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Topologies for network music

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Topologies for Network Music

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Abstract

Sonic Arts Research Centre
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Doctor of Philosophy

Topologies for Network Music

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This thesis presents a body of theoretical research, combined with a portfolio of artworks, residing within the field of network music. Network music is a musical practice in which conceptual, technological, ideological and/or philosophical concepts of the network are included in the design, composition, production, and/or performance process. The thesis contains analysis of three historical examples of network music, as well as critical reflection of three artistic responses that have been created by the author. The responses investigate how contemporary technologies allow increasingly complex perceptual and technological understandings of network concepts, ideologies, strategies, and topologies to be explored within network music. The thesis also contains description, critical reflection, and analysis of one original artwork, which investigates a theme that emerged during the research process. The original work explores how a performance topology, adapted from the field of machine learning, alters the perception and interpretation of the network for involved agents, as well as analysing the impact it has on the participