emergence because it is not reducible to its parts or elements or even to the operations that were realized during its composition. Therefore we can neglect here the word << Causality >>. […] The musical work will constitute itself as an emergence (a singularity), and not as a simple globality, since it manifests itself not as that which constitutes the product from the parts of a whole, or even as the epiphenomenon of its components, but as simply as that what it is, without any reduction.*
> ;?aggione, "#$#, p.11<

5mergent music should thus e'ist as a singularit that should be taken for what it is without an reduction. Causalit can be understood as being due to interaction in emergent s stems. ?aggione e'plains how for music the same principle applies. Music should not be seen as a totalit or as an ensemble of its part, but rather as an emergence that occurs from the relation of these parts. In a process=based &iew of the world, causalit is something important to reflect on. It is also something musicall &er important to deal with in contemporar music which operates outside the gra&itational forces of tonalit .

Causality

So wh and how do e&ents occurE Dhat brings one thing forward instead of another oneE Causalit will be treated here as being both part of the process and subject to decisions made b the composer. It is e'actl the relationship between the compositional choices and the emergent beha&iors of a compositional en&ironment that are fundamental for our discussion. Composition can occur on &arious le&els. *or e'ample sound processes can be carefull designed but when put in relation with other sound processes, the compositional focus would shift from the details of the process to the interactions between processes.

Sound processes ha&e three important causal features, how the start, how the stop and how the relate.) sound process will start, or be caused to start b an e'ternal factor and then relate to further e'ternal control while it lasts. In this sense all its de&elopment is caused through how it relates. In cases where the relationship between processes is of primal importance these causal functions ac>uire a significant role. *"Causality, where one event seems to cause the onset of a successor, or alter a concurrent event in some way, is an important feature of acousmatic behavior."* ;Smalle , $332, p. $99<. +rocesses can be instantiated b e'ternal forces, interactions or e&en b other processes.

+rocess beha&ior can be affected b the de&elopment of other processes which the can in turn also influence. This makes it possible to create comple' causal chains and is also to be understood as an important propert of process relations. +rocess causalit is thus often *external* and manifested b interaction or manual inter&entions. There also e'ists *internal* process causalit , where the concern is with the beha&ior of process interiors, usuall on a smaller scale.) sound process can thus be started and left alone to e'pose its internal patterning. !ow its non super&ised beha&ior occurs is a matter of internal causalit .

Dhen combining processes on different structural le&els, it is useful to speak of *lower-level* and *higher-level* causalit ;Sturgess, $393<. The former is based on what occurs within an e&ent or local section, the later applies to higher le&el structures or totalities.) composition could for e'ample be made of a handful of formal, higher=le&el structural logics. 6n the lower=le&els howe&er, e&ents could happen due to different causal functions. In this wa related processes could be instantiating each other, cross=influencing their beha&ior or characteristics, while at the same time being guided b global laws determined b a higher=le&el causalit . Tensions created b the differences or similarities of causal functioning can be interesting for musical purposes and e&oke causal relations on se&eral time=scales.

6perational le&els, where one fi'es the window of anal sis, are an essential part of nesting processes and causal mechanisms.)nother important aspect is predictabilit . !ow e&ents succeed each other is part of how their causalit is percei&ed. !ow a succession process takes place is part of directionalit and musical progression. *"This predictive connection of present and future is held to be the essential feature of causality. Such expectations, whether realized or not, constitute in our imagination goals toward which the music is directed."* ;!ast , $39:, p. :"<. If and how music should be directed towards a goal or e'perienced as goal=oriented &aries greatl and often depends on conte't. Strongl causal music often relies on gesture and arri&al points which can be regarded as goals in a structure ;Smalle , $332<. It is not howe&er the intention here to create foundations for a causal music per se. The coupling of causalit and gesture within a goal oriented framework is also misleading for the current discussion. Indeed, a process=based &iew of sound beha&ior does not alwa s fall neatl into the categories of te'ture and gesture. Dhat is &ital here is to reflect on the &arious wa s in which causalit takes place and how process=based compositional thinking can benefit from this.

Complexity

In a musical realit where process characteristics and interaction are put to the foreground, internal, e'ternal, low=le&el and high=le&el causalities ac>uire importance as musical elements. Causalit can also be discussed from a percepti&e point of &iew.) musical composition can be percei&ed as containing a comple' network of causalities where elements seem to in&oke each other.

> *A new systems model in music and its processes will surely redefine the role of the composer or artist who until now has been seen as the mastermind of precisely controllable variables. The new paradigm will more likely see that person's role as a guiding element in a complex process that links artifact to context.*
> ;Trua', $33", p. /#<

Trua' predicted that a s stems model would gain increasing importance in contemporar computer music. It remains doubtful if this is an actual truth in toda @s musical climate. It still does remain an interesting option and one of high importance for compositional en&ironments based on relational processes. The guiding beha&ior certainl has an appealing image and one that has attracted man people in the field of algorithmic music ;Schipper, "#$$<. It does still seem essential to define on what le&el this AguidingB occurs. MP& =Meblond ;as cited in ?aggione, "#$#< mentions that comple'it can be understood to happen where mutual interactions between different le&els are manifest% This makes it e&en more important to understand these different le&els and how the can become part of the creati&e process% Can the concepts of scale, temporal frames or nested processes be translated to le&els of comple'it E Dh does the interaction ha&e to be mutualE

The possible relationships between processes is what is guiding this anal sis% Can composition be concei&ed onl b creating these relationships and as such be seen as emerging from these relationsE

.elations between processes can also be studied simpl in terms of similarit and difference between them% The degree of difference in acti&it is then understood as being the d namic link of relations% This degree is measured b the parameters that control a process% (ifferent parameter positions can be compared as well as combined states of se&eral parameters% This recalls ,oenig@s &iew of comple'it %

> *Relationships can be produced or perceived within a parameter [...] Here we find a point for point dependence, such as the longer the softer, or a combination of clearly marked parameter/time fields, such as rising pitch and volume fluctuating around a central point. We shall speak of higher complexity if the individual values have many relationships to one another, and of low complexity if only a few relationships are clear.*
> ;,oenig, $3:1, p% :<

,oenig also introduced the concepts of *direct* and *indirect* comple'it % (irect as being when two clear distinguishable, successi&e or partiall o&erlapping sounds are compared% Indirect when se&eral sounds forming a section are compared% These relationships &ar and the comple'it of that &ariation is registered on the &ertical a'is% The nature of the sounds is &er important% (ifferent sounds of high comple'it form more comple' relationships than different sounds of low comple'it % The same goes for similar sounds with simple or comple' relationships%

Comple'it can be understood as occurring in sounds, their relationship through parameter &alues and the &ariation of these relationships% This applies e>uall well to the sound processes that ha&e been introduced pre&iousl % Sound processes share &arious aspects with comple' sounds such as the parametrical importance in terms of definition and control% This makes them fle'ible since the comple'it can easil be e'plored through different parametrical configurations%

?iewing relationships as being comparable representations of parametric states can be applied to other aspects besides comple'it % In fact the pre&iousl co&ered topics of complementation, susceptibilit or e&en causalit can be understood as relationships of difference and similarit % 6n a hori-ontal a'is the relationships of comparison ac>uire a temporal dimension% Time is indeed somehow an important factor of all these relations%)s such this temporal dimension can also be anal -ed as a relationship of &alues that bring forward temporal e&ents% *"Time is neither a substance independent from events, nor itself change or process. It is rather a form of relationship between events."* ;!ast , $39:, p% :#<%

In section "%" the discussion was directed on how le&els could be understood in perhaps a more open wa then the temporal one. So it might come as a surprise now to come back to temporal issues and declare them as being simpl relationships of different &alue states. ! owe&er, it is a &er important statement to make at this point. Both structural time containers used when creating music as well as how music is e'perienced and understood, are to be seen as a being a relationship of similarit and difference. Dhen composing b creating states where &arious processes interact, the comparison of these states and the parameters that form them is a powerful compositional tool. Musical time, the time e'perienced when listening to a piece of music is also &er much created b the listener when comparing current e&ents to pre&ious ones and b that process forming e'pectations. Dhen one is listening to a piece of music often one has the feeling that time is being articulated b the relationship of the elements that form the music. This is not to be confused with the structural le&els or hierarchies formed when creating the music.

! ow things change is often what gi&es the feeling of time. Music is ma be characteri-ed b its &arious degrees of change. In the compositional en&ironment that will be presented in the ne't two chapters, there is a clear focus on a elements which ha&e certain states. Dhere one thing is clearl defined b its state, the &alues that create that state and the difference between that element and others based on these state &alues. 6ne could sa that the difference between one state and another, their positions in the state space so to speak, create time when put into interaction in a musical conte't. Time is thus e'perienced as the relation of different state positions. Dhen the listener reflects on a pre&ious musical e'perience, it is not alwa s the duration of elements that remains the most important factor, but also the degree of difference and similarit between them.

Time is an abstraction at which we arrive through the changes of things[…] Thus, time as such does not exist but only change […] The quantum universe is likely to be static. Motion and the apparent passage of time may be nothing but very well founded illusions.
;Barbour, "#$$, p. $<

2.5 Time, Memory and Succession

The 5nglish ph sicist Culian Barbour has a theor that time does not e'ist.)ll there e'ists is a great number of "nows" and that time is more of an illusion that we create oursel&es b sort of interpolating between them. This idea is fascinating, not onl for its different world&iew and philosophical implication, but also for music.

In the conte't of this research, the ideas of Barbour are rele&ant in terms of how to design different time containers ;states<, and if these states could possibl be connected to Barbour's nows. Since if time is an illusion created b oursel&es between the passage of these "nows," then it could be argued that music is &er much part of this illusion. Music can also possibl draw attention to what possibl lies beneath this illusion.)pproaching the illusion and the data it is created from then becomes something &er important to deal with for a composer.

> *There are things that you could call instants of time, or 'Nows'. As we live, we seem to move through a succession of Nows, and the question is, what are they? They are arrangements of everything in the universe relative to each other in any moment, for example, now […] What really intrigues me is that the totality of all possible Nows of any definite kind has a very special structure. You can think of it as a landscape, or country. Each point in the country is a Now. I call it Platonia, because it is timeless and created by perfect mathematical rules.*
> ;Barbour, $333, p. "<

6ne interesting aspect of Barbour's theor and a fascinating one is the landscapes of nows. It implies that one can tra&el freel from one now to another. !ow one should tra&el in time like this still remains unsol&ed b Barbour. Henakis saidG "*For the moment, one cannot conceive the halting of time. it is a presently impassable frontier"* ;Henakis, $33", p. ":/<. Can music perhaps help to create the illusion of this possibilit E

Snapshots

It is possible that it is actuall change that gi&es substance to time. Imagine for e'ample a series of photographs where someone is throwing a ball. 6ne sees the ball in different positions in different photos. In the series of photographs one sees the mo&ement. Dhat one sees is nothing more than a series of snapshots in different positions. This mo&ement in time is nothing but a series of positions in space, which our brain interprets as mo&ement in time. 7ot all possible positions but onl certain ones ;G. +ape, personal communication, (ecember :, "#$$<. Barbour himself has talked about his "nows" as being sort of snapshots and there e&en e'ists a documentar about him where he is walking around with a polaroid camera.

The world is to be understood not as matter/mass moving in a framework of space and time, but of more fundamental snapshot-like entities that momentarily fuse space and matter into single possible arrangements or configurations of the entire universe. Such configurations, which can be fabulously rich and complex considering the vastness of the universe, are the ultimate "things" of reality.
; ! ameroff, "##/, p\ $<

So is it possible to transfer ! ameroffBs configurations to musicE (oes this not seem a &er static &iew compared to the process and change based tone of &oice in the te't so farE Can music e'ist outside mo&ement and what is process thenE +erhaps it is the combination of the two that creates this magic called music\ Both the data used to create the music and how it sta s in memor corresponds &er well to a world made of static snapshots\ The process is what happens when this AdataB is e'perienced, when a possible snapshot becomes a current one\ The process can be seen as being part of the illusion of time, musical data and traces in memor as imprints in a snapshot\

Music participates both in space outside time and in the temporal flux. Thus, the scales of pitch; the scales of the church modes; the morphologies of higher levels; structures, fugal architectures, mathematical formulae engendering sounds or pieces of music, these are outside time, whether on paper or in our memory.
;Iannis Henakis, $33", p\ ":4<

Henakis had &er profound ideas about the relationship between the inside and outside time aspects of music\ ! ow he thought about the relation between what is in or outside time also corresponds well with the ideas e'pressed b both Barbour and ! ameroff\ ! e also had a certain &iew on how snapshots are a useful metaphor for defining states and how those connect in networks\ This will be discussed in further in section 1\4 of this thesis\

Memory

Interesting for the current discussion is how Henakis saw time as being created b comparable temporal situations\ *"We seize time only with the help of perceptive reference events [...] these reference events would have to be inscribed somewhere, it would suffice in our brain, in our memory"* ;Henakis and Brown, $393, p\ 92<\ Dhen comparing these reference e&ents with other remembered ones the impression of the passage of time occurs\ The order of these e&ents becomes important so that the can be compared to other percei&ed e&ents\ These e&ents result from the e'perience of the *flux of time* and are conse>uentl stored in memor as outside time information\ ) nteriorit is needed to determine the order of e&ents that are being looked up in memor \ *or anteriorit to e'ist, the outside time representations in a listeners memor will need to contain clear boundaries of what constitutes them, *"it is necessary to be able to distinguish entities, which would then make it possible to "go" from one to the other"* ;Henakis and Brown, $393, p\ 92<\ This implies that one can perhaps inde' the stored information b using different strategies than na&igation through the temporal order b which the are stored in\ Could music be used to create non=linear links between the entities as it de&elopsE Could these links become compositional choicesE (o the perhaps ha&e something in common with the relations of difference and similarit E

The temporality of inner thought processes, is often not linear. Our minds can follow but one branch of the tree of associations; we must return later if we wish to explore another branch. We constantly project fantasies, hopes, and fears into the future; we recall and juxtapose more- and less-remote pasts; we turn our attention from one thought chain to another, often without apparent reason. The temporality of the mind is seemingly irrational.
;, ramer, 39, p. 144<

, ramer as well as Henakis understood the process of e'periencing music as being like a chain of musical e&ents. !ow these chains are formed and how the links between elements are made is what makes the whole for a piece of music.

6ne could argue that for the temporal art that music is, the linear succession of e&ents is how it is remembered b. Succession is of course &er important in the unfolding of music. It remains unclear howe&er, if succession is alwa s e'perienced as linear or recalled in the same order as it was percei&ed. Some musical compositions are more likel to be e'perienced as pure presence, as series of self=contained moments whereas others are percei&ed as a more linear flow of temporal e&ents ; ! ast , $39:<.

It takes a time for a process to be percei&ed and its aspects to unfold.) certain duration is needed for the listener to feel that he is e'periencing a moment which he can clearl feel different compared to other moments in a composition and that their difference is to be percei&ed as a relationship. These moments could be regarded as states. 5ach state could be seen as containing one or more processes. 5ach process has its uni>ue >ualities and beha&iors. Sates could also be seen as a collection of processes at a gi&en point in time. The aspects or parameters that define the states can be seen as temporal entities that can be na&igated through in &arious wa s. These can become the basis for a compositional process.) compositional framework and en&ironment.

It was as if memory, like a worker striving to erect a solid foundation in the midst of a flood, while making us facsimiles of these fleeting phrases, would not allow us to compare them to those that follow, and to differentiate them. Thus hardly had the delicious sensation Swann felt expired, but his memory gave him a provisional and summary transcript of it even while he continued to listen. He took a good enough look at the transcript while the piece continued, so that when the same impression suddenly returned, it was no longer impossible to grasp.
;+roust as cited in (owling, Tillman, and) ers, "##$, p. "2/<

)t this point it is important here to grasp the topics co&ered so far. The connection between compositional processes and the scale the occur on. !ow different scales and le&els of focus relate to the constraint and definition of musical material. !ow musical material can again be thought of in terms of processes and process=based frameworks. !ow sound processes or processes in general can gi&e rise to emergent beha&iors. !ow causalit and comple' relations are an important factor for musical processes. !ow time can be understood as being an illusion, or how time can be thought of as a series of different snapshotsLstates that become an illusion &ia the process, the process which unifies the whole of music.

3. Representations

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There is no musical process without representational systems at work—a plurality of representational systems, depending at which level or time scale we are operating. Algorithmic representations cover a substantial part of this plurality and are certainly pertinent, as they can match at least some of the assumptions underlying a given music production system, especially when including the condition of interaction, revealing its many simultaneous levels of articulation as well as its direct anchoring in perception.

;?aggione, "##$, p. 19<

3.1 Music Systems

The man imaginable wa s of creating sounds and control structures using a computer raise the >uestion of how materials, operations and musical arrangements are represented b the computer. Dith digital technologies almost e&er act performed during the process of composing can be accuratel stored and reproduced. Da s of generating sounds can be codified as algorithms to be e'ecuted when sound is desired to be heard. Sounds can be recorded and stored as a string of numbers. Methods can be created that operate and manipulate the sound data and comple' structures concei&ed as collection of sounds and operations. !ow this is made accessible to the composer is something of great importance since the representation of data and the a&ailable operations to manipulate it is what will be interacted with during the process of composition.

Certain &iews ha&e become common practice in the field of computer music. Man of them refer directl to pre=e'isting non digital constructs such as ideas coming from the analog studio. (espite rapid technological de&elopment in toda @s societ , it does seem that the issue of how to represent musical data is not so much addressed and that the standard &iews ha&e become accepted b man . The wa materials for a composition are represented is certainl not something that should be thought of a being fi'ed. Indeed the precise definition of materials, possible operations that transform the material and relationship between them is part of what is to be composed for.

Modes

Traditional western musical notation or ideas deri&ed from it ha&e to some e'tent been emplo ed in representing data in computer music. The earl M8SIC=7 programs and its descendants use note lists to represent the IscoresJ that make a section or piece of music. These note lists contain lines that are read &erticall in time where each line corresponds to a note which has an instrument and a list of parameters such as duration and d namics. 5&en if this model can be fle'ible and allow for &er precise control of musical materials it is strongl based on a traditional wa of musical representation and thus somehow limited. The MI(I standard which was de&eloped in the eighties is another e'ample of how ideas deri&ed from traditional notation ha&e been used in some kind of catch=it=all fashion in order to be fle'ible enough for the demanding composer. The choices made when the standard was created, its parameters and resolution ha&e put restrictions on the wa man people ha&e interacted with computers in order to create music. Man possibilities offered b digital technologies, or compositional ideas that are uni>ue to computer music, can simpl not be successfull represented b note based s stems.) s remarked b Stephan Tra&is +ope when discussing the Sm6 , e music representation and description languageG I *Events need not be thought of as mapping one-to-one to "notes," though they should be able to faithfully represent note-level objects. There may be one-to-many or many-to-one relationships between events and "notes." Events may have arbitrary properties, some of whom will be common to most musical note-level events (such as duration, pitch or loudness), while others may be used more rarely or only for non-musical events.*J ;+ope, $33", p./<

(etails of what makes each sound are usuall not part of how computer s stems ha&e generall implemented ideas from traditional notation. The boundaries with regards to the micro=&ariation of a sound when heard and the medium which produces it are &ague in computer music and something that is to be open for compositional choices. . oger B. (annenberg has remarked that representation s stems often ha&e difficulties when integrating continuous and discrete data ; (annenberg, $33/<. The scope of how e&ents and details are represented is indeed &er important and perhaps a hard problem to sol&e in a general manner. ! owe&er, if the sonic details of musical materials are something to be composed for in the sense of being accessible to s mbolic treatment, then it re>uires a representational framework that makes it possible to do so.

?aggione identifies three main representational modes in computer music s stems. *Circular*, *sequential* and *stratified* ;?aggione, "#$#<. The circular mode is often connected to patches made in graphical en&ironments such as M) HLMS+ where conditional programming encourages a circular approach to time. The se>uential mode is a linear na&igation as e'plained abo&e regarding the M8SIC=7 programs. Both of these approaches ha&e their strength and weaknesses. The circular approach is a powerful one for modeling e&ol&ing processes and direct interaction with elements that form the process. It does howe&er often lack in terms of data structures and higher le&el changes. The se>uential mode can model in detail comple' beha&ior, but its linear aspect somehow limit it as well. The stratified mode is described b ?aggione as encapsulating se&eral temporal representations in what he calls *objects*. These objects also contain &arious operations that are to be performed on the data the contain. This has been e'tensi&el e'plained b ?aggione and will be discussed in the following section. It is be ond the scope of this te't to compare these three methods in detail. Dhat is important for now is to reflect on the representational issues, their weaknesses and strengths and how this affects the compositional process.

Models

6ne of the problems regarding musical representation is the difference between what is percei&ed and what is represented. Is the designer of a modern musical s stem to model that what is heard or that what is desirable to compose forE ?aggione states that I *Numerical representations are dynamic, carriers of form: this is why one uses them in musical composition, and not for their supposed power as descriptors of a world pre-existing to our work.*J ;?aggione, "#$#, p. 19<. In the conte't of this te't it is also desirable that representational s stems model the compositional ideas a composer has, and less what he might possibl desire to e'perience in terms of acoustic results% This also raises the >uestion of the generalit of music s stems and their relationship to compositional choices% Trua' belie&es that *"all computer music systems explicitly and implicitly embody a model of the musical process that may be inferred from the program and data structure of the system"* ;Trua', $32:, p% "/#<% In fact, how could optimal solutions be implemented for sol&ing those problems when addressing difficulties e'isting s stems ha&e in terms of representing desired musical productsE !ow could these solutions b &alidated if not b comparing them to the issues that ha&e been obtained b the e'isting s stems that ha&e alread pro&en to be incapable to sol&e these problemsE Dhat is then the difference between a representational s stem based on personal compositional ideas and a compositional modelE Muc (Qbereiner defines compositional models as *"a view of composition which is concerned with rendering conscious the determining and condition constraints and limitations of the composition and its production process."* ;(Qbereiner, "#$#, p% 4/< Dhat happens conse>uentl is that the *"model thus takes the place of mediating representations."* ;(Qbereiner, "#$#, p% 4/<% In his understanding of compositional models, a high degree of formali-ation is implied% It also includes a focus on constraints and rules% +erhaps the compositional act can be understood as operating inside the possibilities and limitations of the gi&en model% The composition can thus be seen as a sort of an e'ploration of a specific model% The model is therefore an important part of the composition that is made with it% This is a &alid and interesting point and can be seen as being radicall opposite to representation s stems that aim to generali-e e&er possible thing a composer could think of%

)s mentioned in the introduction, the 5+6C en&ironment represents an important part of this research and man of the ideas that will be discussed in the following sections are represented in this s stem% The 5+6C is in a wa a representational s stem and under some circumstances it could also be seen as a compositional model% The 5+6C aims at representing comple' sounds and control structures and it also has its own compositional logic that influences pieces that are produced with it% The idea behind the 5+6C is howe&er not to pro&ide a set of limitations or rules specific to a compositional idea% The en&ironment can be used to e'plore different compositional models created to be tested within it% This would re>uire additional constraints and limitations to be e'ternall imposed when using the s stem and these could &ar % The additional factors would not be part of the en&ironment itself but belong to the composition to be reali-ed within it% 6n the other hand, the 5+6C is also not at a general tool aiming at the broadest possible in terms of a&ailable functionalit % It has its own specific constraints but these are rather part of a potential compositional path, or framework from which different compositions ;each with their own logic< can be reali-ed% This is wh the term *compositional environment* is the more useful than representation s stems or compositional models% In the following sections the ideas behind the 5+6C en&ironment will be discussed and what concepts it is based on% Chapter four will then e'plain how the en&ironment works in practice and how the representation concepts ha&e been implemented%

An occasion of experience is an activity, analyzable into modes of functioning which jointly constitute its process of becoming. Each mode is analyzable into the total experience as active subject, and into the thing or object with which the special activity is concerned. This thing is a datum, that is to say, is describable without reference to its entertainment in that occasion. An object is anything performing this function of a datum provoking some special activity of the occasion in question. Thus subject and object are relative terms. An occasion is a subject in respect to its special activity concerning an object; and anything is an object in respect to its provocation of some special activity within a subject.
;Dhitehead, $3:2, p.$29<

3.2 Objects and Processes

) potential definition of an object is to e'plain it in terms of its properties and attributes, of its definite being.)n e'tension to the definition includes &iewing it in terms of its doings, in terms of beha&ior and action.)n object can also be understood purel from a perspecti&e point of &iew, as a fi'ed material entit that one can percei&e b his senses. This &iew of an object is perhaps the closest one to the *objet sonore,* a concept de&eloped b +ierre Schaeffer and widel used in the field of electroacoustic music. !ere the sound object is to be seen as an encounter of an acoustic e&ent that has an identit and clearl defined limits with regards to other sonic phenomena or objects. The sound object I*represents a global perception, which remains identical through different listening; an organized whole that we can assimilate to a "gestalt" in the sense of the psychology of form*J ;Chion, $39/, p. /4<. This perspecti&e can be useful for a categori-ation of sounds or when creating music where the focus is on transforming and &ar ing those sound objects. In which case the sound objects constitute the material used to create a piece of music.

Objects and occasions

The interpretation that will be used in this te't is different and understands the object in direct relation to composition. In the >uote abo&e, Dhitehead describes the object as being that with which the acti&it of becoming is concerned with. It is performing the function pro&oked b the acti&it of an occasion based on its datum. In the wa objects will be understood in the following discussion is that an object is concerned with the becoming of a composition based on its datum. The composition is a process, its creation as well as its materials, which are the objects. The act of creating a piece of music, including all of its multiplicities can thus be recogni-ed as the *"complex occasion which is the process itself"* where the *""objects" for an occasion can also be termed the "data" for that occasion"* ;Dhitehead, $3:2, p.$9$<. In this sense an object is that what relates the unfolding of a music in time ;its becoming< and the structures and data it is created from ;its outside=time properties<. The encapsulation of compositional data, its beha&ior and actions, and the interacti&e relationship between the composer, the object and the musical result is what is essential for this understanding.

Composing can be seen as the correlation between the composer and his objects of composition. The act of composing is one of creati&it , an actuali-ation of some of the possibilities the objects offer. This creati&it is responsible for pro&iding the objects needed for the moment where an interaction between objects and composition occurs. Composing can also be seen as belonging to a subset of creati&e action.) creati&e compositional process includes all interaction of that what is possible and that what is finall created. That what in the end becomes actual. *or the distinction of what is potential and what is actual it is the object that forms the necessar bridge.) n object is a container of possibilities. It offers the data and actions needed for di&erse paths of potentials. ! owe&er, these potentials do not become important until the moment of becoming actual. This happens during the interacti&e phase of composing, the process of creati&it which can be seen as the *"actualization of potentiality, and the process of actualization is an occasion of experiencing. Thus viewed in abstraction objects are passive, but viewed in conjunction they carry the creativity which drives the world."* ;Dhitehead, $3:2, p.$9$<

) n object in the wa it is being presented here is a d namic entit consisting of information and beha&iors. It is not to be seen as something static with a fi'ed identit nor as something that can onl be percei&ed acousticall as proposed b Schaffer. In relation to a percei&able sonic outcome the composer object should be able to create a &ariet of choices. The result of this choices should indeed be percei&able but this could occur in &arious wa s. *or e'ample an object responsible for creating te'tures could create a whole collection of different te'tures where some could e&en be percei&ed as being different sound objects in the sense of Schaffer. It is the beha&ior that gi&es the object its identit as well as the sound processes it creates. This means that that the object should be operati&e in nature and that its operations are what is most important for its place in the compositional process. Compositional, operati&e objects are not like sound objects that are AfoundB b listening and then later recorded and transformed. The are e&ol&ing, functional units which ser&e as placeholders for musical material in the interaction between a composer and a composition.

Objects and Vaggione

This brings back ?aggione and his ideas of *composing objects*.

> *Composing objects means creating active entities, each of which is endowed with specific behavior modes (methods), determined in digital fashion (codes), and whose functions depend on their own methods as much as on the context in which they are being used. The objects may be functions (algorithms), lists of parameters (scores), scripts (successions of actions to be accomplished), or they may be sounds (products as well as sources).*
> ;?aggione, "###, p.$4<

(isappointed b a&ailable score=generators based on randomness and linear algorithms, ?aggione ;who was interested in detail at all possible le&els of articulation< became interested in creating *"composition microworlds where the programming aspect is based on a collection of autonomous musical objects forming a flexible and open-ended network of functions"* ;?aggione, 33, p. "#3.< The techni>ues that he de&eloped opened a wa of dealing with *"both the sound data and the "methods" (behaviors) of sound objects"*. It is interesting that this was done in a computer en&ironment that itself did not recogni-e the notion of an object. The object idea was therefore solel created b ?aggione and his compositional strateg . 6bject oriented programming languages and their concept will be discussed later but what is important now is to understand the abstraction that ?aggione@s concept allowed. The object concept pro&ided a means for grouping elements and creating la ers of abstractions. This made it possible to relate different musical aspects in no&el wa s. *or e'ample b appl ing the concepts of objects to scores and sounds and then b *"encapsulating both in one* *and the same object, one is blurring the distinction between them, with significant consequences"* ;?aggione, 33, p% "$#<%)nother powerful concept with regards to time is pol morphism% !ere I*objects receiving identical messages, when activating their own specific properties and methods, can on account of the latter produce uniquely different results*I ;?aggione, 33, p% "$/<% ?aggione defines three compositional conse>uences of appl ing object oriented ideas to musical applications% 5ncapsulation, pol morphism and inheritance ;?aggione, 33, p% "$"<% These are also fundamental concepts of object oriented programming which is an important concept for the present purposes%

Initiall inspired b ?aggione@s objects, the following discussion will e'plain a compositional thought and en&ironment based on processes, objects, states and networks% It is important to note that e&en though the terminolog is often similar to ;and inspired from< ?aggione, the concepts that will be introduced should stand on their own% In fact man of them ha&e in the end not so much in common with ?aggione@s &iew, so it is crucial that their definition is not confused with the one of ?aggione% The en&ironment and its components are to be seen as an e'tending or deri&ing from some of ?aggione@s thought rather than incorporating his ideas%

Objects and programming

6bject=oriented programming ;66+< is a programming paradigm using IobjectsJ, data structures and methods together with their interactions% Inherit to 66+ are features such as data abstraction, encapsulation, messaging, modularit , pol morphism, and inheritance ;Shallowa and Trott, "##4<%)n object is a software bundle of related state and beha&ior%) class is a blueprint or protot pe from which objects are created%)n interface is a protocol for unrelated objects to communicate with each other% Dith inheritance, subclasses ;or deri&ed classes<, inherit attributes and beha&ior of pre=e'isting classes% 5ncapsulation means that the internal representation of an object is generall hidden from the outside of the object's definition% +ol morphism is the abilit of an interface to be reali-ed in multiple wa s%

The 5+6C en&ironment consists of &arious control mechanisms and the objects the control% The en&ironment will be e'plained in detail in chapter 4% *or now it is important to illustrate the link of a object oriented perspecti&e with regards to the s stem% In the 5+6C an object is an instance of a class in &er much the same wa as was e'plained in the pre&ious e'ample%)n 5+6C object is responsible for all communication between sounds and control structures%)n object starts and stops a sound process and controls it while pla ing% The object might pro&ide initial data for the sound process and filter its control and polarit states% The initial data and polarit states might be seen as outside time, the sound process as inside time and the object in=between%

The &arious objects that the make up the 5+6C s stem all respond to a set of common polarities% In the current conte't the polarit &alues can be understood as messages% If for e'ample two different object recei&e an increasing &alue of the Adensit B message, then both of them will increment the percei&ed densit in the sound process the are responsible for% The might howe&er do this in a completel different wa since it is not the details of implementation that is important but rather that the message gets clearl interpreted%

Objects and composition

The object is important as an interface for the composer. The object is not a process, it is responsible for and interacts with, sound processes and is itself an important element in the compositional process. ! owe&er it can also be seen as e'isting outside=time, not as a process but as data, and when used in time, as operations coupled with this data. ?arious tasks such as taking care of resources, initiali-ing data and communication with other components is implemented b the object and is therefore not necessar to be known b the composer. The object encapsulates beha&iors and hides details so that the focus can be on the a&ailable methods it has to offer and relations to other compositional objects.

The control the composer has of the 5+6C s stem is thus abstract but also somehow limited. The object interface and the &alues of the polarities might seem as insufficient to control all important details of a sound process. This is howe&er one of the main ideas behind the s stem. The control is limited and more high=le&el than the microscopic music that the s stem generates.

6f main importance here is the abstraction pro&ided b the object and the few, general operations carried out b the composer. Both the object and the sound it generates can be of &arious kinds and do not change the operations the composer e'ecutes. This is the abstraction that the 5+6C en&ironment is all about. The focus becomes on clear actions, not the details which are implemented inside an object. In this sense using the objects can be understood as an approach of separating clearl details and higher le&el control. The details e'ist, inside the objects and can be addressed b editing object data and initial &alues. ! owe&er, once an object has been initiated, the details can not directl be addressed, onl the object beha&ior, through the limited amount of polarities all objects share.

Object boundaries

)n important design choice is the magnitude of an object with regards to the task at hand.) choice has to be made of whether an object should be e'tensi&e or if its functionalit should be carried out b more than one object. +ope identifies this as an important factor for musical s stems and that this I *tension is well-known in object-oriented software design and implementation. One of the extreme cases is a design that uses abstraction heavily and develops into a wide and/or deep class hierarchy with very many classes that have only a few (perhaps one) methods each. This case is called class explosion. The other end of the scale is a design that leads to a very large and indivisible class (all messages in class Chord), which is known as a monolithic class problem.* J ;+ope, $393, p."<. The 5+6C object are usuall of the later t pe, comprehensi&e classes that can be &er powerful on their own but also relate to other objects.

The temporal fle'ibilit of an object instance is essential to its &alidation as a solution to musical representational problems. +ol morphism can function in order to unif s mbolic understanding o&er different time=scales but also as an important grouping method. Imagine for e'ample a case where an object represents a note and arra s of objects are needed to represent note groupings. If an amplitude en&elope is to be applied to the whole group the operation is more comple' if this has to be done to an arra of objects instead of just to one. The 5+6C objects can indeed contain se>uences and note groups where appl ing an amplitude en&elope is fairl straightforward. This can be a trick problem for note=list based s stems such as Music ? and some of its successors%

The idea of robust hierarchical representations is essential in this te't% It is &er important that the hierarch of le&els, temporal or structural, can be easil interacted with and na&igated through b a composer% The common polarities can function on different scales and allow for fle'ible groupings%

Objects and time

)nother temporal factor that is useful to discuss is the relation between the outside and inside time interaction internal to an 5+6C object%)ll the data needed for an object to reali-e its function can be set before an sound is made% The object does in man cases ha&e additional parameters or settings that can be configured before the object is instantiated% These are its outside time >ualities and the render the objects &er fle'ible for usage% Dhen these choices ha&e been made the operations become more limited%)fter the sound generation process is started the onl wa to communicate with the object is &ia its rather general and abstract polarities%

The inside time control of an object is in fact an interaction with its *sound process.* Sound processes are independent streams of sound characteri-ed b their beha&ior o&er time% The are designed to be capable of pla ing for a certain amount of time without changing greatl or becoming &er repetiti&e% This is a ke factor for the sound process% It does not ha&e the natural attack, continuation and deca phases most organic acoustic sounds do% 6pposed to for e'ample a piano note, which has clear direction to deca from its high energ attack phase, the sound process can be initiated and left running for an unspecified amount of time% The sound process should not remain static howe&er, it should contain low=le&el change in beha&ior that could be interesting on its own%)le'andre .%C *ranRois has distinguished *volatile* data as the one that occurs in a flow of time and *persistent* data as the one that occurs outside an temporal flow of time ;*ranRois, "##3, p% $/#<% *or the 5+6C one can compose persistent temporal orderings for the objects before actual sound is e&en heard and interact to the &olatile beha&ior of a sound process while it runs and thus interacting with its temporal aspects%

Sound processes

) sound process should allow for e'pressi&e changes through the control of its polarities. These will be co&ered in the ne't section but for now its important to state that the beha&ioral aspects of sound processes is onl controlled b their common polarities% Implementation or the inner workings of a sound process should not matter once the process has been created%)n object could howe&er produce different kinds of sound processes that are created according to additional parameters% Their relationship is &er important as such but the boundaries might sometime seem unclear, as stated b 6tto 5% MaskeG *"the distinction between the notion of 'object' and 'process' is ambiguous. Objects define data needs of processes and, once imagined, necessitate their own constitutive processes."* ;Maske, 33, p% "/3<% 6ne aspect of an object is to function as a factor or creator for possible sound processes occurring in time% This distinction of pre=made object time and while=running process time as well as the polarit decisions is &er important for the en&ironment% It could be seen as limiting but does in fact often turn out to be >uite the contrar %

Formulating a strategy differs from composing a piece in that not details, but basic conditions, are established - in minute detail, however. Formulating a strategy, after all, means generalizing formal relationships, which is at variance with the common practice of expressing musical ideals as concrete musical forms. Generalizing, unlike specifying, means making sure that everything can occur once somewhere, but that it may not be 'missing' either. It is hard to define 'everything': as something both present and absent.
; , oenig, 33, p%$2 : <

3.3 Polarities

Christopher) ri-a defines *Idiom-affinity* as the *"proximity of a system to a particular musical idiom, style, genre, or form"* ;) ri-a, "##1, p% 4<% The degree of idiom=affinit defines the possible musical outcomes of a s stem%) plural idiom=affinit s stem can produce music in multiple st les and forms whereas a singular idiom= affinit is more limited in scope%) ri-a finds an e'ample of the later in , oening@s +roject one ;+ . $< which he states as being a l *system with a singular idiom-affinity: the system, designed primarily for personal use by Koenig, exposes few configurable options to the user and, in its earliest versions, offers the user no direct control over important musical parameters such as form and pitch."* ;) ri-a, "##1, p% 4<% In its earliest &ersion, + . $ did indeed limit user control o&er &arious aspects% The limited control consists of choosing the number of calculated points in time, a starting number for the random generator used, a list of : metronome tempi and a list of "9 entr dela s ; , oenig, $32#<% + . $ has : program blocks for the parameters that are calculated ;rh thm, pitch, se>uence, register and d namics< and 2 program sections% These sections represent a progression from aperiodic formations to periodic and as such &ar from irregular to regular for each parameter%

> *All the parameters involved were supposed to have at least one common characteristic; for this I chose the pair of terms, "regular/irregular". "Regular" means here that a selected parameter value is frequently repeated: this results in groups with similar rhythms, octave registers or loudness, similar harmonic structure or similar sonorities. The duration of such groups is different in all parameters, resulting in overlappings. – "Irregularity" means that a selected parameter value cannot be repeated until all or at least many values of this parameter have had a turn.*
> ; , oenig, $39#, p%9<

The degree of periodicit and aperiodicit , which affects all the parameters of + . $, is an e'ample of what will be termed here as a being a *polarity*.) polarit uses a range of possible &alues to determine settings of other musical parameters that are calculated in a generati&e manner% The relationship between a polarit and the &alue of the parameters it affects can &ar but the polarit alwa s has a primal importance in the generati&e calculations% In + . $, oenig was generating material and organi-ing relationships based on steps of one polarit , that of periodicit and aperiodicit % *or each of the musical parameters, &alues are assigned according to the polarit range of one to se&en% The program then generates 2 sections, where each of these steps happens once% The choice of ha&ing a corresponding section for each of the polarit &alues, and that each of the &alues occurs onl once *"clearly demonstrates, a particular compositional principle is concealed behind the rules for selection and combination of elements"* ; , oenig, $32#, p% /"<% This principle is deri&ed from serial composition% Dhat is interesting here is to note how this principle is manifested through the polarit state of periodicit and how this in turn influences all calculated parameters as well as the form of the sections% The polarit thus has great impact on e&er thing that the s stem generates% The polarit state in this conte't becomes itself a musical statement%

The polarit of periodicit can also pro&ide means of representing relationships between parameters% 5ach parameter has a position relati&e to the polarit state% These relationships are therefore e'pressed in terms of where the occur in the polarit range% It is therefore the polarit that produces the relationship that can be percei&ed inside a parameter *"by comparing the alterations in the same parameter [...] but also between two (or more) parameters. In this case we compare the alterations of the one parameter with those of the other"* ; , oenig, $3:1, p% :<% Dhen the polarit state occurs onl once for a set of calculated parameters and that this e'presses a section in the resulting composition, then the relationships can be seen as a series of steps differing b a certain section% These are abstract relationships that ha&e a profound impact on the composition the belong to, which make them &er interesting as something to compose for%

The 5+6C en&ironment can be seen as an e'pansion of composing within a compositional field of polarities% The objects of the en&ironment each contain a set of nine different polarities% These polarities are identical for all of the objects but ha&e different implementations and relations to the generated parameters that control an object beha&ior% The possible range for all of the polarities is from one to -ero% This defines a broader range than in the case of +.$ which has a se&en step resolution% The 5+6C polarities allow for a common language or mode of communication that occurs within the limited range of the nine that are used% Compositional ideas can be tested within the framework that treat the polarities as material for the compositional process% This allows for high abstraction that focuses on these nine aspects, their relationships and e&olution%

The polarities can be understood as being *multidimensional* in the sense that the often control more than one aspect of a sound process beha&ior% Since the implementation depends on the conte't of each object, the onl wa of implementing them is b percepti&e judgment% This makes the problem a &er comple' one since the objects and the sounds the produce &ar greatl % There can ne&er e'ist a perfect definition of what e'actl an 5+6C polarit means since its function alwa s depends on its local conditions% 6ne of the greatest problem when creating the 5+6C en&ironment was therefore to tr to achie&e a global balance of how the polarities are percei&ed% This is unlike +.$ where parameters are generated b the s stem but also interpreted b the composer after the ha&e been calculated% *"Project 1's approach to the problem may be described as "interpretation": this covers both the evaluation of the idea for a composition before the computer can process it, and the composer's evaluation of the tabular score generated by the program"* ; , oenig, $391, p% $<% In the case of 5+6C, the process of interpretation is part of how the polarities work and the wa pol morphism functions in this conte't% This does howe&er ha&e its ad&antages% B pol morphic &ariation of how the polarities work, a certain richness is created when the interact% This resembles the wa a conductor works with group of impro&ising musicians% The conductor can gi&e abstract signs to indicate for e'ample that the musicians should all pla faster or increase the current pitch% 5ach of the musicians can interpret this message in a different wa but the percei&ed change can be percei&ed as more interesting just because of the different wa it is achie&ed%

Constraints

The polarities represent a reduction in the sense of limiting the elements that one composes for. B gi&ing importance to onl a defined set of characteristics it follows that certain aspects of the totalit of control might be suppressed b compositional choices that ha&e alread been made. Dhen defining which polarities to use in the conte't of the 5+6C, the objecti&e was to find the smallest amount of controls possible while still maintaining e'pressi&e interaction with the general process beha&ior. The idea was to ha&e it as general as possible while still being conditioned b the chosen polarities. The wa in which the were concei&ed was b progression, starting b the smallest amount and adding necessar ones once absolutel needed.

wa to communicate with a sound process once it is running.

*ollowing now is a look on each of the polarities and a general description. It is not the purpose here to generali-e or tr to aim for a global definition. .ather, the following e'planations should be understood as brief descriptions of the ideas behind each of the polarities which includes some e'amples of their concrete implementations.

Speed usuall refers to the rate of acti&it within each sound process. This is closel linked to musical tempo or pace regarding rate of change.) possible definition is the number of e&ents per second.)nother e'ample is how fast a trajector that defines a process beha&ior is read. The speed polarit is closel connected to the densit one. Speed can also influence the beha&ior of other polarities. *or e'ample high entrop is sometimes implemented b adding randomness to parameters. In this case the speed polarit could ha&e an affect on the rate of the random generator ;on how fast it generates random numbers<. Speed was chosen for its crucial role with regards to the tempo of a sound process.

Density is not regarded in the same wa here as it does in granular s nthesis which would be closer to the abo&e definition of speed. (ensit is rather measured in terms of *mass per unit volume* in the sense of filling the acoustic space. (ense e&ents are those that fill this space and are opposed to sparse ones where gaps and silences can be found. In his book *Microsound* Curtis .oads defines a granular *fill factor* ;ff< as being the product of densit ;number of grains per second< and the duration of each grain. ;.oads, "##$<. The fill factor can be sparse, co&ered or packed. 5&en though densit does not appl to e&ents per time unit in the 5+6C, the concept of fill factor describes well its function.) sound process can contain rapidl changing sonic entities ;of a high speed< but where their duration is &er short and thus densit low. 5'amples of densit are the en&elope duration of a micro=time e&ent in a se>uence or number of la ers for te'tural sounds. (ensit was chosen for the purpose of controlling the fill factor for a sound process, ranging from dense to sparse.

Entropy is borrowed from its use in information theor where defined as being the measure of uncertaint . Henakis often used the term for noting a degree of order or disorder ;Henakis, $33"<. 5rik 7 strQm has also found it useful for discussing the le&el of randomness, irregularit and uncertaint within te'tures. +rocesses with high entrop could be said to *"describe states of "incoherence", e.g. chaotic situations, where hierarchies are not obvious and the music seems to take several directions at the same time"* ;7 strQm, "##3, p. 43<. The 5+6C &ersion is inspired b his &iew but it also simpl through the notion of regularit or irregularit . It is the polarit that comes closest to ,oenig's concept of periodicit and aperiodicit . In +.$ periodicit was implemented b the wa elements are repeated or not. In the 5+6C implementations &ar , and this has pro&en to be one of the hardest polarit to render con&incing. .andomness is not alwa s eas to impose on sound processes and neither is order.)n e'ample of implementation is random de&iation for the selection of durations or buffer choices when pla ing a se>uence of sounds.)nother e'ample is random de&iation for fre>uenc , amplitude or an of the other polarities. In sample based objects increased entrop often causes fluctuations of reading placement in the buffer or the rate its been read at. 5ntrop was chosen in order to control regularit and irregularit within a sound process.

Position was the latest polarit to be implemented and perhaps the one that has the least ob&ious e'planation% +osition was created when it became clear that in the wa the implementation of the polarities had de&eloped, each of the objects seemed to contain its own special low=le&el beha&ior% This follow from the sound process direction the objects took where each object should be capable of producing sound for undefined amount of time but still manifest a minimum of internal beha&ior% +osition was needed in order to na&igate within the internal beha&ior, to mo&e between different placements of where one would be at a gi&en moment in time% +erhaps a more fitting term would be Aprocess offsetB% 5'amples include where to start a se>uence, read a buffer or begin a trajector % In the last case one can imagine a generati&e function creating a trajector used for e'ample b an amplitude modulator% This will be part of the minimum beha&ior of the object% B using the position polarit an offset can be set for where to start reading the trajector &alues% In the case of a generated se>uence, the position can change the start element of the se>uence to be in the middle instead of the beginning% +osition was chosen for fine grained control of acti&it offset within a process%

Amplitude is dealt with in terms of relati&e subjecti&e response rather than measured decibel &alues% Moudness would therefore perhaps be a better definition of how amplitude is usuall implemented% Moudness is strongl influenced b both the fre>uenc and spectral composition of a sound ;(odge, $391<% ?arious positions of other polarities often alter the amplitude parameters in order for their change to not affect the percei&ed amplitude% 8suall amplitude is implemented similarl to the wa it occurs in an analog mi'er and its transfer function often takes a shape close to the logarithmic ones found in such mi'ers%)mplitude was chosen to control the loudness of a sound process%

Frequency is in most cases related to the central ares of prominent fre>uencies of a sound process% The general idea is simpl to ha&e distinct low, middle and high fre>uenc parts that can be e'plored within a process% In practice the low and high ones often get more space than the fre>uencies occup ing the middle range% 5'amples of implementations are b transposing sampled sounds and fre>uenc controls of oscillators or filters% *re>uenc can also influence other polarities such as color ;fre>uencies of resonators< and surface ;fre>uenc peaks in filters the surface polarit handles<% *re>uenc was chosen to control the fre>uenc or central fre>uenc area of a sound process%

Surface was primaril concei&ed for representing a &er generali-ed &iew of timbre control% The range is to be from soft to rough% The implementations &ar greatl but often include some kind of filtering when the polarit state is low and another kind of filtering when high%)lso when &alues are approaching the higher regions of the surface range, distortions are often used% Concrete e'amples are lo=pass and band=reject filters for the lower range and wa&e=shaping or distortion for the higher range% Surface is possibl the polarit with the greatest &ariet in implementations and differs from the others b the fact that different processing is usuall applied if its state is abo&e or below the middle% *or objects using granular processes, surface often sets a harsh grain en&elope when the &alue is high but a more gaussian=like one when low% 6ther applications include implementation of bit=crushing ;distortion b bandwidthLresolution reduction< or e'perimental signal alterations b using binar operators ;for e'ample fold, modulo or di&ision<% Surface was chosen to control the timbral softness or roughness of a sound process%

Color is usuall discussed in terms of timbre when it occurs in a musical discourse% ! ere it rather refers to a diffused coloration that can lead to blur the original sound% Color is measured in much the same wa as a re&erb of e'isting between *wet* and *dry*% Dith increased color a signal usuall fills more acoustic space but this might also smooth out a sound and cancel its sharpness% Color might also be used to gi&e an artificial tail or prolongation to a sound% In man cases color resembles closel to what Smalle has defined as *spectral density,* where *"a packed or compressed spectral space is compacted so that is suffocates and blots out other spectromorphologies. A transparent spectral space lets spectromorphologies through, while something in between (translucent, opaque) has a masking effect." (Smalley, 1997,. p. 121).* Color occupies a special position among the polarities since it has onl an increasing effect, color can ne&er ha&e negati&e &alues, it will either increase or remain low% 5'amples of color is through dela , re&erb, con&olution, comb=filters or resonators% Color can ha&e an effect on percei&ed fre>uenc since diffused sounds tend to fa&or lower fre>uencies in the spectrum where these fre>uencies will fade more slowl than higher ones ;(odge, $391<% It can also greatl affect the percei&ed space a sound is heard in and therefore affect the location polarit % Color was chosen in order to impose diffused and reflecti&e characteristics on a sound process%

Location is perhaps the most simple polarit to e'plain since its range of -ero to one almost alwa s corresponds to the left to right stereo field% Mocation has pro&en to be a fruitful field of e'perimentation regarding stereo=techni>ues since &arious implementations ha&e been concei&ed% 5'amples of panning include linear left=right panning, constant power panning, channel filtering and de=correlation techni>ues% The panning range &aries between objects and location can ha&e subtle effects when changing simultaneous polarities with similar &alues% Mocation was chosen to situate the spatial center of a sound process%

The polarities understand &alues in the range between -ero and one% This defines the space of possible &alues that are recei&ed b a polarit % There is howe&er almost alwa s a mapping operation between the &alue that a polarit recei&es and the one it uses to calculate the parameters it influences% This mapping happens &ia a *transfer function*% The transfer function is simpl a trajector that maps the input from a one to -ero input space to another output space, also ranging from one to -ero% This wa of mapping can be used in &er creati&e wa s when different transfer functions are applied to the parameters a polarit controls% That the output space is different for each parameter that belongs to a polarit can create *zones* of different non=linear beha&ior in the parameter range% *or e'ample the region from #%" to #%4 can be &er e'pressi&e for one output parameter but perhaps >uite dull for another one, which in turn might become &er interesting in the range between #%: and #%2% The richness of the comple'it when na&igating these A-onesB can lead to &er creati&e compositional choices% In the diagram below there is an e'ample of one implementation of the entrop polarit % A)mountB here means the amount of entrop and BSpeedB the rate at which the random generator that is causing fluctuations in a sound process operates at% These two parameters are mapped >uite linearl from #%# to $%#% The A?alue ! ighB and A?alue MowB define the limits within which the random generator will choose his &alues% The create a sort of mask, which is not temporal but working inside the polarit range of -ero to one% *inall there is a ACitterB parameter that controls the amount of multiplication the random generator is working with⁝ If it is high the multiplication will be little and around $, if it is low it fluctuates between $ and #⁝ So here illustrated is how fi&e different parameters are controlled b one polarit range⁝ Dhen obser&ing the diagram one can also notice that how these lines o&erlap, different -ones are created and that the polarit beha&ior when mo&ing from -ero to one is non=linear⁝

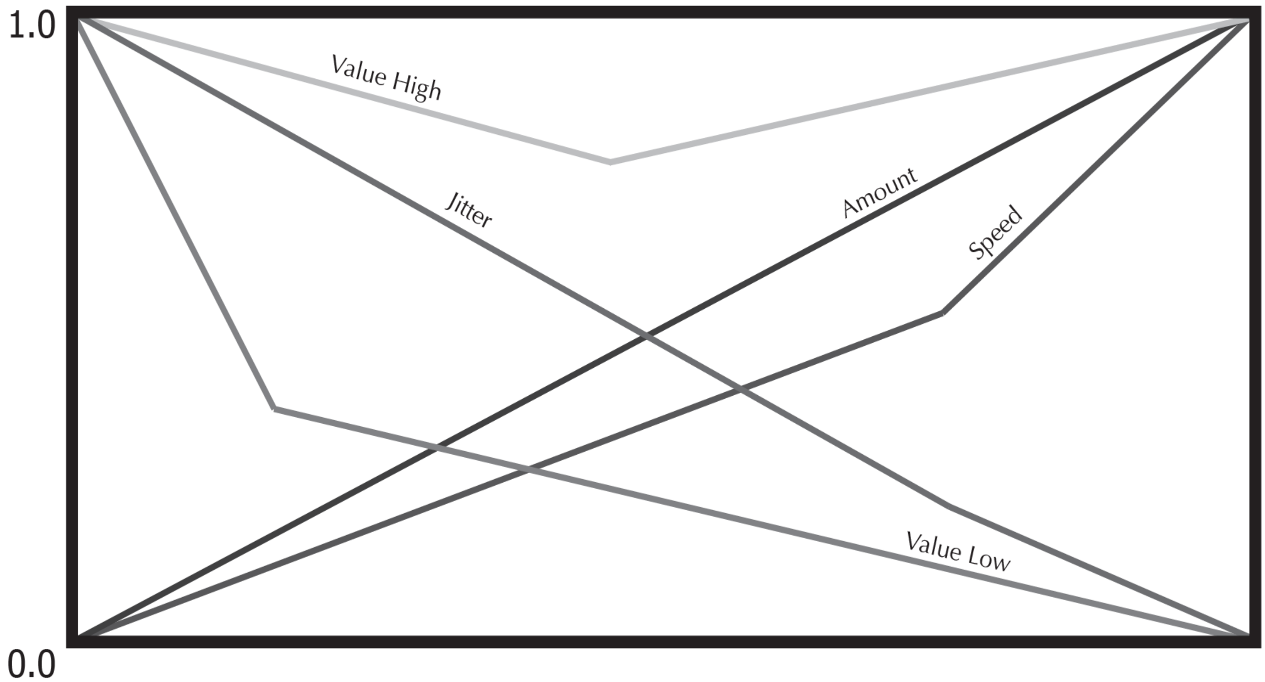

Figure 1 Transfer functions for mapping entropy

)nother important factor is how the parameters do influence each other⁝ In + . $ the calculated parameters *"are independent of each other except that the size of chord depends on the entry delay."* ; , oenig, $32#, p⁝ /1<⁝ In the 5+6C the polarities are often related as mentioned for e'ample abo&e with regards to densit and speed or amplitude and fre>uenc ⁝ This raises the >uestion of hierarch between different polarities and how it should be approached⁝ ?arious methods e'ist in the 5+6C in order to organi-e a set of polarit states compared to others⁝ The can for e'ample be compared b a total sum or difference of their polarit &alues⁝) more heuristic approach treats the polarities with different GÔuestiof")oee trear GÔmetere ofc, ! r

It is neither the thing that dominates the being nor the being that dominates the thing. They are reciprocal and equivalent, but in their momentary meeting they are also distinct. They are produced on the spot, together in difference, any prior objectivity and prior subjectivity is invested in this momentary and complex production but does not subsume it.
;?oegelin, "#$#, Chapter $, Section 1, para% "<

3.4 Nodes, Relations and Interaction

Sound processes which are go&erned b objects and which beha&ior is controlled b polarities, share the interesting feature of not being temporall defined% The can run fore&er, for a predefined amount of time or until the are stopped b e'ternal forces% Dhat defines different parts of a composition made with these processes is therefore mainl how the are combined in &arious configurations% B associating different objects and processes, a temporal continuum can be composed for that spans from the detail to the whole% Consistenc between &arious aspects of a composition is often regarded as desirable% The link between the &arious compositional products is howe&er not alwa s ob&ious or an eas one to make% 6nce this is established, it can enable the composer to abstract his craft%

Abstraction

*or man composition in&ol&es a great amount of abstract thinking% Certain algorithmic music could also be seen as a tool for abstracting musical procedures so that composers using algorithms can step awa and focus on higher le&el choices%)bstraction of objects and processes is of a great importance when composing with them in the conte't of 5+6C% Sharon , anach, who worked closel to Henakis and was a translator of his works, had the following to sa about his approaches6

> *I think the keyword also is abstraction. This is what he preached - morning, noon, and night. Getting away from figuration, from narration, for him, going deeper and deeper into the fundaments of making music or making architecture or making whatever. The more and more abstract you are, the more original you can be. This was always his quest - of trying to take the very basic materials and doing something original with them.*
> ; , anach, "#$#, p% $<

Going deeper and deeper into the fundamentals of one@s work is of course something attracti&e to achie&e% 8nderstanding and dealing with the fabric of these fundamentals can be made possible b the means of abstraction% This applies well to the importance of the process which has been a central theme in this te't% To interact with the basic principles of creati&e acti&it b gi&ing a substantial importance to the acti&it itself, instead of e'ternal factors% More profound thought when using abstraction can also appl in the conte't of composition b unif ing and creating bridges between the different elements that create a piece% To de&elop a wa of abstract communication between different kind of structures that can be interacted with in a simple and general wa % Compositional ideas can be the &er basis of how such modes of communication can be concei&ed%) personal &ocabular that a composer has, can be reflected in the abstractions that he uses to create his pieces% Standards in computer music s stems can sometimes be dangerous with regards to this, since common ideas and solutions become the norm% Dhat should be desirable is a compositional framework where the controls that a composer uses are part of his ideological &iew In the computer music language , ma there e'ists an attempt of unif ing elements with objects and hierarchies of objects

> *One of the ramifications of this abstract, recursive definition is that Kyma makes no distinction between "samples," "live audio input," and synthetically generated signals. They are all Sounds that act as sources, and they can be manipulated and composed using the same sets of unary and n-ary functions. Another ramification of the Sound object definition is that Kyma does not draw a distinction between "instrument" and "score." Instead, it provides an abstract way to build hierarchical structures that might or might not correspond to traditional musical organization.*
> ;Scaletti, "#$#, p 1<

Hierarchy

B combining objects into higher le&el elements, it is possible to create customi-ed structures that fit personal compositional ideas !ierarchal grouping can certainl be a &er powerful wa to achie&e both abstraction in terms of interaction as well as to create large structures from small ones Man researchers ha&e tried to de&elop hierarchical representations and implementations in software composition s stems *"One advantage of hierarchically structured descriptions of music is that transformations such as tempo or pitch can be applied to aggregates of musical objects."* ;(annenberg, $33/, p "<) nested structure could therefore be made of &arious sub=structures which each would be able to communicate and e'change information

In the 5+6C, objects and polarities can be assembled on higher le&els 7o&el objects can be created from collections of other objects and the totalit be controlled b separate polarities or b sharing the same one The structure that enables the grouping is called a *node*. This comes from network terminolog which will be discussed in the ne't section) node can contain an infinite number of objects, a global polarit collection as well as other nodes Dhen an object belongs to a node it will be assigned with two temporal parameters, a start time and duration This happens since the node is designed to work in a temporal conte't) node can e'ist in the framework of succession and therefore be made to beha&e as a state) state would then consist of a group of objects ha&ing different start times, durations and polarit settings These three aspects could all be controlled b the node, before and while the objects are pla ing)pproaching states as building blocks, possibl with higher le&el control, the act of composition can perhaps become e&en more creati&e 5ach objet in a state has duration and offset times 5lements can thus be o&erlapped or stretched) 4# sec state could become a 4 second or 4 hour one Comple' states can be concei&ed and radicall altered within a node onl b changing these three elements that are common to all Grouping things together can make the entire creati&e process much more interesting This also enables work on different parts at a time This enables one to IswapJ objects within a node for other objects while all other compositional logic remains (namic states allow e'perimentation with &arious configurations and offer a great le&el of abstraction This abstraction happens b focusing onl on the polarities, the start and duration times, but on &arious le&els, for different musical constructs and structures

States can be controlled in a pol morphic fashion 5ach object has its own interpretation of the compositional messages that circulate within the framework In addition to this, nodes can not onl be seen as states but also as la ers, chords or e&en instruments¦ B grouping se&eral objects together so that their polarit states are influenced b a global one, e'pressi&e entities can be created¦ Composed states can also be e'panded and used in an instrument like wa ¦ *or e'ample to shift fre>uenc or increase densit in a node with four different objects, that each ha&e different ;and carefull composed< polarit settings¦ 5ach object would then change their own polarit setting either in offset to the node polarit state or b inheriting totall the state¦ Some musical ideas can be deri&ed from working with the polarities¦ *or e'ample *¦increase speed slowly while at the same time make the sonic surface become more roughB¦* B grouping objects in nodes, statements like these can be applied to whole states or collection of objects, resulting in increased richness and creati&e possibilities¦

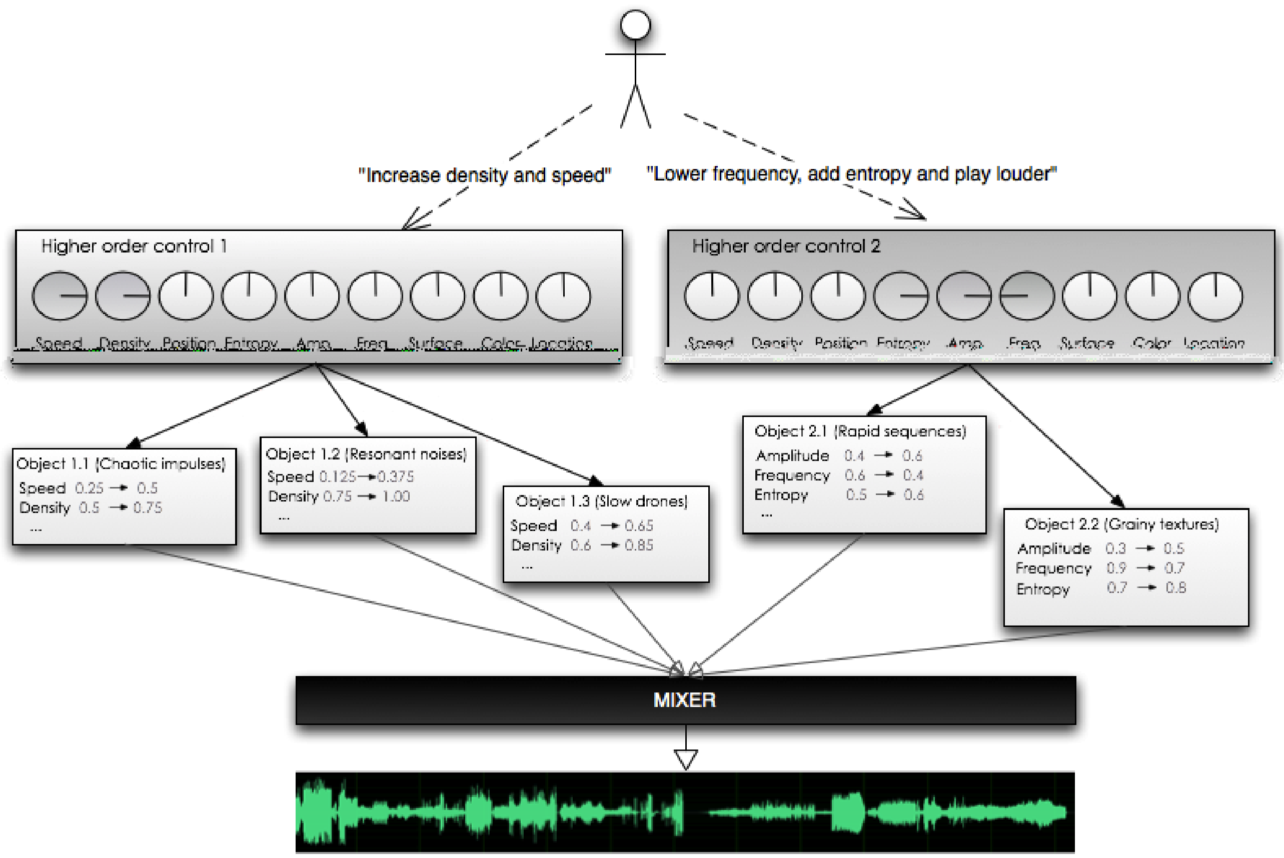

Figure 2, An example of 'higher order control'

Interaction

(annenberg defines two main models of music representations ;(annenberg, 33, p¦ "<¦ *irst is the resource model, where sounds are seen as resources that are controlled b updates¦ 8pdates can be discrete e&ents, for e'ample a Inote onI message and continuous ones such as updating the amplitude of a sound¦ The updates are made to the resource which is alwa s the same¦ There can onl be one sound produced at a time for that representation¦ The second is the instance model which is not concerned with the resource, but onl the attributes of each sound¦ So for each sound there is a new sound instance created¦ These instances are independent and there is no limit on the number of simultaneous sounds¦ B grouping objects in 5+6C nodes, the strength of both of these approaches is possible%)n object is similar to the resource model where the object is alwa s updating the sound process of which there is onl one instance% The node can be seen as an instance model in the sense of being capable of containing an unlimited amount of instances which still are being updated b themsel&es as well as b the global node controls% The possibilities in terms of pol phon and other &ertical relationships can be e'plored in interesting wa s b nodes in such a wa %

The relationships that polarities within a node ha&e is also interesting to in&estigate% +olarit states of one object can be set into relationship with the polarit states of another one% *or e'ample using one to one, in&erse, difference or relati&e mappings% Comple' chains of beha&ior control can be created &ia these relations% This adds further to the possible e'tensions of nodes and node objects% In fact, it is b its hierarchal modes that the 5+6C arguabl shows its most original aspects% B connecting objects and e'ploring these connections and the resulting relationships, interesting disco&eries can be made% .elations can also be seen as simpl within a polarit &alue of a node% The &alue a particular polarit has in objects within a node and how these &alues can be subject to higher le&el control and compositional strategies%

The wa communication occurs between a composer, the polarities and higher le&el nodes, can be thought of simpl in terms of interaction% The 5+6C s stem is real=time and all actions which ha&e been discussed can be made with real=time interaction% The 5+6C is howe&er not designed as an instrument to perform with as such% (esign considerations for an instrument=like s stem ha&e not been taken into account% It can be used on stage to create music in real=time that is interacti&e% It is still important to note that the 5+6C is not designed as an instrument and note the difference between light interaction and intense interaction% Curtis .oads defines these as *"light interactions experienced in a studio-based 'composing environment,' where there is time to edit and backtrack"* and *"intense real-time interaction experienced in working with a performance system onstage"* ;$33:, p% 94:<% 5+6C would be in the middle of those two interaction modes% It is mainl thought of as a compositional s stem as opposed to something to use on stage, howe&er it can easil be used on stage to perform interacti&e compositions% In the case of nodes containing &arious objects with different relationships, the higher le&el controls can be seen as an interaction with an algorithmic s stem% ?aggione stated that l*interaction is more important that algorithms*J ;?aggione, "#$#, p% 13< !e also labels algorithmic music that is created with closed s stems as l*Turing music*J% There are numerous problems that result from working with black bo' approaches where the onl interaction is to define input or edit the output of the s stem% In man cases it is highl desirable to interact directl with generati&e process and the compositional logic the contain% Inter&ention of the 5+6C processes and constant interaction with the en&ironment is one of the en&ironment@s most important characteristics%

Two chains of contiguous events without a common link can be in differently synchronous or anterior in relation to each other; time is once again abolished in the temporal relation of each of the universes represented by the two chains. Local clocks serve as chains without gaps, but only locally. Our biological beings have also developed local clocks but they are not always effective. And memory is a spatial translation of the temporal(causal)chains.
;Henakis and Brown, $393, p% 99<

3.5 Networks

The highest element in the 5+6C hierarch is the *network*%) network is a set of nodes where each node is connected to one or more nodes through links% The network does not e'ist as an object itself, it is rather defined through the relationships between the nodes that form the network% The links that form these relationships are simpl indicators of what other node;s< should be pla ed after a node has finished pla ing%) composition made with the 5+6C can also be understood as being a network% 5&er section of the music is then a node in that network and the totalit of succeeding nodes becomes the o&erall network% In mathematical terms, a network is called a graph and the pre&ious description of a linked composition would be called a ApathB through this graph% This also applies to some e'tend to the 5+6C network% The final percei&ed musical result is indeed a chosen passage through the possibilit space of connected nodes% This does howe&er not mean that the composition e'ists onl as a path%) composition could include the possible and actual links and nodes that form the piece% In the 5+6C each of the nodes has a weighted list of links from where it will choose which of these possibilities will become actual% This could be open for aleatoric choices or completel deterministic as decided b the composer% This creates possibilities for open works and gi&es importance to succession and how it occurs in the conte't of the 5+6C%

Temporal links

The function of the 5+6C network is purel temporal% It is concerned with what happens, when it happens and the order it happens in% Time is therefore the material a network operates with% Time can also be seen simpl as a wa of di&iding space% It is e>uall possible to make a se>uence of sounds that will di&ide space differentl and a se>uence of sounds that occurs within a composition% ! ere time becomes a con&enient wa to sa when the ne't thing happens with relation to other things that ha&e or will happen% It is sometimes easier to talk in terms of seconds than in spatial coordinates which would be &er difficult% ! owe&er, for structures that e'ist outside=time the opposite might be true%)n interesting option for e'ploring this is to map them using different spatial strategies% 7etworks can be seen as creati&e alternati&es to represent musical architectures% The are for e'ample not necessaril read from left to right ;such as in traditional notation or se>uencers<, or from top to bottom ;note=list s stems<% Interesting combinations of these can be concei&ed which might result in different modes of interaction with musical structures%

B defining the network as all possible routes through its nodes, the >uestion is which of these routes are the most interesting to e'plore%)dditionall , how does the order that the are pla ed in affect the resulting musicE 5+6C allows for eas e'ploration of possible paths in a network and how this is concei&ed is open to e'perimentation and compositional choice%) n important factor regarding the order of nodes is also the similarit and difference between them% This can be anal -ed without the added comple'it of taking into account e&er thing that has happened before in a temporal succession% Dhat is it that the ha&e in common and what is it that differs themE) possible method of comparing would be through the polarit states and the node duration% This allows for automatic >ualification of the nodes and adds et another la er in the polarit hierarch % If the 5+6C would be used as a compositional model then defining the judgmental criteria according to the polarities would seem an ob&ious choice% This does howe&er sometimes turn out to be rather limiting% *irst of all sections can be made of se&eral configurations of polarit states in &arious positions in time%) dditionall these can be la ered and used in hierarchical wa s% ! ow useful structural information can then be deri&ed from the polarities is not ob&ious%

The diagram here below shows an e'ample of an 5+6C network% It contains eight nodes and ten connections% 5ach connection shows a possible path for what happens after a node finishes pla ing% *or e'ample A7ode $B could send a message to either A7ode /B or A7ode "B so that the would start to pla % This creates possibilities of different ordering of elements within a piece%

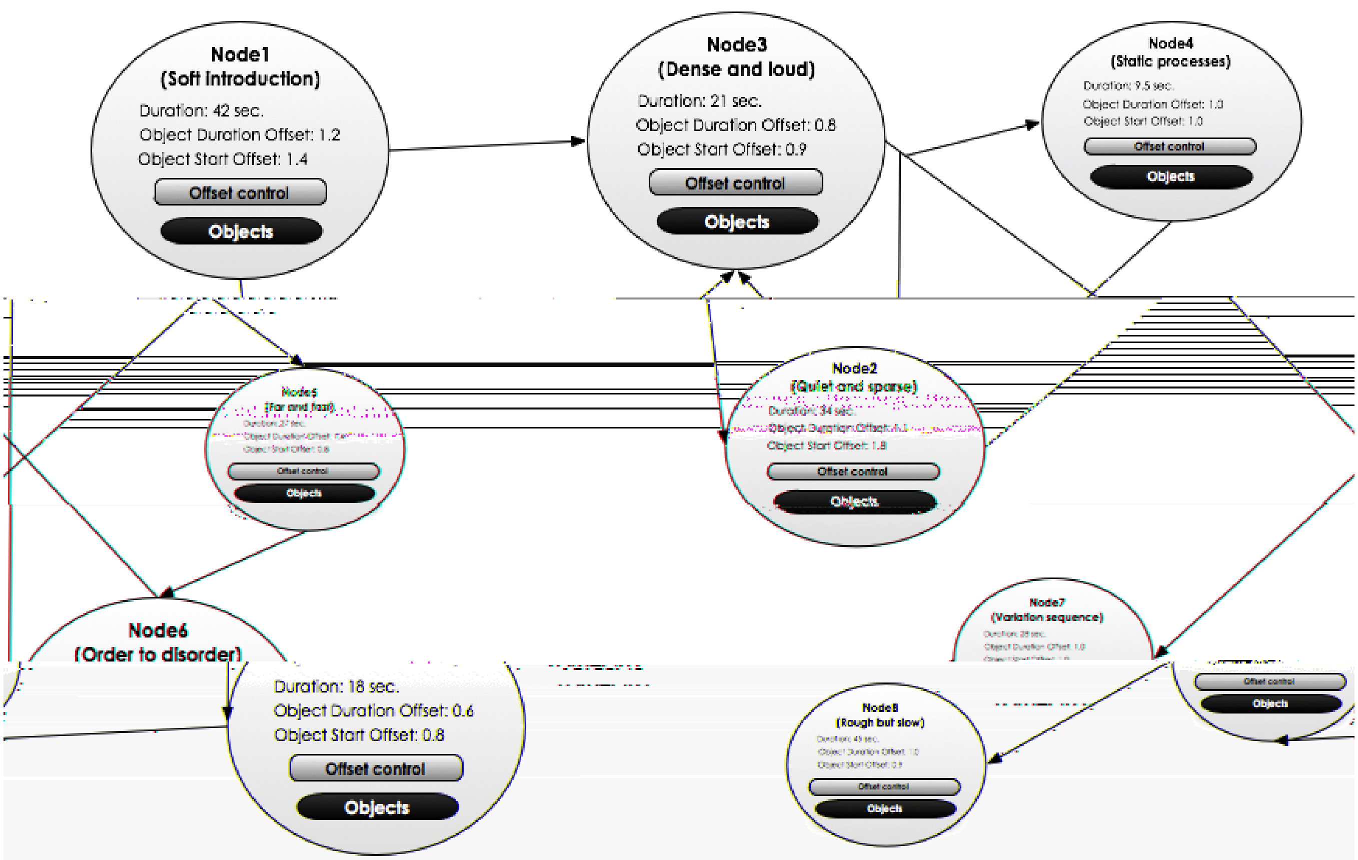

Figure 3, An example of an EPOC network

Navigation

The summing, subtraction, timbral and temporal weight algorithms discussed in section /%/ appl when comparing singular instances of polarities for an object, but not so well when comparing sections that contain man of them% In *Terminus* , oenig deri&ed the relationship between sections b their mode of production%

> *The systematic derivation of material structures which due to their mechanical procedure are structurally related; neighbouring relationships are not formally established but appear as the derived materials are presented – successively or simultaneously. This shows the form problem in a very mediated guise, because the possible form-sections (the prefabricated derivations, whose number can be increased at will) are closely linked, owing to their past history in terms of production technique without having a goal oriented relationship to each other.*
>
> *(* , oenig, $392, p% $2#*)*

This approach is powerful in the sense that form is deri&ed directl from the material and when carefull applied often results in con&incing forms% D hen comparing , oenig@s form=sections to nodes in a network, what is needed in the 5+6C is a method to establish this close link which does not impl a goal oriented relationship% The 5+6C objects can not be compared b mode of production since this does not ha&e an &alue for the objects that implement real=time s nthesis for e'ample% It is howe&er &er desirable to deri&e the path through a network somehow from the characteristics of the nodes, of the material% This is still unsol&ed and remains an interesting topic when working with the s stem%) nother option would be to sort nodes in terms of their structural importance for a gi&en piece% This implies assigning indicators of structural importance to each of the nodes and sorting them accordingl % This is actuall the most promising idea de&eloped so far but does ha&e the weakness that the indicators are often assigned according to formal ideas that are e'terior to them%

Variants

) possible network configuration could also be seen as generating a &ariet of pieces based on the path chosen% *or each configuration the number of possible pieces would be the number of possible paths and the could be generated automaticall b the s stem% Christopher) ri-a has found similarities between , oenig, ! iller and Henakis in terms of generating multiple pieces from the same mechanism%

> *Gottfried Michael Koenig frequently used the term "variants" (translated from the German) to describe the many possible outputs a CAAC system produces from a common system configuration […] Lejaren Hiller used the term "versions" to describe interchangeable movements created from common procedures with "small to substantial but presumably significant changes of input data" […] Iannis Xenakis referred to the outputs of a single system as constituting a family: "the basic law ... generates a whole family of compositions as a function of the superficial density.*
>
> ;) ri-a, "##2, p% $<

This wa of generating compositional &ariants could also be seen as a how the networks in the 5+6C work% 6nce certain relationships and polarit states ha&e been composed these can be e'plored further b using the network for e'perimenting with na&igation strategies%) s discussed in section /%4, each of the nodes in a network has a set of global polarities and start and duration offset for the corresponding controls of the node% B na&igating a network of pre=composed nodes, and setting the global controls according to a compositional strateg radicall different &ersions of a composition can be rendered% *or e'ample a composition that consists of ten nodes could be altered that in these ten steps, densit would drop and entrop double% The wa this occurs of course depends on what is the state of densit and entrop within each node% This is then a &ariation techni>ue that enables higher le&el compositional ideas based on polarit changes% This brings to mind , oenig@s words about +.$ form=&ariants6 I *Form-variants are not open or variable forms, but variants of an initial position which is described algorithmically and – rather like an idea not yet executed in detail*J ; , oenig, $392, p% $2"<%

The idea of higher=le&el control b composing for the global polarities of the nodes, and that this is decided before the actual order of the nodes, again increases the abstraction of compositional choices% If this becomes the main focus of a piece, then one could e'periment with changing objects that reside within the nodes, or e&en swap e'isting nodes for new ones to reali-e what it is reall that defines a piece and if the whole creati&e process might actuall be re&ealing itself%

4. The EPOC Environment

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Gyorgy Ligeti compared the various interpretations of open-compositions to flash-photos of a Calder mobile, in which changes are manifested only indirectly, since each performance is merely a momentary incarnation of the manifold possibilities of the form. In a Calder mobile, the shape, color, and design of each part is fixed, with the order and angle constantly changing. […] This implies art as a process, no longer will objects of music exist in that sense, but each new performance, each new circumstance will create a continually variable process of ideas.

; ! anoch= . oe, "##/ , p% 1<

4.1 Design Considerations

In this chapter the 5+6C ;5n&ironment for +rocess and 6bject Composition< will be presented% The elements that will be presented here are concrete implementations of the topics that ha&e been discussed in this thesis%) working &ersion of the s stem can be found in the (?(supporting this thesis, as well as e'amples of how it can be used%

The 5+6C en&ironment is a compositional tool% The moti&ating ideas behind it came across as potential solutions to encountered compositional problems% The 5+6C can also be used to generate new sounds or in a li&e situation% !owe&er, it must be clear that the main idea is that it beha&es as a compositional en&ironment that offers no&el solutions to e'perienced compositional problems% The en&ironment is used to create networks of musical objects%) musical object in this case is an operational entit that interacts with a sound process% Se&eral objects which are connected together form a network% The network defines their relationship, interactions and the direction of a gi&en composition% B making musical objects communicate within a network, attention is gi&en to the relationship between these objects and the musical processes% This &iew of a working en&ironment is helpful in order to increase possible relations between the &arious elements that form a composition% It also allows for direct control of &arious elements simultaneousl and to concurrentl compose on multiple le&els%

The 5+6C can be understood as a solution to problems concerning interaction and relationships between materials and processes, and their influence on de&elopment and form in music% The main concern is how to define musical processes as operational objects, how these objects can interact in a network of objects and how this can create a fle'ible and adaptable composition en&ironment%

The design considerations behind the en&ironment will be co&ered in the following paragraphs% These are mostl ideas that e'isted before the s stem was de&eloped but it is important to understand some of the moti&ations% The ne't section will e'plain an e'ample scenario when using the 5+6C% This includes e'amples of its interfaces and a possible wa of constructing a piece of music b using the s stem%

)dditional e'amples are included on the companion (?(and outlined in)ppendi' B. Section 4./ will describe the main components of the s stem and how the connect to each other. Implementation issues will also be discussed as well as the s stem architecture. *inall some conclusions and thoughts regarding the e'perience of using the en&ironment will be presented in section 4.4. The sections in this chapter do not depend on each other and can be read in a different order then the one the appear in here.

Composing instead of editing

The 5+6C came about as a possible solution to problems when composing with multi=track se>uencers and time=line en&ironments. The possible wa s of generating or manipulating sounds with the computer toda are endless. The a&ailable methods b which these sounds can be combined and used in a composition does seem more limited. Se>uencers, that are based on a time=line that reads from left to right, are a popular ;and powerful< option to assemble sound materials. The are howe&er &er much based on a model that is deri&ed from editing materials, not composing. Man e'amples ha&e been e'perienced where a se>uencer was used to compose music where the material was la ered, do-ens of tracks filled with small bits of audio, plugins used and all this e'tensi&el automated. 6ne of the problem of these editing en&ironments is that manipulating the massi&e amount of created information is limited. It is also &er hard to abstract ideas directl from that information or for it to adapt to compositional desires. Dhen looking at a se>uencer page filled with data there is no clear option for how to use it with interaction on a higher le&el. *acing a situation where hundreds of sounds are scattered in a se>uencer, all with their edits and automations, there is no eas wa to make e&er thing Ago fasterB or Abecome more randomB. Dhat se>uencers offer is mainl editing and not compositional tools. This inspired the initial idea behind the 5+6C. To create an en&ironment where multiple things could be composed together. The could be happening at the same time or not, but the would all understand a common language of compositional commands that would make interaction effortless and creati&el interesting.

Common communication protocol

) comprehensi&e language was to be implemented as a set of multidimensional parameters for describing beha&ior. These were later labelled A+olaritiesB. The idea was to find a small set of polarities that could encapsulate a broad range of control for &arious sound processes. The should be as few as possible. This is desired in order to simplif possible combinations and compositional ideas reali-ed b using them. The should howe&er not be o&erl limited in use and in the end more polarities got added then initiall was thought to be necessar .)dditionall the should all work on the range from -ero to one and be both *expressive* in the sense that changing their &alues would ha&e a clear effect but also *in range* which means that e'treme &alues would be neither dull nor cause e'treme artifacts such as sonic e'plosions.

Self-containment

)n important feature of the 5+6C objects is that the can e'ist independentl and take care of themsel&es. The should not onl work as elemental units in a comple' framework but also completel on their own. B t ping the name of the object and tell it to initiali-e and pla , it should immediatel generate sound. (efault &alues should be pro&ided for all parameters and the polarities.)ll resource management ;for e'ample locating buffers or output channels< is taken care of b the object itself. If samples are used in some of the sound processes then the 5+6C pro&ides default samples as well. B making them self=contained the can >uickl be put to use as well as possibl being used in other conte'ts than inside the 5+6C.

Real-time control

The polarities, start and stop commands for objects, and higher le&el controls should be easil accessible in real=time. This puts a limitation on the generati&e procedures carried out b the objects since the ha&e to work in real=time. Indeed some of the objects respond better to real=time control then others. It alwa s takes a certain time to percei&e the characteristics of a sound process and if the &alues that are used to generate a particular process are changed within this temporal threshold, then the outcome might be disappointing.

External control

*ollowing the real=time re>uirements, these same controls should be possible to adjust with e'ternal MI (I controllers. This should not be fi'ed but instead implemented with a learning function which assigns a control in learning mode to an incoming MI (I message. B following this learning method, d namic and comple' control settings can be generated, for e'ample mapping one midi controller to se&eral polarities.

Process-based

The sound that an object generates should be Aprocess=basedB in its nature. This means an object can be set to pla for an undefined amount of time. Dhile it is pla ing there should alwa s be an internal acti&it that is changing within the sound. It could &ar how much effect this local beha&ior has, but the goal was to be able to listen each object for some minimum amount of time without it being too constant or boring. This also means that there is actuall nothing that denotes a beginning or an end for a sound process.

Algorithmic assistance

Since the 5+6C is &er much based on a common language across all the en&ironment, algorithmic tools should e'ist for generating &alues for all the polarit and time &alues. These should generate &alues that are editable b the composer using the s stem as opposed to e'ist inside an object or some control structure. *or e'ample start times of multiple objects could be created with &alues obtained from a brownian motion algorithm. These &alues should be generated and assigned to the start times of the objects but as parameters that can be immediatel changed or further manipulated b the user.

Broad palette of sound generating methods

The 5+6C objects are limited b some e'ternal factors such as being process=based and ha&ing to effecti&el implement all of the polarities. 6therwise the 5+6C should function as an e'perimental background for &arious kind of sound generating methods. Indeed what kind of s nthesis or sound manipulation methods adapt well to the 5+6C en&ironment has been of its most important ;and time consuming< aspects.

The basic resources, for sound artists and producers, are now digital. Production tools have for the past decade been moving from hardware to software; this process has recently reached saturation point, such that the computer has completely internalized – virtualized – the studio: the only vestige of hardware is an audio interface, necessary still to convert between data and audible signal. Creative sound culture is restless; casting around for new resources, it appropriates and misappropriates whatever it can.
;Dhitelaw, "##4, p% $<

4.2 Usage Examples

The 5+6C was designed to be used with a minimum o&erhead% Its different elements should be able to stand on their own and initiali-ation routines hidden from the user% The 5+6C can be used in multiple wa s where production phases could occur in different order%

)n e'tremel important point to note, is that when using the 5+6C, it is possible to insert oneself on e&er le&el% This means for e'ample that there is no fi'er order of doing things%)t e&er point objects or collection of objects can be used in an part of the s stem% In the 5+6C, hierarch is widel emplo ed so operations that appl to an object, can also appl to groups of objects% Dith regards to time=scales fle'ibilit is big, objects can be made to create &er short sounds on a micro le&el, or to e'ist as whole sections% This applies also to en&elopes, generati&e methods for polarit &alues, se>uencing objects etc%)n interesting wa of using the 5+6C is e'actl to e'plore this hierarch and fle'ibilit of groupings% To create objects that are interesting combined with certain polarit &alues, group those and appl polarit transformations to the group, insert the group into a combination of groups, which would recei&e et another change in terms of polarit &alues and so on%

The following section will e'plore one possible scenario when using the 5+6C and its &iews% !owe&er, it must be clear that this is just a potential se>uence of e&ents% Dhat is obtained at the end of this e'ample could easil be subject to the same process on a higher le&el% The order of e&ents could be re&ersed or na&igated though in different wa s% This fle'ibilit and approach to grouping and hierarch is crucial to understanding the en&ironment%

The first step is to choose a set of objects to work with% The e'ample here is roughl based on a work in progress currentl named A)D).5B% The piece is, among other ideas, based on e'ploring simultaneousl e'isting objects that ha&e different characteristics% *our groups of objects were created% The ha&e been named A*ragmentedB, A7oisesB, ATe'turesB and A+atternsB% 5ach of this groups contains se&eral objects that ha&e been prepared for the group t pe, which refers roughl to the group name% Dhen preparing the objects, certain decisions ha&e alread been made such as which buffers objects in the fragment group should use, duration &alues for some of the se>uences and s nthesis t pes for some of the noise making ones% *or each group a dedicated editor is created and the four editors launched simultaneousl %

Object Editor
)n object editor holds eight different slots into which objects can be loaded%)n object is selected from a list that is filled with objects to edit or work with when the editor is initiated% *or each of the slots there is

a button for startingLstoping, a button for indicating if the slot object should be included in randomi-ation, a AlearnB button for assigning midi controllers and an additional amplitude setting% Dhen an object is loaded into a slot it can either use the &alues from the current polarit sliders, or o&erwrite them with its pre&iousl assigned settings ;if the are supposed to be edited<% The editor has nine faders corresponding to the 5+6C polarities% If more than one slot is used in the same editor at the same time, all objects will ha&e the same polarit settings% These faders can be controlled manuall with a mouse, with a MI(I controller or b using one of the se&en generati&e functions the editor offers% The generati&e functions work within a range set b the user and assign &alues according to a random distribution% The a&ailable distributions are a linear one, an e'ponential one, a bilinrand ;probabilit is highest around # and decreases linearl towards $ and –$<, a brownian one, a beta distribution, one where &alues tend more towards higher &alues and another one where the tend towards lower ones% Some parameters ha&e been fi'ed for simplicit but it is be ond the scope of the current discussion to e'plain which, or how these different distributions work in detail%

Figure 4, The EPOC object editor

The screenshot abo&e illustrates how the editors look like when being used% !ere, fi&e objects are being pla ed as indicated b the gra buttons labeled I67J% The fader settings ha&e been set with the random distributions% The &iew that holds the A*ragmentedB objects has its faders set according to a brownian distribution% The &iew that holds the ATe'turesB objects with a beta distribution% The &iew that contains the

‘7oises’ with an e'ponential one and the ‘+atterns’ with the distribution that fa&ors higher &alues of the desired range% The &alue span that the distributions use is in all cases from #%#$ to #%33% The te'ture and pattern &iew on the right both ha&e two polarit faders that had not been included when the distributions were applied% These are ‘)mplitude’ and ‘Mocation’ for the te'ture &iew, and ‘*re>uenc ’ and ‘+osition’ for the pattern one% In man cases one tries to e'plore different configurations or snapshots of an object b using the random distributions% 6ften it is not desired to e'plore all the polarities and therefore the option e'ists of e'cluding them%

6nce desired settings ha&e been configured, the code that represents an object state is obtained b pressing ‘+.I7T’% The code is then printed in the SuperCollider post window from where it can be copied and used in other parts of the s stem% This code does not contain the description of the whole object ;which is alread compiled in the language< but onl the object name, polarit settings, duration and an additional, object specific parameters%

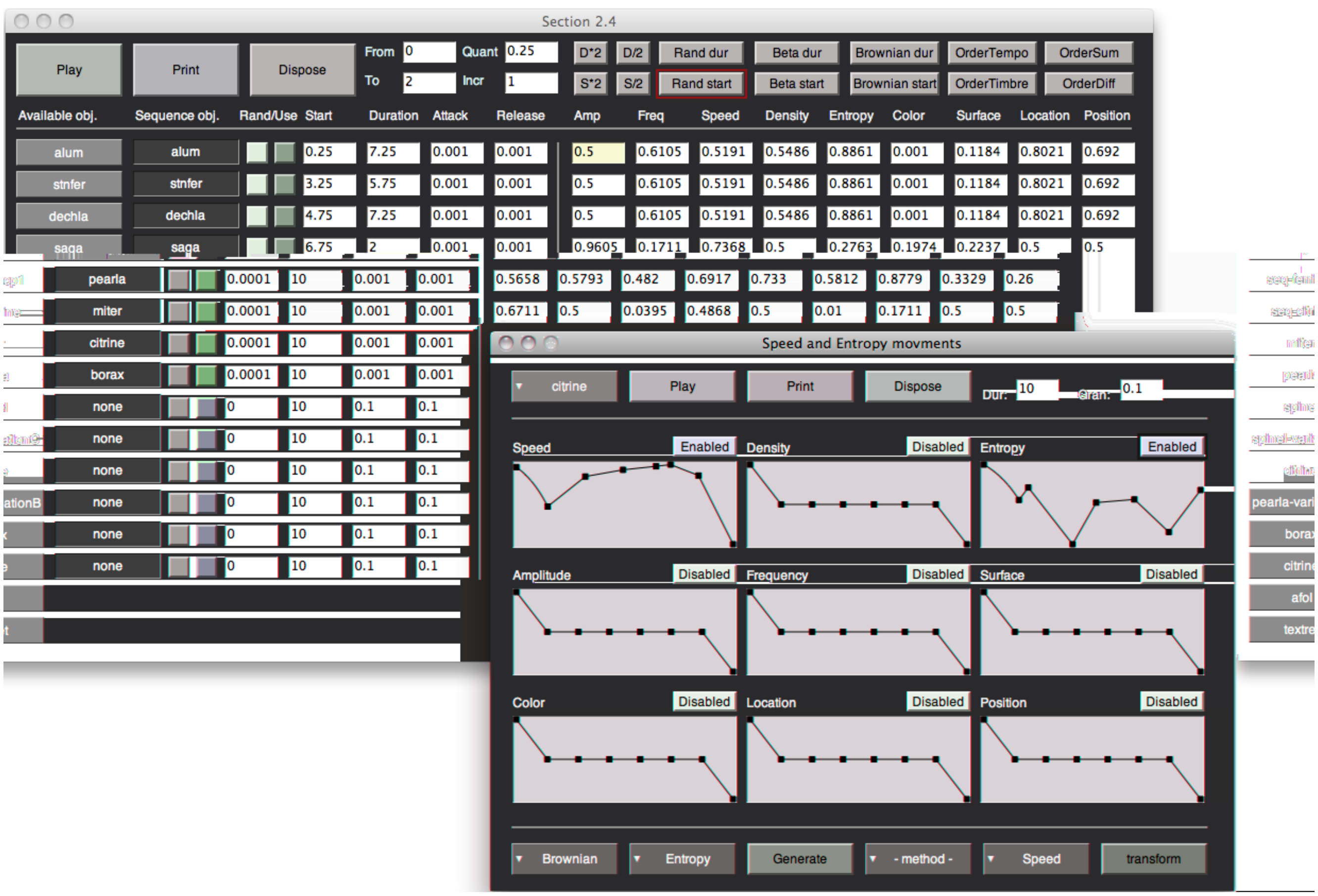

Figure 5, The EPOC Object Sequencer and Envelope view

Object Sequencer and Envelope view

)fter collecting numerous objects from the object editor, the codes can be fed into other &iews for further work% In the screenshot abo&e there are two &iews &isible, the ‘6bject Se>uencer’ and the ‘5n&elope’ &iew% In order to create time=&ar ing trajectories for polarit &alues, the en&elope &iew is used% In the e'ample abo&e, trajectories ha&e been created for the speed and entrop polarities% Those are the onl two ones acti&e as indicated b the A5nabledB button% Both of these trajectories were created b using random distributions that can be accessed at the bottom of the &iew% These correspond roughl to the ones found in the object editor but additionall a ATransformB method e'ists that transforms e'isting en&elopes b either re&ersing the points used for the time or le&el arra s% The duration of all of the en&elopes in the &iew is the same and is set in the upper right corner of the &iew% 7e't to the duration setting is a AGranularit B one which determines the update rate of an en&elope% In certain cases it is not desirable that a polarit is constantl being updated since a change in an object beha&ior connected to that polarit could take a moment to be percei&ed% The update rate is therefore an important parameter to set for an en&elope% *inall the code for the en&elope can be printed for it to be assigned to an object and be used in other parts of the en&ironment%

The object se>uencer is used to create se>uences of object instances in time% 6bjects can be dragged from a prepared list ;&isible on the left side of the &iew< into slots from which the are se>uenced% The number of a&ailable slots is limited onl b the screen space and is set when the &iew is created% In the e'ample abo&e eight objects ha&e been assigned to slots% The first four objects are acti&e ;indicated b the green A8seB button< whereas the lower four are inacti&e% The first four ha&e also been made acti&e for generati&e methods as indicated b the A.andB button% The main parameters for a se>uence are the AStartB and A(urationB times% These can be set b hand ;t ped or dragged< or b the generati&e methods found on the upper right part of the &iew%)ttack and release times for an amplitude and settings for all of the polarities can also be assigned or edited for e&er slot% If a polarit has been assigned to an en&elope, its &alue can not be altered and this is indicated b labeling the number bo' ellow ;shown abo&e in the amplitude bo' of the first slot<%

The a&ailable generati&e methods are random distribution, linear, beta and brownian ones% These methods use the &alues from the number bo'es on their left to set their range, their >uanti-ation and increment of each generated &alue%)ll the generati&e functions work onl for the start and duration times, not for the polarit or attackLrelease settings% The start and duration times can also be doubled or di&ided b two, using the corresponding controls ;(S", (L", SS", SL"<% *inall there are four ordering methods that reorder a se>uence% The a&ailable methods compare objects b summing or subtracting polarit &alues, or according to weighted algorithms that fa&or either the temporal or the timbral polarities of an object% Dhen the objects are reordered their start and duration times remain connected% This allows to keep a composed se>uence while swapping the objects in place based on their different fla&ors%)fter a se>uence has been completed, it can be printed for use in other parts of the en&ironment%

Network Sequencer and Network Editor

)t the top of the hierarch of the &iews, are the A7etwork Se>uencerB and the A7etwork 5ditorB% These work similarl to the object editor and se>uencer, e'cept that the perform operations on object collections called nodes% There, polarit settings are used as offsets to the polarities of all objects in a node% *or e'ample if a node contains two objects one could ha&e its AColorB polarit set to #%" and the second to #%2% Dhen a network se>uencer is created to pla the node, and its color polarit set to #%4, the first object changes his color &alue to #\$ and the second to #\:\ The difference of #\$ is subtracted since that is the distance from #\4 to #\1 ;the middle<\ *or most aspects the network editor works similarl to the network se>uencer but additionall offers the option to o&erride the polarit &alues of a node\ It also offers start and duration offset times\ This means that start and duration times of objects inside a node can either be stretched or compressed b a multiplication factor\ 6bjects can therefore e'tend or shorten their duration as well as making their internal se>uence more dense or sparse\ B using the network editor, pre&iousl composed se>uences can be pla ed and used in an instrument kind of wa , and it is here where the power of the higher le&el control is the most effecti&e\ *or e'ample pla ing se&eral sections simultaneousl while changing their densities can result in rich change of beha&ior when these section contain multiple objects pla ing at the same time\

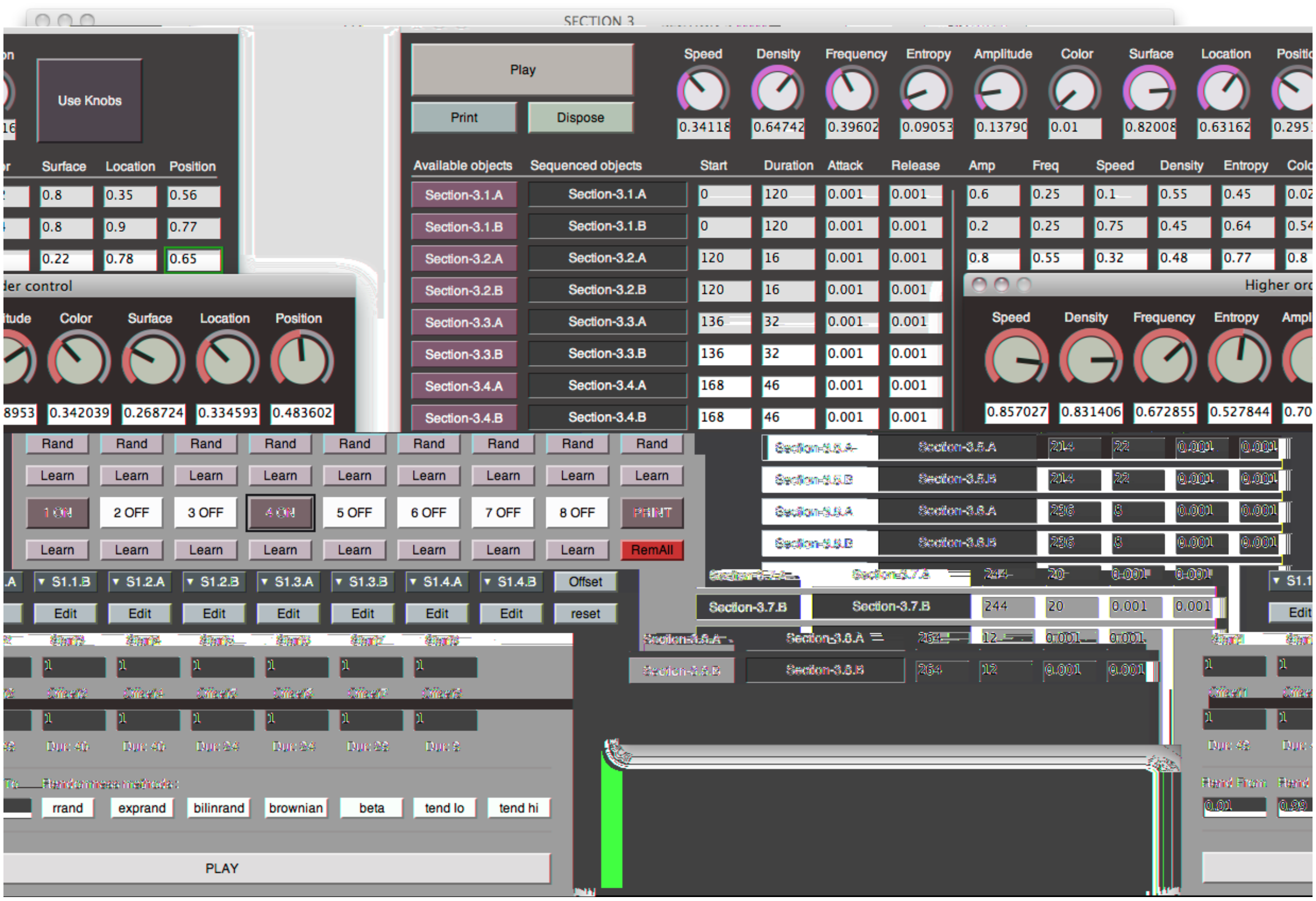

Figure 6, The EPOC Network Sequencer and Network Editor views

Code

The network se>uencer can be used to create complete compositions when choosing the order nodes appear in and creating succession either b making them follow each other linearl or b o&erlapping\ There are howe&er certain limitations such as the number of &isible slots on the screen, trajectories ha&e to be composed before, and the temporal order has to be fi'ed\ Creating networks b writing code directl increases fle'ibilit \ 7odes can contain references to list of other nodes with probabilities of which to pla ne't\ This creates the possibilit of a non=linear unfolding of a piece\ *or e'ample A7ode)B can contain references to 7ode B and 7ode C where the probabilities are high for the former and low for the latter If 7ode B is then pla ed it could contain references to 7ode (but also to 7ode) which could then be pla ed again) nother ad&antage of creating networks directl from code are the &arious e'tensions and transformations that could be done This includes transforming the polarit &alues of a node, sorting objects in a node or using object lists with more elements than the a&ailable screen space of a &iew In practice, parts of a piece can be created b using the &iews but the final result put together b code This is facilitated b the fact that each &iew enables printing of its products So an interesting wa of using the en&ironment is to use e'plore different areas with the editors and then print them to use in code where additional features can be added 5'planations of the SuperCollider en&ironment that the s stem is written in will be co&ered in the ne't section

T)D).5 U V

```
TauburnItems U Mistnew
TindigoItems U Mistnew
Tfla'Items U Mistnew
TcapriItems U Mistnew

TauburnItemsadd;B7etworkItemnew;BGenMitharge, Xdurations, #11, $, #1, ", 4, #1, $ , Xamplitudes, #3, #$, #9, #", #4, $, #$, $ , 0Mit=7oise0,
BControlnew;speed#393$, densit #:: , fre>uenc #$, amplitude#", entrop #33, color#$39$, surface#3923, location#$, position#3933, attack#$,
release:<,
 start$", duration$2<<

TindigoItemsadd;B7etworkItemnew;BGenCitrine, Xsound, 0L8sersLbjarniL(esktopLS7(LawareLse>uencesLasawa&0, 0se>=citrine0,
BControlnew;speed//#9, densit :41$, fre>uenc 449:, amplitude:$//, entrop "1"3, color#1::, surface#394, location/4#3, position$12$,
attack#$, release#$<,
 start"1, duration3<<

Tfla'Itemsadd;B7etworkItemnew;BGenTrona, nil, 0Trona=Te'ture0,
BControlnew;speed$#2/, densit #33, fre>uenc $$#1, amplitude/"#9, entrop #$$:, color:$1, surface#33, location3229, position#$#:,
attack#$, release#$<,
 start$9, duration4<<

TcapriItemsadd;B7etworkItemnew;BGen+earl, Xdurations, #1111, $, #1, ", 4, #1, $ , Xamplitudes, #33333, #$, #9, #", #4, $, #$, $ ,Xfre>uencies,
 "##, 9##, $4##, /4 , 0pearlp0,
BControlnew;speed$"":, densit #"9/, fre>uenc 2142, amplitude#11, entrop $$/", color$, surface$4$1, location:#/9, position99:9,
attack##$, release##$<,
 start9, duration/#,
B7etwork5n&elopenew;5n&new;#3, #9, #/, #3, 3, $#, $#<, #, 0fre>uenc 0<
<<

Tauburn U B7etwork7odenew;"2, TauburnItems, control6ffsetBControlnew;fre>uenc $"1, color#21, speed"1<, 0auburn0<
Tindigo U B7etwork7odenew;"2, TindigoItems, nil, 0indigo0<
Tfla' U B7etwork7odenew;4#, Tfla'Items, control6ffsetBControlnew;amplitude#21, surface#11, location$1<, 0fla'0<
Tcapri U B7etwork7odenew;"4, TcapriItems, nil, 0capri0<

Tauburnne't7odesadd;Tindigo, Tfla', #9, #"<
Tindigone't7odesadd;Tcapri, $#<
Tfla'ne't7odesadd;Tcapri, Tauburn, #2, #/<
Tcaprine't7odesadd;Tindigo, Tauburn, #4, #:<

Tauburnpla
Z
```

Figure 7, Code example of an EPOC network instance

The potential of creative perception is natural. Creativity originates in the depths of the generative order, and the proper role of mental energy is to respond to such perception, and ultimately to bring it to some manifest level of reality.
;Bohm and +eat, "###, p.4$"<

4.3 Implementation and Architecture

The 5+6C is programmed in the SuperCollider en&ironment ;McCartne , "##"<. The 5+6C can be used directl in a SuperCollider document, from within the SuperCollider en&ironment, with MI(I controllers or b using a G8I.)dditionall assigning MI(I controllers is fle'ible and the G8I@s are organi-ed as &iews. These &iews can be created on=the=fl containing different objects or nodes, and the number of concurrent editor instances is unlimited.

SuperCollider is both a programming *language* and a realtime sound s nthesis *server*. The programming language is based on Smalltalk and is used for creating programs that communicate with the s nthesis ser&er in order to make sounds. 8nit Generators ;*UGens*< are used for generating and processing audio signals within the s nthesis ser&er ;+arameter, "#$$< Interconnected 8Gens are packaged into a *SynthDef* which describes which 8Gens are used and how the connect ;Cottle, "#$$< These definition are then used b the s nthesis ser&er to create *synths* based on that recipe. SuperCollider language *objects* bundle together data and methods that act on that data. *Classes* describe attributes and beha&ior that objects ha&e in common ;Fannos, "#$$<. Sound files that are pla ed or transformed are stored in *buffers* that e'ist inside the s nthesis ser&er.)udio channels that SuperCollider s nths use for sending their sound through are called *audio buses.* *inall to implement compositional logic and algorithms, SuperCollider *patterns* are used. +atterns offer higher=le&el representations ;or blueprints< of musical tasks and can be understood as *"abstract representations of sequences independent of any specific performance."* ; , ui&ila, "#$$, p. $93<. +atterns can for e'ample pla notes b using random distributions for pitches or durations. In the following paragraphs specific technical terms will be a&oided as much as possible. Those introduced abo&e will howe&er occur and important to keep in mind when describing the en&ironment.

The 5+6C is implemented as a class framework which means that the all the parts forming the en&ironment can be used within SuperCollider in different conte'ts. It also means that the parts are compiled into the programming language. Dhen compiling the s stem as a set of classes, it becomes part of the SuperCollider language, just as a number or a list. Dhen doing this a choice has been made of what is &ariable and what is not. Gi&en the nature of SuperCollider, its real=time and li&e=coding capacities, it might seem an odd choice to compile e&er thing as classes. This does howe&er isolates s stem code from compositional one and allows for &arious kinds of facilities such as easier testing, initiali-ation, &ersioning, maintenance and man of the ad&antages 66+ offers. *ollowing is an o&er&iew of the main elements that the 5+6C consists of. Their function will be briefl e'plained and important attributes named. ?isual representations of these elements and how the communicate will succeed these descriptions.

Objects

The object is the bridge between compositional ideas and generated sound. It is also where the polarit logic is implemented. There e'ist two kinds of 5+6C objects, generators and se>uencers.) generator is based on directl controlling SuperCollider S nth (efs while a se>uencer uses the pattern framework for generating algorithmic sound processes. These differences are onl technical since patterns work differentl than directl accessing a S nth (ef or a group of S nth (efs. The wa the look to the outside world is the same.) n object is itself responsible for sending S nth (efs to the SuperCollider ser&er when initiali-ing itself. It will start and later update its s nths either directl or b using patterns.) n object owns an instance of a *Control* which is basicall a container for the the polarit controls. It also contains &arious additional attributes that are used for different settings depending on the object such as en&elopes or lists. 6bjects alwa s come tested with default &alues as the are all supposed to function properl without ha&ing to set those. If re>uired howe&er, additional attributes can be set for increased fle'ibilit . The main logic of an object lies in its *update* function. ! ere all &alues for the sound process are calculated according to the polarit states and additional attributes. This is where the algorithm behind each object is implemented and all the mapping is done. The object also has methods for pla back, pla ing for a certain duration, stopping, stopping with amplitude deca and disposing resources.

Sound Processes

The sounds generated b the objects are called *Sound Processes*. This comes from the fact that conditioned b the polarities, the sonic constructs of the 5+6C ha&e become audio processes, categori-ed b beha&ior. Man different implementations e'ist in the en&ironment. 5'amples are pulsar s nthesis, additi&e s nthesis, subtracti&e s nthesis, wa&eset distortions, impulse trains, noise generators, chaos generators and &arious t pes of granular s nthesis and sound transformations.) ppendi' C documents all the s stem modules and a more e'tensi&e list of a&ailable techni>ues can be found there.

Controls

The nine polarities are encapsulated in a structure called *Control*. It holds their gi&en &alues as well as methods for increasing and subtracting current &alues, randomi-ing &alues, multipl ing them b an offset or cop ing &alues from another control. It also takes care of keeping the &alues in range and comparing them b choosing from summing, difference, timbral or temporal orderings. In addition to the nine polarities, a control also contains attack and release settings for the amplitude of objects.

Nodes

To form groups or sections, objects can be grouped together in nodes. 7odes can function in the conte't of a network or on their own. 5ach node contains a collection of *NetworkItems* that are containers for objects but add functionalit for them to work in a network.) 7etworkItem sets the start and duration times for an object in a node. It also has a list of en&elopes that are used for the polarities which &ar in time. The node contains offsets for start time, duration and the polarities. These are used for higher le&el control and are common to all items that belong to a gi&en node.) node also contains a reference list to the possible nodes that will pla after it has finished pla ing its own objects.

Networks

) gi&en totalit of connections between nodes is termed a network. 7etworks are therefore better understood as relationships instead of objects. *or each node in a network there are possibilities of which nodes succeed those pla ing.) node also contains offsets that are important for the understanding of a network. *or e'ample, after completing its pla ing time a node can ha&e the choice of pla ing itself again or a cop of itself &ar ing onl b the offset controls.) melodic phrase for e'ample could choose to pla a &ersion of the same melod where the offset fre>uenc is doubled and densit increased, or where fre>uenc is lower and speed increased. It could of course also pla a different node.

Views

In the 5+6C there are fi&e different graphical interfaces that can be interacted with.)n object editor, an en&elope editor, an object se>uencer, a network editor and a network se>uencer. The object editor is mainl used for assigning or editing polarit &alues for objects. The en&elope editor is for creating time=&ar ing trajectories for the polarities. The object se>uencer is used for creating se>uences of different object instances. *inall the network editor and se>uencer work similarl as the object editor and se>uencer but instead of working with objects, the work with nodes.)s nodes contain groups of objects, the network editor and se>uencer therefore work on a higher le&el structurall .

Composer Objects

The composer objects contain &arious functions that se>uence, transform or &ar objects and polarities. It contains for e'ample a se>uence method that takes objects and patterns as arguments and thus allows using the SuperCollider *Pattern* librar directl with 5+6C objects. There are also methods for making interpolation between objects, tendenc masks for polarit states and &ariation based on polarit relations ;for e'ample when fre>uenc increases for one object it means it decreases for another one<.

Scores

Scores use objects, trajectories ;score mo&ements<, start times and durations to make simple se>uencing. Much of the functionalit that a score offers can also be found in networks or nodes, howe&er the setup is more straightforward so the come in hand for light se>uencing scenarios where the functionalities of networks and nodes is not needed.

Architecture

Two diagrams are displa ed below in order to e'plain &isuall the software architecture of the 5+6C. *igure 9 illustrates how the en&ironment can be seen in terms of nodes, networks and &iews. The network is shown as a container of the relationship between its nodes and appears on top of the hierarch . 7odes also contain objects which contain polarit collections grouped in the AControlB structure. The objects additionall ha&e start and duration times as well as e'tra parameters specific to the object ;for e'ample oscillator t pe or buffer<. *inall , the nodes contain start and duration offsets as well as an offset control for its objects. 6n the right part of the diagram, the &iews are grouped together and their relation to specific 5+6C parts is illustrated. The network se>uencer is used to create network instances and relations, the network editor to edit the higher le&el controls of nodes, the en&elope editor to create trajectories for polarities, the object se>uencer to create temporal successions of objects to be used in nodes and the object editor to create and edit object instances, including their polarit states‰

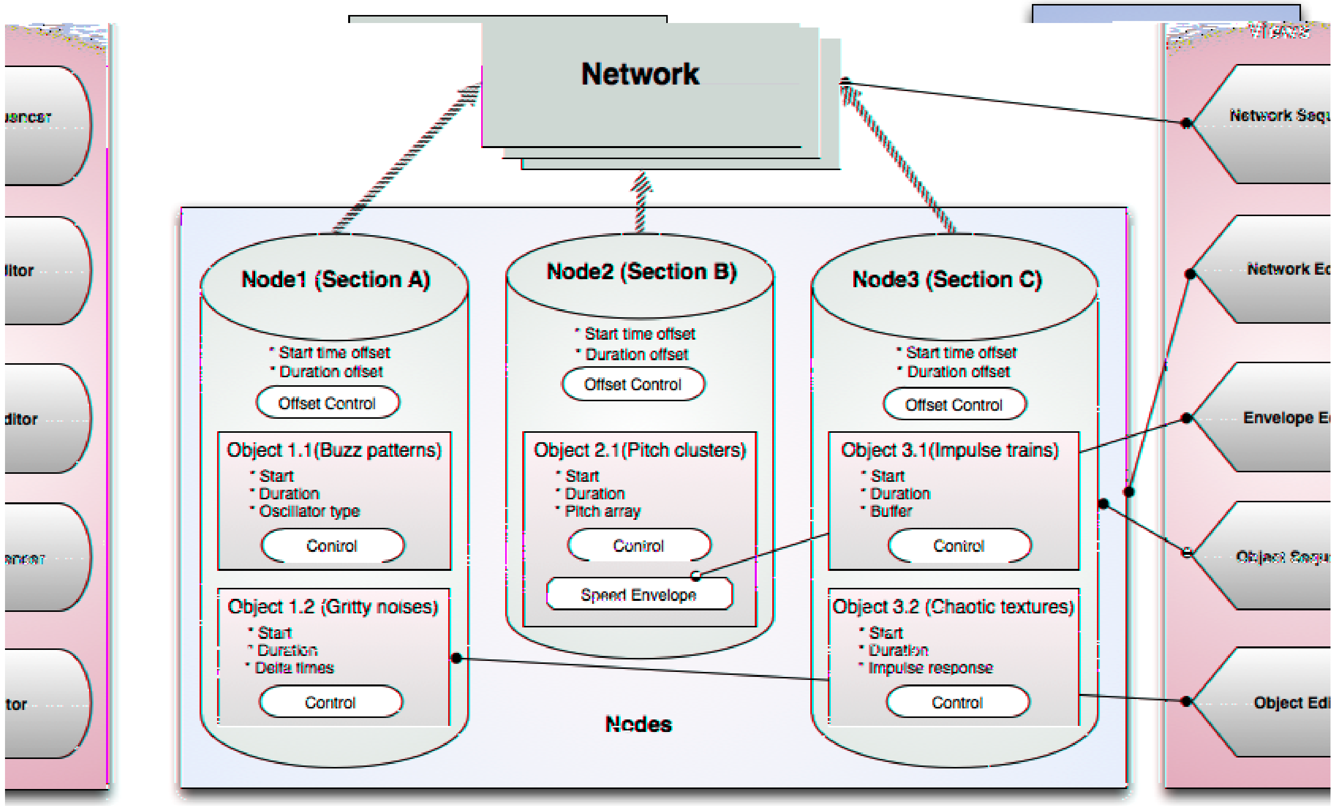

Figure 8, EPOC overview

The second diagram shows the blueprint of how the main 5+6C classes relate as well as their attributes and methods‰ The illustrati&e language used in this diagrams is called 8MM ;unified markup language<‰ Dhat is shown here are abstractions of 6 6+ definitions and relations‰)ctual instances can ha&e different &alues but the purpose of the diagram is to show an o&er&iew of the en&ironments interior design‰ Specific objects are not included ;onl one e'ample instance of a se>uencer and another e'ample instance of a generator<, neither are utilit classes or the G8I &iews‰

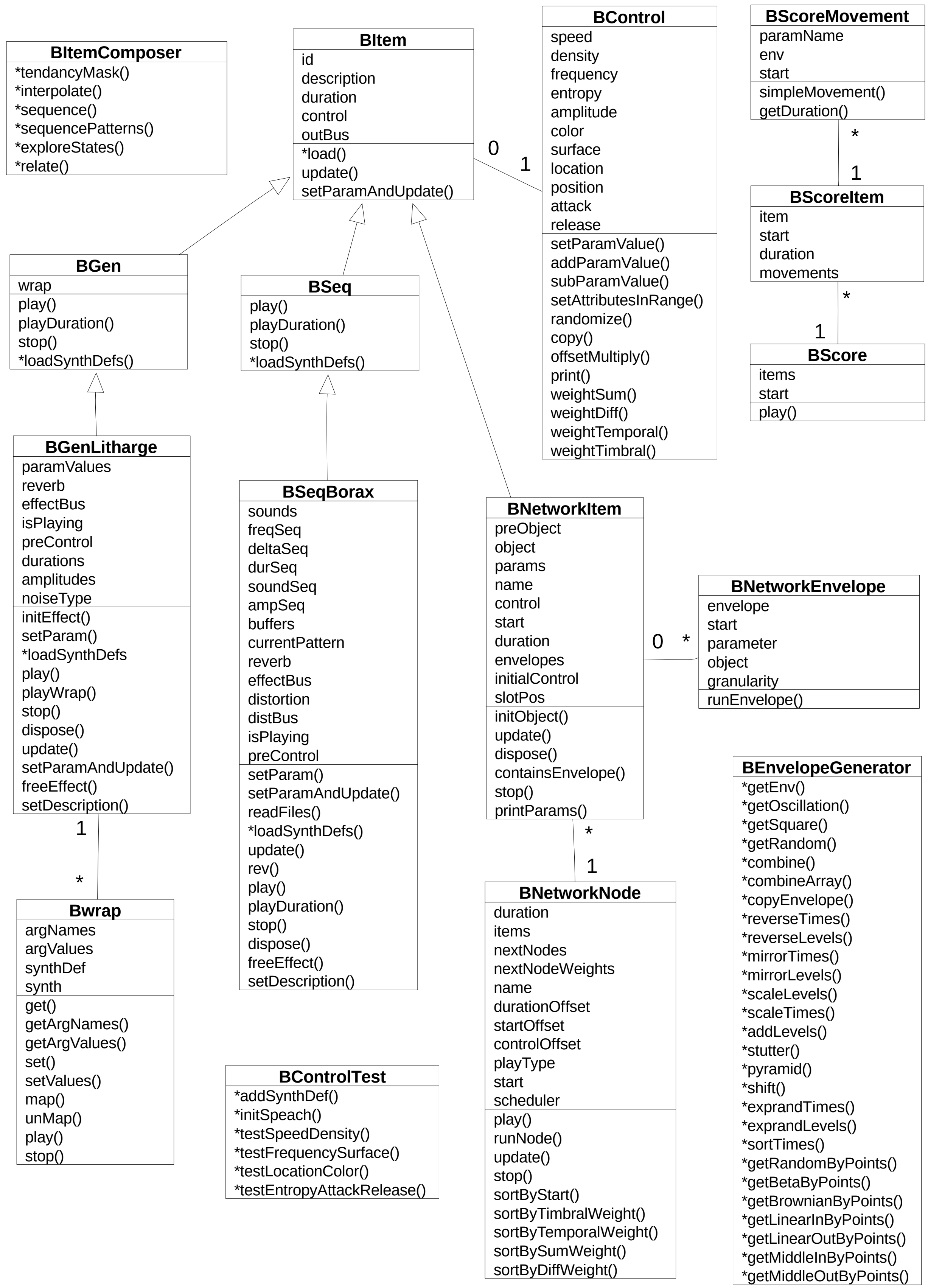

Figure 9, A UML class diagram of the core CCE classes

Ultimately, the limitation with the computer is only the limitation of the imagination itself. Perhaps our imagination is not yet open enough or vast enough to know exactly what to do to exceed our limitations. I think that this is one of the reasons why someone like Xenakis was interested in a program like the Gendyn program; he wanted to be surprised. He wanted to do something in which he had some control over the process, but in which the results would go beyond what he could possibly imagine. The question of how to use one's imagination but not be constrained by its limitations is a central one in regard to the use of the computer in creating music.
;+ape, "##/, p."2<

4.4 Reflections

The 5+6C has until &er recentl been in constant de&elopment and its functionalit been e'panded and impro&ed.)n important idea behind the 5+6C is that it can be used to create entire pieces so that it does not function as just another material generator.)t this point in time, onl one piece has been made completel with the 5+6C but se&eral pieces ha&e been made using the en&ironment on different stages of its de&elopment. It is therefore a >uite difficult task to e&aluate its totalit or make an final conclusions. !owe&er, it is &er clear that the en&ironment has turned out to offer man possibilities that ha&e opened new doors and facilitated no&el solutions. It has also some shortcomings and will for sure continued to be de&eloped further.

The 5+6C has been used in man cases as generating and transforming material for fi'ed media pieces. 6ne of its uni>ue features is the nature of the sounds it generates. The polarities create conditions and limitations under which the sound processes ac>uire certain characteristics which ha&e pro&ed to be surprisingl original. 6ne of the original goals was to implement a broad range of sound generation methods and to tr to find which of those would fit the conte't of composing within the en&ironment. In practice, all the sound processes seem to share some similarities. This is probabl due to the implementation of the polarities. The range of possible sounds is still wide but the beha&ior characteristics and process=based approach is something which links them together. It might sound like a disappointing outcome but on the contrar results in fresh and original sound material that is tightl coupled with the whole concept of the en&ironment.

6ne of the initial goals set for the s stem was that it would embrace relations on &arious le&els. In practice this has turned out to work >uite differentl than e'pected. The automatic relationships, such as network nodes triggering other nodes with weighted randomness or polarit groups with fi'ed relations to other such groups, has not been &er successful so far. These functionalities appear to be &er e'citing and offer man new possibilities but ha&e so far pro&en a bit too ImechanicalJ when put into use. *or e'ample when creating an in&erse relation between fre>uenc of one object to the fre>uenc to another, this relation often becomes to simple and boring.)lso when a node triggers another one which then triggers the first one again, some kind of stiffness or >uanti-ation feeling results. More successful ha&e been the composed relations of different objects in a section defined simpl in terms of different positions within a polarit and higher le&el control of this. B e'ploring the spaces created b the polarities of se&eral objects at the same time, one usuall finds the most interesting relationships. These can then become subjects of compositional attention. Dhen these relationships ha&e been defined the &ariation of them &ia higher le&el

controls has produced &er interesting results. This is one of the great surprises of the s stem and perhaps its most successful aspect so far.

B using abstractions and clearl defined interfaces of its modules, the 5+6C can be used in multiple wa s. This is not something that was an e'plicit goal in itself but has tuned out to be a &er interesting possibilit when using the en&ironment. B using the different &iews, coding directl or b combining the two in some wa , fle'ible configurations can be created and arranged for &arious compositional situations. This does howe&er also ha&e its own problems since each of the different modes has its own functionalities which sometimes could work better when accessible all at once. *or e'ample if there would e'ist onl one G8I that encapsulates the functionalities of all the others some tasks would be easier to complete. This of course remains a possible addition to implement in future &ersions.

The real=time control of the entire s stem is certainl something that has alwa s been of central importance. In the current &ersion this works well and the interaction resulting from this offer man interesting possibilities. The 5+6C can for e'ample be used to create d namic real=time compositions where sections can be pla ed in different order, higher order control applied and object instances pla ed. The 5+6C has howe&er not been designed as an instrument. The objects themsel&es can certainl be used in a pla able, instrument=like conte't but would need more domain specific control modes. This could probabl be achie&ed b using different object groupings and more intelligent control mappings and is certainl something worth to e'periment with in future &ersions.

+erhaps the most important idea of the initial ones, was to be able to use the 5+6C as a compositional tool where one could complete entire pieces. This was understood in the wa of challenging the working mode traditional se>uencers use, where access to detail is rich but abstraction and higher le&el control is poor. In its current state the 5+6C looks &er promising with regards to this. Much of the information that is obtained during the creation of a certain part of a composition can be transformed and used for other parts as well. 6bjects can easil be replaced, their order changed, durations stretched or polarit settings applied to other objects or e&en entire sections.)dditionall , when sections ha&e been created, the wa the appear and b using higher le&el controls, &arious &ersions of a composition can easil be tested. To ha&e achie&ed such a fle'ibilit with regards to d namic compositional configurations is a &er important goal to reach for the 5+6C. This can certainl be e'tended e&en further in future &ersions but for the moment it appears that the proper framework has been founded for this to work in.

5. Musical Issues

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I mentioned the notion of "style" […] i learned from collaboration that this notion can be dangerous when it turns from an ensemble of methods/strategies/procedures to a kind of recipe that one tries to apply every time... i find that one should have a style without trying to create a style... it's important to feel free to follow the materials inner tendencies, it's potential sonic reality, to use not only the methods, etc., that have worked well last time but always try to get a fresh perspective on how a piece may grow to it's final form. you see, my main idea about my music is that it should not be like language, […] it should have it's very own existence, it's very own sonic reality.
;GNnter, $339, p. /<

This chapter will focus on music that has been inspired b man of the concepts co&ered so far. The pieces that will be discussed are part of this research and ha&e hea&il influenced both the ideas discussed in this te't as well as the de&elopment of the 5+6C. The en&ironment was e'tensi&e used to create different parts and materials used in the pieces. ! owe&er, the onl piece that is entirel composed with the 5+6C is the last one co&ered here, *Concomitance*. *or the other pieces, the en&ironment was used as it e'isted during different phases of its de&elopment. Ideas that emerged during the process of composing the pieces strongl influenced the de&elopment of 5+6C which in turn also affected the direction of the pieces. It is not the intention to onl point out some direct links between the music and the en&ironment. The idea is rather to discuss the music as part of an o&erall thought of which the 5+6C is a crucial component.

5.1 Particulars and Intervention

8sing algorithmic tools for music making is an e'cellent path towards new disco&eries. This applies on &arious le&els. *rom combining sections in a piece down to the tiniest detail of generated sound. Through s stematic or stochastic procedures, surprise and no&elt can emerge. This often results in something which would be hard to obtain b intuition. *or an artist using such techni>ues, an area of concern is how to capture and de&elop une'pected elements that appear in the generati&e process. This can be a difficult problem as noted when discussing compositional processes in section ".$. In man cases the onl choice is to either modif the procedure itself or its input or output. Since the output is often that what contains curious >ualities ;forming potential elements to e'plore further< and that generati&e processes contain randomness that is hard to repeat, it is the output from which things are often e'tracted. Henakis was know for editing the results that his stochastic or mathematical procedures ga&e, and to *"apply his own judgment to the results, changing details or reordering events, as he saw fit"* ; ! arle , "##4, p. ":<. The result of this is held b man to be one of Henakis compositional strengths. In some cases, inter&ention b intuition can howe&er be seen as destro ing the pureness of an algorithm. This of course depends highl on conte't and purpose. (e&elopment of material could for e'ample be seen as sculpting it, where the artists task is to create b remo&ing. . ich and interesting sounds can form a starting point from which an artist -ooms in to unco&er interesting details.

Computers are fantastic for implementing both compositional and sound s nthesis algorithms. The are also e'ceptional in bringing to the foreground the infinite small or hidden details of &arious magnitudes. The 5nglish composer !elena Gough describes her microscopic approach with the following words: *"Taking everything possible from the tiniest element, making the smallest things significant… Exploring the qualities of a sound. A process of uncovering, of revealing hidden details and turning perspective on its head"* ;Gough, "##2, p.$<. Inter&entions can also ser&e as mediating between techni>ue and intention. The outcome of a calculated or stochastic process ma be close to what a composer had in mind but perhaps still be missing something.) process can also be imagined as means of getting somewhere, but once there it is perhaps not desirable that traces of the path are left. 5'posing the products of a method instead of the method itself, as stated b the computer musician Cohn Dall, *"when you become aware of technique, the music is failing"* ;Dall, "##9, p. "<.

Angst and Grey Seeds

5'periments in composing with &arious microsound techni>ues resulted in the piece *Angst* that also consists of found sounds. 8sing h drophones to record the central heater of an apartment, a flow of sounds was created to be directed b the slow mo&ements the heater produced when put into motion. The resulting sound material for)ngst is a mi'ture of &er short sounds, granular te'tures and transformations of the low pitched drones produced b the heater. These sounds interact in &arious wa s producing a &er dense and intro&erted world which fluctuates between states of order and disorder. *Angst* has a duration of $":#" min and can be said to roughl e'ist of three sections. 5ach of these is more sparse in terms of intensit compared to its predecessor. The music howe&er &er much beha&es as a stream from which things appear and later disappear into. *Angst* is &er dense in terms of simultaneous sounds but changes are mostl continuous. It is therefore better understood as a unified mass of sounds rather than a sectioned whole. This is also one of the reasons it is discussed here. 6f the pieces co&ered in this chapter, *Angst* probabl least articulates change. 5&er thing in the piece was supposed to flow. The material of the piece is rich and how it is put together is percei&able as being &er detailed. The problem is that the constant flow and o&erlap of elements greatl reduces the impact the piece could ha&e had. *Angst* was not reall a failure, howe&er the wa it finall turned out did not reall highlight its material. This inspired future pieces to focus more on change, less la ering and structures that would emphasi-e material >ualities.

Grey Seeds is a fi'ed media pice made from recordings of broken branches and forest winds. 5+6C objects were used for generating sound se>uences and te'tures based on the recorded material. These were howe&er still in an earl stage and much of the processing is done with &arious other s stems. Initial material obtained from the 5+6C was without general parameters or an e&olution in time. 5ach sound producing entit had its uni>ue interface and the polarities did not et e'ist. Most compositional choices were made after the material had been generated.

The piece is &er gestural in nature and in man cases relies on "call and response" de&elopments. The wa these occur is often in a &er abrasi&e and forceful st le. The piece contains sonorities found in some other pieces such as elastic stretching materials, bouncing resonant grains and dr crackles. !owe&er these ha&e a different fla&or here, probabl due to the fact that most of the material is greatl based on recorded sounds which makes the piece >uite unusual compared to others% *Grey Seeds* can be di&ided into / sections where the first two contain two subsections each% These can be described in the following wa G

01a = (r ness with broken branches and trees% ;#$G#4 min<
01b = Ca&ernous, more resonant spaces% ;#"G#9 min<
02a = Dinds in the wood% ;#$G/9 min<
02b = Storm in a desert% ;#$G/ : min<
03 = The far and the near% ;#4G#$ min<

Grey Seeds is &er much created b editing where micromontage techni>ues are used on the timeline of a se>uencer software% Materials are carefull composed on &er small time=scales and put together in pointillist wa s% This follows from pieces I had pre&iousl composed and the 5+6C objects here function purel as sound generators and not as compositional tools% Man of the processes used generate stochastic patterns made from short sounds of the dr crackles% The piece has man interesting moments but sometimes the relationship between e&ents on a micro=scale and the o&erall form is not &er clear% The first &ersion that was presented lasted $#G"2 min% In its current state, *Grey Seeds* has a duration of #9G#9 min, where section #"a was remo&ed and se&eral passages reduced% In retrospect the final section is the one that remains perhaps the most con&incing% ! ere the music switches between temporall static states% It's deeper, darker and somehow more curious then the rest of the piece% It also feels as if the music has arri&ed at a new point, and one which might be interesting to e ' plore further%

Grey Seeds can be said to ha&e a &er AgranularB surface in terms of sound >ualit and le&el of detail% This is partl due to some granular s nthesis procedures used in the piece, but also of the nature and treatment of the material% The dr sounds of branches breaking and micro=time editing materiali-e strong granular >ualities% I would argue that granularit and detail are closel linked, especiall in the case of short sounds% Dhen describing the music of Henakis, Makis Solomos states that *"we find granularity in a lot of his works, limited to precise sequences: his music has undoubtedly a granular "sensibility""* ;Solomos, forthcoming, p% /<% It is the sensibilit and detail that I find &er inspiring in the &ision of granular sound and man of the 5+6C objects created after *Grey Seeds* contain this element without necessar using the well known algorithms of granular s nthesis%

Aukera

(uring the process of composing, man different choices are usuall made that in the end form a piece of music%) fter completing a piece a composer might reflect on its creation and think which of the choices he took had the most influence on the final outcome% This reflection might also take into consideration the relationships between the choices he took and the possible hierarch the form, where some influence each other directl and others do not% In man cases an initial idea or concept can ha&e a &er strong impression on the final outcome for a piece of music% In other cases ideas formed during the process take o&er%

> *When the artist works, he may think that he is composing with sensibility because he is attracted by some ideas or by*

some other things. That might be the starting point sometimes, but in the course of the work, the things start "living" and he's fighting with these things all the time, changing them and being changed by them, so the starting point of his feelings becomes very remote. What remains finally can be expressed in a much more abstract way because it's the result of this thought. ;Henakis, $321, p%3$<

The initial idea behind m piece *Aukera* was to create a compositional framework where the piece would remain open for substantial changes until the &er end% To be able to let the final decisions be the most important ones% This re>uired a reflection of choices made earlier in the process% Could the appl in other conte'tsE Could the order the are taken in be altered to drasticall affect a pieceE Could the choices e&en be considered as compositional materialE These relationships of choices inspired the creation of *Aukera* where the aim was to keep track of e&er step of the process in order to enable backtracking for all actions taken%) hierarch of e&ents was created that could be changed at e&er moment so the piece would remain completel d namic and open until it was recorded% The aim was to put focus on the formal choices and how those choices could be manipulated and composed with%

Aukera initiall consisted of $9 short passages% These were combined in different wa s forming "" sections or states% It was here that the concept of higher=order parameter control was de&eloped% 5ach section was filled with &arious configurations of 5+6C objects, with both static and time=&ar ing parameters%)ll objects in a section had relationships with section &ariables% These includes selected polarities ;speed, densit , fre>uenc and amplitude< as well as duration and object offset% Sound files used for some of the object buffers and durations were also stored as global &ariables common to all sections% This could easil be changed when interacting with the sections% *or e'ample four different sets of sound files were created where sounds had corresponding similarities, but also differences and one could >uickl shift between% 8sing these d namics ga&e much space for interesting combinations, e'perimentations and creati&it % !ow the piece was finall structured came about after e'perimenting with some sections and hea&il bending them with the higher le&el controls% It was still just a potential path, in the end onl eight sections are used in the piece% These were recorded and finall the material was reduced e&en further to e'plore what remained important and what was essential for this piece composed around its own creation%

Aukera has eight sections that last for ##G1", #$G":, ##G/", #$G"", ##G4", #$G/:, #"G"# and #$G#" each% Total duration is #3G1" min% The material of the piece consists mostl of sustained, e&ol&ing masses combined with intricate patterns of noises, impulses and high fre>uenc sine wa&es% Se&eral t pe of transitions e'ist between sections% In three cases sharp cuts occur from one state to the ne't% !ere, change is felt but the difference of material is not &er pronounced% It is rather like the feeling of switching &iewpoints, looking at the same elements from different angles% The first half of the piece contains two transitions of gradual shifting of elements% This part of the piece can itself be described as graduall streaming totalit % 6ne transition is of dissipati&e nature, gi&ing the feeling of possible energ loss% *inall there are two transitions where space occurs between each, total silence is ne&er reached but where new states appear as o&erlapping tails of pre&ious ones%

Both *Grey Seeds* and *Aukera* focused on bringing forth outstanding >ualities of their material and interacting with the generati&e algorithms of 5+6C% These inter&entions are in the end what perhaps defines those pieces% The tension between algorithmic beha&ior, compositional choices and detailed editing is also &er much what process=based compositional thought brings forward%

Although the recipe or instruction set for process production is, or in a certain sense may be, timeless, the process itself must nevertheless be temporal. This means that processes can be said to exist only through their concrete historical manifestations. For processes, to be is to be exemplified […] this means that the process must exist in time (with its full realization unfolding "in the course of time," so to speak). As long as it is not concretely realized, we have only a possible and not an actual process.
;.escher, "###, p% "1<

5.2 Attention and Predictability

)s discussed in section "%1, time can be understood as being a propert of change% B appl ing ideas proposed b Barbour and !ameroff, the uni&erse can be thought of as being static%)ccording to their theories, the world onl consists of a great number of states, Aconfigurations B or Anows B% B na&igating through these states, time emerges as an illusion of how change is percei&ed in the matter that the are made of% Time is therefore onl anal -ed through change where the notion of its continuous flow is the product of our perception% Taking this point of &iew, music can be said to be that which makes time audible%

+erhaps also an illusion, music clearl offers interesting perspecti&e for comprehending change% The sonic perception of time can possibl pro&ide useful information regarding its structure% B anal -ing time through change, the relationship between what is actuall changing becomes important% Taking this further, time could also be seen as being a collection of relations between changing materials%)s discussed in section "%4, time is not something independent from e&ents or itself a process% Time can be understood as being a form of relationship between e&ents where *"the apprehension of difference, far from separating discrete events, requires that we bring events together into a relation, otherwise we could not be aware of difference"* ;!ast , $39:, p% :#<% Instead of focusing onl on time as a set of relationships, time will be discussed in terms of change and relations of and inside materials% Time therefore e'ists as an abstraction of change% This abstraction is manifested through the relationships of discrete e&ents and materials concerned with those e&ents% These abstractions and relationships can be understood in no&el wa s through musical composition and acoustic e'perience%

Signac

In m composition *Signac*, musical states e'ist as Asnapshots B between which the piece slowl na&igates% The piece has a duration of #3G49 min and can be di&ided into two main parts% The first one lasts :G$# min and the second /G"9 min% Both contain different states of &arious durations% The first section has 2 states that last for ##G/:, ##G$", ##G49, ##G1", #"G$", #"G## and #$G1" min each% The second section contains three states of #$G"#, ##G4# and #$G"1 min each% Man of the sound processes used in the piece originate from work initiall done for *Angst*. The two pieces ha&e somehow similar sonorities as the progress, while still remaining structurall &er different%

Signac starts with an e'plosi&e, low=pitched and resonant percussi&e sound% The resonance tail is >uickl spectrall fro-en and transformed into a subtle background te'ture% This leads to streams of microscopic sound processes that graduall appear. These relate b different means without pro&iding much feeling of directionalit . The percussi&e sound returns three times and in each case announces a new state. +rocess=based clusters of &er short sounds also continue to appear in different configurations as well as softer and more clearl pitched te'tures. These streams interact in &arious wa s and finall take o&er and become the main occupation of the music. 6ccasionall , remains of the initial percussion come forth, here in a shape more close to drones or background surfaces, changing at a &er slow pace. The tempo of the piece becomes increasingl slower as the it unfolds where noticeable changes are manifested mostl b arri&als of new states, which in the end are also ambiguous. States o&erlap and melt together until the piece finall drifts awa .

Signac is different from man of m other pieces in terms of how slowl it appears to de&elop. Much of the material is rich, the sound processes contain interesting internal patterning but their connection to the o&erall mo&ement of the piece is not alwa s &er ob&ious. Some appearing states contain interesting sonic spaces but somehow the piece becomes o&erl IambientJ and predictable. 6ne possible reason is that much of the strong energ the percussi&e beginning announces is ne&er again obtained once the piece starts to flow.)nother factor might be that on a surface le&el, the material seems similar between states and &ariation is not &er clearl pronounced. The third important factor is that the duration of states seems to be alike throughout. This might be due to the fact that as the piece progresses, states become longer in duration and somehow when changes occur the seem e'pected. This results in a lack of tension that could also be attributed to the fact that towards the end, these snapshot are o&erlapping and blending much more.

Composed in $3::, *Telemusik* b ,arlhein- Stockhausen consists of /" sections ;or moments< that each last between $/ and $44 seconds. 5ach new section is introduced b the sound of a Capanese ceremonial drum where I*each initiating drum or gong stroke signals the passage of time, and a change to a new procedure of intermodulation, or style of resonance"* ;Maconie, "##1, p. "::<.)lthough sharing almost no common attributes with *Signac*, the wa in which percussi&e sounds start a new section does seem structurall somehow related to its beginning. This initiall led to the idea that the tension loss of *Signac* might be due to the fact that the initial percussion sound is less important as the piece de&elops.)fter being introduced to *Telemusik*, attempts were made to keep the percussion sound of *Signac* for each new state introduced, in hope of increasing integrit and focus. This did howe&er not work &er well, and was far from being the problem. Speaking of moments Stockhausen states that: *"Every present moment counts, as well as no moment at all; a given moment is not merely regarded as the consequence of the previous one and the prelude to the coming one, but as something individual, independent, and centered in itself"* ;Stockhausen as cited in ,ramer, $399, p. "#$<. *Signac* was not composed in moment form. Certain aspects of moment form are actuall far from the ideas that inspired the piece. *or e'ample, that order of moments does not matter or that e&er moment should be able to purel stand on its own could not be applied to *Signac*. It was, howe&er, composed as a piece that e'plores different states and that the order the appear in should not appear linear or causal. !ow this was done could perhaps ha&e been more articulated.

) state ;or moment< could be seen a relationship between material and duration. It takes a moment for a musical process to manifest itself as such% It is thus &er important that its duration fits the o&erall scheme of a composition% The e'perienced duration has probabl something do to with what kind of material occupies that duration and how it relates to materials of other states%

Portholes

Connection or continuit in a musical conte't can be thought of being highl related to predictabilit % The predicti&e relations of present and future can be understood as being an essential feature of causalit ; ! ast , $39:<% The task of not loosing a listeners attention while still producing unpredictable and e'citing music remains hard to accomplish% Through its own s nta', a piece of music can also create e'pectations towards which attention is directed% In man cases music is not percei&ed linearl , for e'ample when we *"hear a later event clarifying an earlier one and an earlier event implying a later one"* ; , ramer, $399, p% $:9<% ! ow these connections come about is howe&er not alwa s e&ident%) possible starting point is to relate e&ents through the similarities or differences of the material the consist of% B mentall comparing these e&ents the can possibl shed light on each other, where no&el relations emerge which are not necessar in a linear Abefore=afterB relationship%) reoccurring theme in this te't is how to find wa s to create music that challenges linearit and introduces its own internal relationships% Causalit ;discussed in section "%4< or direction towards a goal should be challenged and effort be put into how pieces can bring forward their own special logic and modes of communication%

In a documentar directed b Michel *ollin, the ! ungarian composer G Qrg Migeti discusses an inspiration for his piece *Requiem* ;$3:/[:1<% Migeti describes a situation where one opens a window to disco&er on the other side a music of an eternal duration% It is possible to arri&e at, and listen from the window, but the music on the other side has alread be sounding fore&er, and will continue to do so e&en after the window is shut% The piece *Portholes* is partl inspired b Migeti@s &ision, as well as b ! enri BergsonBs description of the temporal flu' being a succession of states% ! ere, Bergson describes a situation where each state announces the ne't and is contained in the pre&ious, where in realit no state begins or ends, as the all e'tend into each other ;Bergson, "#$"<% ! ow one could think of music as e'isting outside windows from which one could ha&e a peak through, and the wa arri&al, collision or fusion of numerous states occurs, is what inspired the creation of *Portholes*%

Portholes has a duration of #9G1/ min and can roughl be di&ided into si' sections% It consists of two &er different material t pes% Short but highl articulated impulse or noise structures, and dense spectral clusters of different sine wa&es% In fact, the piece was made b combining two other pieces, where each one occupies three sections in *Portholes*% These occur one after the other, starting with rapid impulse se>uences that get interrupted b a dense cluster, that in turn is sharpl cut to impulses again and so on% ! ere, a window can be imagined where the granular acti&ities remain within dr spaces and the clusters outside, co&ering a more spacious en&ironment% Compared to *Signac,* the pace of *Portholes* is faster and the materials are gi&en more breathing space% The big difference between the two material t pes, and how these occur in time, makes the piece much less predictable then *Signac*% The sense that a shift between the two will occur is alwa s in the air and this keeps a tension throughout the piece% The duration of the more fragmented states is #G1, ##G1: and ##G/9 min% The duration of the continuous ones is #$G11, #$G"$ and #"G/3 min%

This corresponds roughl to the ratios of $, /L4, $L" in the first case and /L4, $L" and $ in the latter.)dditionall the sections of the clusters ha&e almost the double duration compared to the impulse states. These proportions were not decided beforehand so it came as >uite a surprise to disco&er them.

) possible conclusion is that the duration of a state should be in a close relationship to the material of that state and that for an con&incing o&erall form, clearl defined ratios of duration work better then more comple' ones. The focus=shifting method of *Portholes* is howe&er probabl used to its fullest in the piece. It is hard to image that it could continue for a longer amount of time b the same logic without loosing tension. Dhat *Portholes* shows though is that contrast in terms of material and ratios of duration can be an important factor to keep in mind and this re>uires further e'ploration.

The main thing is: how to change. This is a matter of music, of knowledge, of the universe. Everywhere you feel the changes. The plants are changing, maybe not so fast as the human mind. They're changing slowly, as the particles do. Probably these particles are changing in the universe on a much larger scale of time. We know at least through astrophysics today that some of them are really mid-life, like the heavy ones. They did not exist at the beginning, and the lighter ones did not exist at the very beginning. So if even the matter itself is changing, everything is changing.
;Henakis, $39:, p% /<

5.3 Changes and Conditions

6ne of the main characteristics of the sound produced b the 5+6C is that it is process=based% Sound processes should be able to continue to pla fore&er% There is nothing that indicates how a sound process should start or stop% 5&er high=le&el change is e'ternall imposed, either &ia the polarities or b starting or stopping a process% The wa change occurs for these processes is therefore one of the main decisions that ha&e to be made when using the en&ironment% In some sense this also applies to the process of composing ;discussed in section "%$<%

The compositional process is often related to change% Gi&ing form to no&el structures, finding new wa s of putting things together or a&oiding fi'ed order of actions while alwa s embracing &ariance% Time has also been pre&iousl defined as being something that can be abstracted from change% +erhaps this might sound as if temporal issues are ignored, but the idea is rather to put focus on change itself as a fundamental compositional issue% In music there often e'ists an unceasing &ariation of sound in terms of how it is percei&ed% 5&en &er static situations create perceptual illusions of change or de&elopment, producing prolonged and continuous transitions% Chopping things into discrete element, as is for e'ample done in this te't, is like taking snapshots of the temporal flu'% To be able to produce sonic flow, a composer has to find wa s of de&eloping his materials, which perhaps remains the main problemK how to change%

Folded and Pedicel

M composition *Folded* was created especiall to e'plore different and discrete polarit states% The piece consists of eight sections, each consisting of two simultaneous la ers% In all of the states uni>ue combinations of polarit &alues are e'plored% These combinations are di&ided between two different material t pes, se>uences and te'tures% This differentiation reflects a general separation that e'isted at the time of treating se>uences and te'tures separatel in the 5+6C% The idea behind *Folded* was to use static &alues of parameters to determine how the material is generated and processed for each section of the piece% In the compositional process, the aim was to generate the se>uences and te'tures with the 5+6C, but also using &arious other s stems% The piece was to ser&e as a field of e'perimentation for different techni>ues, to gather knowledge useful for future polarit implementations in the 5+6C% 5&olution in time of each parameter was not important, polarit states sta the same during a whole section%

6f the nine a&ailable polarities, si' of them are e'plored in *Folded.* The order in which a polarit highlight occurs was concei&ed through a &er simple permutation of elements% The se>uences e'plore the polarities of densit , speed and entrop % The te'tures na&igate through spaces created b combinations of surface, fre>uenc and color% The wa these permutations occur is shown in the table below%

NR	TEXTURES	SEQUENCES	DUR
1	high=fre>uenc , low=surface, low=color	low=densit , low=speed, low=entrop	#$G#4
2	high=fre>uenc , low=surface, high=color	low=densit , low=speed, high=entrop	##G49
3	high=fre>uenc , high=surface, low=color	low=densit , high=speed, low=entrop	##G49
4	high=fre>uenc , high=surface, high=color	low=densit , high=speed, high=entrop	#$G#4
5	low=fre>uenc , low=surface, low=color	high=densit , low=speed, low=entrop	#$G/:
6	low=fre>uenc , low=surface, high=color	high=densit , low=speed, high=entrop	#$G#4
7	low=fre>uenc , high=surface, low=color	high=densit , high=speed, low=entrop	#$G"#
8	low=fre>uenc , high=surface, high=color	high=densit , high=speed, high=entrop	#"G$"
			09:56

Folded remains in the end interesting mostl for the part that focuses on the se>uences% +erhaps a more original &ersion of the piece could ha&e been made without the te'tures% The separation of polarit permutations between the material groups also results in a clear di&ision between the two material t pes% The piece would surel ha&e benefitted from doing this in a different wa , where differences and similarities would be more clearl articulated% , eeping polarit &alues constant throughout a section also restricts &ariation of the material and when a permutation occurs, the energ of a pre&ious state often dissipates without being full taken ad&antage of in succeeding sections% *inall the length of sections is &er similar and despite e'tending as the piece progresses, changes do not ha&e the impact the should%

Pedicel is a four channel fi'ed media piece and was composed b using some of the material generated for *olded%)lmost all of the te'tures were discarded and the idea was to focus mainl on the se>uences in a different conte't% 7ew material was also added, low pitched percussi&e sounds and sustained, ringing chords which occup the higher registers% +edicel consists of nine sections that last for #$G##, ##G49, ##G/", ##G$:, ##G1", ##G"9, #$G#4, ##G49 and #/G44 min each% The total duration of the piece is #3G$" min% *Pedicel* appears to e'tend and impro&e *Folded* in man wa s% The low=pitched percussion points add richness in how se>uences are articulated and de&eloped% 7o drones or low pitched te'tures occur, which gi&es the piece a much more d namic feeling% The chords add &ariet and further transformation and reconfigurations of the se>uences gi&e the piece a somehow chaotic feel at times% *Pedicel* also marks the end of an area where the focus was on di&iding materials into either rapid, articulated se>uences of short sounds or more directionless and constant te'tures% *Pedicel* pro&ed that &ariation with regards to this resulted in more interesting results which has been an important point since. *inall the duration of sections is a little bit more &aried and how succession occurs is less predictable.

+erception research suggests that memor continues to process pre&iousl presented information e&en while new information is being absorbed ;(owling, Tillman and) ers, "##$<.) listener's e'perience of a piece can be in a constant flu'. The wa this functions is of course dependent on the e'perienced music. If howe&er the aim is to e'plore this possibilit , conditions for &arious internal relationships of the music should be set. !ow meaning is constructed from these different relationships is probabl &er personal but creating &arious possibilities for those to emerge is an interesting compositional task. 6ne possible a'is is b formall e'ploring proportions. These also seem to be an important bridge between measured and percei&ed time, or as suggested b ,ramer:

> *The perceived proportional relationships between section lengths tend to accord with the ratios of objectively measured durations. While our actual estimate in seconds of a passage's length may not be accurate, our understanding of the ratios between section lengths should agree with the actual measured proportions.* ;,ramer, $399, p. 14<.

In the process of e'periencing music constant comparisons are constructed between registered e&ents. Cudgments are made in terms of similarit and difference, but also of proportions and rate of acti&it . 6ne of the problems of *Folded* was that the proportions between section lengths was similar.)nother factor was that the acti&it rate was not &er &aried throughout the piece. 5ach section e'plored a certain polarit configuration. In order to na&igate the space created b different combinations, the music was constantl occupied with e'ploring the polarit states. This resulted in similar acti&it rate throughout the piece. If for e'ample a section would ha&e lower acti&it rate, then the configuration would be less anal -ed and thus &iolating the initial idea of gi&ing e>ual importance to all combinations. The problem with ha&ing a similar acti&it rate is that it tends to narrow the range of the music. Things changing at the same speed can result in the conclusion that things are not changing at all. The feeling of mo&ement and de&elopment is probabl acti&ated b higher order changes in acti&it instead of local ones.

L´imaginaire du parleur

Composed together with Marie Guillera , *L´imaginaire du parleur* is an eight channel fi'ed=media piece for &oice and electronics. The piece was partl inspired b .oland Barthes's grain of the &oice as appears in his essa OMe grain de la &oi'J. !ere the grain of the &oice is that what is lost in transcription, an e'terior bod that when transcribed does not match a personalit ;Barthes, $322<. *L´imaginaire* was an all=inclusi&e collaboration effort, in the end neither of us was totall sure who e'actl had done what. This is one of the great strengths of the piece. !a&ing created music together for some time, *L´imaginaire* was the second piece we composed that was totall fi'ed. The pre&ious one, named *Duality,* was completed some months before and there we had more distinct roles. In *L´imaginaire du parleur* this is completel re&ersed and an important aspect of making the collaboration successful. The wa the &oice and electronics interact is constantl changing and until now, the piece keeps surprising me where unusual and interesting >ualities continue to emerge.

L´imaginaire was reali-ed at the G.M studios in .adio *rance where we had access to separates studios, both e>uipped with eight speakers% This allowed us to compose the spatial aspects of the piece right from the beginning% The working method consisted of creating different sections where we both used &ocal sounds as well as electronic ones% De worked separatel , each one in a different studio% De then proceeded b e'changing each others work% I would recei&e sections from Marie which I would then start working on and she would recei&e sections from me and do the same% This process was repeated until we together decided that a section was completed% This e'change of material is what I belie&e is the ke factor of the somehow uni>ue sonorities of *L´imaginaire*. The process of interaction through switching blurs the egos but brings forth the collaboration% Mistening to it within a proper eight channel configuration gi&es the impression of an e'tensi&e amount of sound sources, where man seem to be in comple', but shifting relations%) part from some of the &ocal sounds, it feels as if origin of the sounds is unknown, lost somewhere in this process of e'change%

The piece consists of eight sections ha&ing a duration of #$G#", ##G$1, ##G4", #$G4", #$G$9, #/G#3, #$G$2 and #"G1" min each% The durations were not decided before but came about as the result of how we agreed when a section was completed% In the end the sections appear according to emphasis, starting b the most articulated and ending at the least articulated%) part from some editing of details and minor adjustments, the piece was not much touched after the sections had been ordered% The final duration is $"G/1 min%

L´imaginaire was interesting in terms of being able to work with rich and interesting &ocal material and to compose from scratch in eight channels% Most important was howe&er the collaboration with Marie, the communication through e'changing materials, and how the piece generated itself through this collaborati&e effort%

Real potentialities relative to all standpoints are coordinated as diverse determinations of one extensive continuum. This extensive continuum is one relational complex in which all potential objectifications find their niche. It underlies the whole world, past, present and future. […] An extensive continuum is a complex of entities united by the various allied relationships of whole to part, and of overlapping so as to possess common parts, and of contact, and of other relationships derived from these primary relationships.
;Dhitehead, "#$#, Chapter ", para% $2<

5.4 Potential or Actual Occasions

6ne of the interesting aspects of *L'imaginaire du parleur* is how sections got ju'taposed after the had been completed% The piece ne&er e'isted as a whole until we had completed all the sections and chosen a method of combining them% The choice of going from the most to the least in terms of articulation was actuall the first idea that was tried% It seemed successful% The form is created from within the sections, shaped b its materials% Dhen thinking about other wa s of na&igating between the sections, it is hard to imagine a more interesting path compared to the chosen one% This could, howe&er, simpl be due to the fact that this choice created the piece as a whole% Dithout it something else would perhaps ha&e emerged% Dhat then is it that gi&es a piece its identit E !ow is the relationship between sections organi-ed and how much does the actual order of e&ents matterE

)n important >uestion when composing is to reflect on how we listen, remember and percei&e music% Composition itself can be understood as a manifestation of how one listens% ?iewing pieces of music as collections of states, e'perienced categories coming from possible e&ents, can be seen as proposing a different strateg of engagement with the music% Some music takes a se>uential form in memor while other pieces seem to be more fragmented% Situations e'ist where sections are not remembered e'actl in the order the were percei&ed% Succession, linear and nonlinear principles and how these are created or broken, is an important factor to think about% Dhat aspects define a state and contribute to its identit E !ow does the order states appear in affect their formati&e weightE Can states be la ered and still remain distinctE Is it possible to create a situation for listeners to construct their personal links between states based on how the e'perience the musicE Galia !anoch=.oe has made an interesting comparison between e'periencing architecture and music when discussing musical space and architectural time%

> *An observer of an architectural construction chooses a ,"path" with which he goes about the space. This path is built of the sequence of his movements and creates a linear process, a succession of events. Each event is relative to the preceding one (moving from a closed to an open space, from light into the dark etc.), and affects future responses and choices. The observer of a building weaves his path by combining choice with restrictions. He may choose to stop, walk faster or slower, look around, reverse his position in space, but his freedom is confined to certain obstacles on his way, corridors, staircases and points of view that affect his perception.*
> ;!anoch=.oe, "##/, p% $43<

The choices this obser&er makes are perhaps more difficult to make in music presented as a linear succession% !owe&er, through attention a listener does contribute to what affects his perception and how relationships are formed% Conte't and personal e'perience are of course &er important% The significance that different musical states e&oke is therefore difficult to anal -e%) composer might take into account elements such as state duration, acti&it rate, rate of change, intensit , surprise, difference or similarit to other states% This list could of course include man other items% The intention here is not to co&er all such possibilities% This te't and the music that accompanies it should rather raise >uestions concerning which factors are part of a possible compositional space, and which potential relationships e'ist between these factors%

Concomitance

Change can be anal -ed into &arious concepts from which the piece *Concomitance* e'plores a &er basic one% In the spectrum of processes it consists of, successi&e shades are e'amined where the focus passes from one shade to another% The piece consists of "$ different sections composed without reflecting on the final order the appear in% These are organi-ed in three groupsG *pointillist*, *uncertain* and *spectral*% The pointillist group contains sections using mostl short sounds that often occur in rh thmic se>uences and high articulation% The uncertain states fa&ored sections of ruptures and discontinuities% *inall , the spectral group consisted of clearl pitched and noisier passages% These states appear in the order as mentioned here, first a succession of eight states from the pointillist group occur% This is followed b four instances of uncertaint states, which in turn lead to the eight sections of the spectral group% *inall , a last section concludes the piece which could also be seen as forming the fourth group, *residues*.

Concomitance was composed entirel with the 5+6C% 6ne of the goals was to e'plore the process=based >ualities of its sonorities% The sections in the piece consist of alternating objects where polarit &alues remain constant in almost e&er case% 5ach object e'poses a &ariet of >ualities where the aim is to concentrate on the internal beha&ior of its sound processes% These occasions appear in ju'taposed configurations whose edges are sharpl defined as the flow b %

The method of creating the material was to use the 5+6C object editor to take BsnapshotsB of different object states% B using random distributions, the potential space within selected objects was e'plored% 6nce a plausible configuration was found, an object state was stored as an object snapshot% B uniting &arious instances of these snapshots, states were composed that in the end form the piece% The snapshots of object &alues and how the appear in the states was originall supposed to function as a framework for reali-ing the piece% 6bject configuration are not related to an temporal information and how the appear can be drasticall &aried b using higher le&el controls% The idea was to create structures that do not ha&e an temporal relationships and use those as a basis for creating the piece% This was partiall inspired b the ideas of Henakis regarding snapshots and outside time structures%

> *The entities would appear, as in a snapshot, reunited in a dense network of non temporal contiguities, uninterrupted, extending through the entire universe. I said, in a snapshot. That is to say that in the snapshot, the spatial relations of the entities, the forms that their contiguities assume, the structures, are outside time (hors-temps). The flux of time does essentially not intervene in any way. That is exactly what happens with the traces that the phenomenal entities have left in our memory. Their geographical map is outside time.*
> ;Henakis and Brown, $393, p% 93<

In the end no higher order control was actuall used% The building blocks were ju'taposed within their corresponding groups and this order was kept% The possibilit still remains to create &ariants for how the chain of states occur in *Concomitance* and this will probabl be e'perimented with later. *or now, the piece consists of four parts% In the first part, sections ha&e a duration of ##G49, ##G4#, ##G"4, ##G#9, ##G4#, ##G"4, ##G$: and ##G44 minutes% In the second part the duration of states is ##G4", ##G"4, ##G/" and ##G"" minutes% The third part has sections that last #"G##, ##G$:, ##G/", ##G4:, ##G"", ##G#9, ##G"# and ##G$" minutes, and finall the last part has a duration of #"G## minutes% The total duration of the piece is $"G": minutes%

In *Concomitance* transitions are ignored in the sense that the alwa s happen in the same wa K sharp shifts from one state to the ne't%)n important aspect of a transition is of course the relationship between the material that e'ists before and after the transition% In order to e'plore this to its e'tremes, the decision was made to ignore transitions which in turn should emerge from the material differences and similarities of a state% The piece should howe&er not just e'ist as a series of interesting passages, but also through the relations brought forth b the attributes of the sound processes%)ll of the states start directl and internal acti&it remains until the &er end of a section% The result is that some of the transitions tend to smooth out where the abrupt nature is not so prominent% This might also be due to the fact that e&en within a section, things often start and stop without an fades%

(espite its sharp changes, *Concomitance* still seems to me &er consistent and focused% This holds e&en though the piece is perhaps the most &aried one in terms of material differences of those co&ered in this te't% +itched material is widel used as well as rapid se>uences, te'tures, noises, discontinuous gestures and chaotic percussion patterns% So how come it e'ists as something more and greater then just a collection of successi&e statesE In m opinion it is because the piece is totall concerned with its own creati&e process%)s mentioned abo&e no higher le&el control is used in *Concomitance*. This, howe&er, onl applies to states as building blocks for control%)ll the material used in the piece is composed b carefull selecting combinations of polarit states% The amount of 'snapshots' used in the piece is substantial and as the compositional process unfolded, more and more 'sensiti&it ' was obtained in how to create these configurations%)dditionall all the material used in the sample=based objects was obtained from 5+6C s nthesis objects which then recei&ed twice a polarit =based treatment% B creating different snapshots o&er and o&er, alwa s using the same set of polarities, the identit of *Concomitance* emerged% +erhaps the states are not rec cled in the sense of higher le&el section control ;although this could be a future possibilit <, but the process of creating these states was repeated a great number of times and this is in the end what gi&es the piece its special character%

In the end *Concomitance* seems an original and fresh proposition, not onl in its current state, but also of how its structure could contribute in generating other pieces or possibilities% It emphasi-es a more fragmented form of discrete states% Man of the pieces discussed in this chapter can be said to ha&e certain streaming >ualities% Those are hard to find in *Concomitance*. The whole path of pieces that ha&e been co&ered here can actuall be described as going from the most streaming one ;*Angst*< to the least streaming one ;*Concomitance*<% !owe&er, the pieces also o&erlap in man different wa s% Ideas flow between them and similar situations are e'perienced 5ach of them still has its particularit and hopefull its percei&able identit ! owe&er, the could also be seen as momentar e&ents, originating from a more continuous flu' of creati&it in which their relationships e'ist in different wa s +erhaps &er much as the states ha&e been discussed in this te't, the compositions can also be said to e'ist in a comple' network of entities

Dhitehead claimed that the uni&erse is made of actual AoccasionsB These occasions arise from potentialities created b prior actual occasions The actual occasions are occurrences modeled on practical e&ents, each of which comes into being and then disappears, onl to be replaced b a successor ;Stone , "##$< If these e'periences form the basic realities of nature then in m opinion this is also a &er realistic description of music Music consists not of things, but of e&ents, and as such is best understood as being a process)s such, it e'ists as a continuousl changing process which creates actual e'perience out of potential one

6. Conclusion

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This research consists of three different poles. The theoretical ideas, the compositional en&ironment and the music. The process of refining those and bringing them together is still &er much in its infanc . It would be >uite laborious to list all the potential wa s this could be done in. *or e'ample when comparing the reali-ed pieces, countless e'tensions can be imagined in order to enhance them or create others from similar ideas.) great deal of the possibilities offered b the 5+6C ha&e onl &aguel been in&estigated and man of the theoretical ideas in this te't ha&e not et been e'plored in an artistic conte't.

I belie&e howe&er that the combination of the three different a'es has alread been fruitful in man wa s. Something uni>ue seems to emerge when all of them connect. Ideas from the s stem became more part of the music then initiall thought. These ideas somehow resulted in more focused compositional ideas, which in turn also influenced the aesthetics. This created a kind of feedback process, which was in the end highl rewarding. *or a project that was initiall all about creating alternati&es and possibilities, the hope is that the process of forming different relationships between what has been co&ered in this te't will continue.

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A. List of pieces and performances

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+ieces and performances made during the period between #$%#3%"#$# and $$%#1%"#$$ are listed below% The are ordered b date%)n earlier &ersion of ')ngst' was presented on the $3%#$%"#$# but was later e'tended and as such presented as part of this research%

+ieces

TITLE	*DUR.*	*PRESENTATIONS*
*allaciesSS	"4G/"	"/%#3%"#$#, SuperCollider S mposium, D*S T8 Berlin% #3%$"%"#$#, Sonolog D*S concert, Meiden% "#="9%$$%"#$#, ST.+ festi&al, 5indho&en%
)ngst	$"G#/	$3%#$%"#$#, (iscussion concert /, Institute of Sonolog , (en !aag% #$%$$%"#$#, C)SS concert, ,oninklijk Conser&atorium, (en !aag%
In BetweenS	$:G##	#/%$#%"#$#, F=-ondag, ?illa 6ckenburg, (en !aag%
Gre Seeds	#9G#9	#1%#/%"#$$, B5)ST *esti&al, Birmingham% "#%#/%"#$$, +entacon conference, McGill 8ni&ersit , Montreal% "9%#/%"#$$, C)SS concert, ,oninklijk Conser&atorium, (en !aag%
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Signac	#3G49	"$%#"%"#$", Collo>uium presentation, Institute of Sonolog , (en !aag%
+ortholes	#9G1/	"$%#"%"#$", Collo>uium presentation, Institute of Sonolog , (en !aag%
Concomitance	$"G":	$9%#4%"#$", (iscussion concert 1, Institute of Sonolog , (en !aag%

S Composed with Marie Guillera
SS Composed with Miguel 7egrco

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DATE	*INFORMATION*
":%$$%"#$#	Concert with Steind]r , ristinsson at +ure magnetic, (e ?inger, (en !aag%
$#%#"%"#$$	Concert with Caike Stambach, 5phemere 1, Studio Moos, (en !aag%
$"%#"%"#$$	Solo concert, Icelandic music da s, Faal $##,)msterdam,
$9%#"%"#$$	Concert with Marie Guillera , Monophonic series, //# li&e, (en !aag%
$3%#"%"#$$	Solo concert and duo with Caike Stambach, Bd Chan- , Montreuil ;+aris<%
"1%#"%"#$$	Solo concert, MM)MC li&ing room concert series, Bru'elles%
/#%#4%"#$$	Concert with Marie Guillera , Trash&orte' series, +aris%
#3%#:%"#$$	Concert with Cedric (upire, 5phemere 3, Studio Moos, (en !aag,
"/%#:%"#$$	Concert with Marie Guillera , 5'am concerts, Institute of Sonolog , (en !aag%
":%#:%"#$$	Concert with Marie Guillera , ')fter Mars der Bescha&ing', at SuperMarkt, (en !aag%
$3%#9%"#$$	Concert with Steind]r , ristinsson at Most Theor festi&al, (eringaj ;Croatia<
"#%#9%"#$$	Concert with Steind]r , ristinsson at Most Theor festi&al, (eringaj ;Croatia<
":%$#%"#$$	Concert with Marie Guillera , C(release, Souffle Continu, +aris%
"9%$#%"#$$	Concert with Marie Guillera , Galler)bilene, Bru'elles%
"3%$#%"#$$	Concert with Marie Guillera , MM)MC li&ing room concert series, Bru'elles%
$#%$$%"#$$	Concert with Steind]r , ristinsson, 5phemere $", Studio Moos, (en !aag%
#3%$"%"#$$	Concert with Steind]r , ristinsson, State=H 7ew *orms festi&al, (en !aag%
$#%$"%"#$$	Concert with Steind]r , ristinsson, *reemote festi&al, 8trecht%
#3%#$%"#$"	Solo concert, Bar du matin, Bru'elles%
$2%#/%"#$"	Concert with Cedric (upire, Centre Mercoeur, +aris%
$$%#1%"#$"	Concert with Steind]r , ristinsson,)taelier Claus, Bru'elles%

B. EPOC installation and examples

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In order to install 5+6C the first step is to set up the SuperCollider en&ironment% It can be downloaded from hereG httpGLLsupercollider%sourceforge%net

5+6C is intended for Mac 6S H% It has been de&eloped and tested in 6S H $#%:%9% running SuperCollider /%4%4% It should be able to run on other operating s stems that support SuperCollider, this has howe&er not been tested%

The S*ystem* director on the companion (?(, which contains the 5+6C, consists of three sub=directoriesG *Epoc, Examples* and S*ounds*% To install 5+6C, the *Epoc* folder has to be copied to the *Extensions* director of SuperCollider which can either be s stem=wide and located inG
LMibrar L)pplication SupportLSuperColliderL5'tensionsL
or user specific located inG
TLMibrar L)pplication SupportLSuperColliderL5'tensionsL

6nce the *Epoc* folder has been put in the e'tensions director , SuperCollider has to be either restarted or recompiled ;Cmd=,<% In order for the sample based 5+6C objects to work with default sound files, the 5+6C sounds ha&e to be copied to the default SuperCollider director % The sounds folder is in the *system* director on the (?(% *rom there the *epoc-sounds* folder should be copied toG
L)pplicationsLSuperColliderL

The *System* director contains an *Examples* folder where / documents with 5+6C e'amples are to be found%

Epoc - Example1 (Objects).rtf shows how to use the objects% Se&eral 5+6C objects are shown and initiali-ed with default arguments% It is shown how the can be pla ed, updated and stopped within a SuperCollider document% 5'amples are also of how to use the 6bject 5ditor with these objects%)dditionall , e'amples are pro&ided of how to customi-e the objects b pro&iding initial arguments%

Epoc - Example2 (Sequences and Envelopes).rtf shows &arious e'amples of how to create se>uences of objects in time% This is done within a SuperCollider document or b using the 6bject Se>uencer%)dditionall e'amples are pro&ided of how to use en&elopes for time=&ar ing polarit &alues% This is done both within a document and b using the 5n&elope 5ditor%

Epoc - Example3 (Higher Order Control and Networks).rtf shows e'amples of how to use higher order control b using the 7etwork 5ditor and 7etwork Se>uencer% !ow this can be done within a document is also shown as well as how to create networks of different se>uences%

C. Description of EPOC package contents

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*ollowing is a &er brief description of all the 5+6C objects and how the 5+6C framework is organi-ed%)dditionall all the classes of the en&ironment ha&e help files which pro&ide additional information% These ha&e been automaticall generated so the documentation is not e'tensi&e, but still useful for displa ing public parameters and class methods%

The 5+6C can be di&ided into two main parts, the **framework** and the **objects**% The framework contains all the s stem classes and the objects all the a&ailable 5+6C objects%

Below are the **Framework** classesG

EnvelopesG

B5n&Gen%sc ;5n&elope generator for &arious en&elope t pes% Can also transform en&elopes<%

GUIG

B5ditor%sc ;G8I for editing objects and generati&e methods for polarities<%

B5n&elope%sc ;G8I for editing and generating polarit en&elopes<%

B7etwork5ditor%sc ;G8I for editing higher le&el polarit and offset &alues for network nodes<%

B7etworkSe>uencer%sc ;G8I for se>uencing network nodes and higher le&el control<%

BSe>uencer%sc ;G8I for creating, editing and generating objects se>uences<%

NetworkG

B7etwork5n&elope%sc ;Contains a polarit en&elope for working in a network conte't<%

B7etworkItem%sc ;Contains an object for working in a network conte't<%

B7etwork7ode%sc ;Contains objects and en&elopes, higher le&el control and offset &alues<%

ObjectsG

BControl%sc ;Container for the polarities and their a&ailable operations<%

BControlTest%sc ;Test class for polarit configurations<%

BGen%sc ;Base class for all 5+6C generators<%

BItem%sc ;Base class for all 5+6C objects<%

BSe>%sc ;Base class for all 5+6C se>uencers<%

staticG

0template%sc ;Class template for static objects<%

Beffect%sc ;Base class for all static sound transformation objects<%

BGSound6bject%sc ;Base class for all static sound objects<%

Bmod%sc ;Base class for all static modulation sources<%

Bobject%sc ;Base class for all static objects<%

Bpat%sc ;Base class for all static pattern objects<%

Brout%sc ;Base class for all routine=based static objects<%

Bs nth%sc ;) method wrapper for all static objecs<
Bwrap%sc ;) S nth (ef wrapper for accessible s nth methods for 5+6C objects<%

ScoreG

BScore%sc ;Simple se>uencer for objects and polarit en&elopes<%
BScoreItem%sc ;Contains an object for working in a score conte't<%
BScoreMo&ement%sc ;Contains an en&elope for working in a network conte't<%
Simple5ditor%sc ;+arameter control for objects in a score<%
SimpleMo&ement%sc ;5n&elope control for objects in a score<%
SimpleScore"%sc ;Generic se>uencer for objects in a score<%
S nthDrap%sc ;Drapper for s nth methods for time=&ar ing control<%

UtilsG

BConstants%sc ;Contains constant &alues to be used globall in the 5+6C en&ironment<%
BItemComposer%sc ;Combines &arious generati&e methods for composing with objects<%
BTempo%sc ;Contains &alues for r thmic calculations<%
B8tils%sc ;Global utilit functions can be found here<%

The objects are di&ided into **generators** and **sequencers**% This is an implementation issue and when using them, the same functionalities and methods appl in both cases% The third groups is the **static** one which is older, and different, mainl since its objects do not respond to polarit messages% These are included in the en&ironment since the offer different functionalities, but can not in the description below% The generators and the se>uencers are subdi&ided into three groups, *chemical*, *mineral* and *nominal*. This responds roughl to when the were created and also to their attributed names% *or access to all a&ailable methods co&ered in this te't, "" objects ha&e been selected in the e'ample files for demonstration% These should preferabl be used% The following descriptions are intended for gi&ing a general idea rather then e'plaining in detail an object%

Below are the **Object** classesG

GeneratorsG

chemicalG

BGenChalk%sc ;Ser&er side micro=patterns using granular s nthesis and comb filters<%
BGen (echlor%sc ;Impulse generators, formlet filters, noise modulators and comb filters<%
BGen5th l%sc ;Con&oluted impulses with rh tmic beha&ior<%
BGen*lint%sc ; . apid granulator reading buffer lists throug resonators and comb filters<%
BGenMitharge%sc ; (ifferent noise generators combined through filters and resonators<%
BGen7itrate%sc ;) udio rate granulator that reads samples using sine wa&es for inde'ing<%
BGen6pal%sc ; 6scillating patterns combining different oscillator t pes and emphasis<%
BGen+earl%sc ; 8ses the Gend / implementations with filters, distortion and resonators<%
BGen+ ro%sc ;*iltered, resonant impulses with stepwise modulators and comb filters<%
BGenTrona%sc ;Stochastic impulses and brown noise through filters and resonators<%

mineralG

BGenBer l%sc ; ! enon chaos generators in audio rate with filtering and re&erb<%
BGenCitrine%sc ;Sample=based, with fast reading modulations and feedback dela <%
BGenGalena%sc ;Combines th M+C5rror 8Gen with filters and modulators<%
BGen , ernite%sc ;) combination of oscillators through wa&eshaping and re&erb<%
BGenMica%sc ;Gend " 8Gen combined with &arious noise generators and feedback &erb<%
BGen+eridot%sc ;Simple, sample=based object with chaotic jumps and trajectories<%
BGen . utile%sc ;Implements **T free-ing with &arious other effects<%
BGenSpinel%sc ;Buffer reader with &arious options<%
BGenFircon%sc ;5'tends the StandardM and Gbman7 with e&en more noise and chaos<%

nominalG

BGenImba%sc ;5ight impulse oscillators with formlet and combi filtering<%
BGen , ari%sc ;) dditi&e s nthesis through wa&eshaping<%
BGen+ulso%sc ; (ifferent impulse=based oscillators through combfilters and pitch=shifters<%
BGen . e-im%sc ;) rra of impulse generators through filters and resonators<%
BGenSaga%sc ;Granulator for te'tures, local postions with longer grains, filters and re&erb<%

SequencersG

chemicalG

BSe>) lum%sc ;+attern grains with random en&elopes and direction possibilities<%
BSe>Bora'%sc ;*le'ible se>uencer with &alue lists, bit=crushing and low=resonance<%
BSe>*erric%sc ;Two &oice brassage with brownian motion for reading points<%
BSe>Mercur %sc ;Simple s nthesis with r thmic patterned beha&ior<%
BSe>+otash%sc ;5'perimental granulator with &ibrato, re&erb and pattern options<%
BSe>Starch%sc ;Interpolation se>uencer between &arious sound sets, crusher and dela <%
BSe>Sucrose%sc ;Brassage with &ersatile pattern for reading points and comb filters<%
BSe>?itriol%sc ;Da&eset distortion object with multiple distrotion and repeat options<%
BSe>Finc%sc ;+ulsar s nthesis with four paralell trains running through resonators<%

mineralG

BSe>Marble%sc ; (ust shaped noises combined with a Gend 8Gen and distortion<%
BSe> . aite%sc ;Se>uencer for short sounds with randomness, bit=crushing and resonators<%

nominalG

B5mpt %sc ; (e&eloper template<
BSe>Brass%sc ;Brassage for sample pla back, filters and resonators<%
BSe>Clame%sc ;Se>uencer for multiple sounds which tends towards rh tmic patterns<%
BSe>*io%sc ;Simple se>uencer for multiple sounds<%
BSe>Gaela%sc ;Se>uencer &ariation with different pattern options<%
BSe>Marin%sc ;Se>uencer with oscillators and patterning beha&ior<%
BSe>Ma a%sc ;) dapted to se>uence short sounds and appl ing grain distortions<%
BSe>Micjaki%sc ;Brassage with nested patterns for reading points<%

D. Contents of the companion DVD

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The accompan ing (?(contains the 5+6C en&ironment, e'amples of how to use the s stem, stereo &ersions of the pieces discussed ;numbered b creation date< and a pdf &ersion of this thesis% Dhat the directories contain is as followsG

- S stem contains the 5+6C en&ironment and e'ample files of how to use it%
- Thesis contains a pdf &ersion of this thesis%
- +ieces contains stereo &ersions of the pieces co&ered in this te't%
    - $%) ngst ;$"G#/ min<
    - "%Gre Seeds ;#9G#9 min<
    - /%*olded ;#3G1: min<
    - 4%) ukera ;#3G1" min<
    - 1%+edicel ;a stereo reduction of the four channel &ersion, #3G$" min<
    - :%M´imaginaire du parleur ;a stereo reduction of the eight channel &ersion, $"G/1 min<
    - 2%Signac ;#3G49 min<
    - 9%+ortholes ;#9G1/ min<
    - 3%Concomitance ;a stereo reduction of the four channel &ersion, $"G": min<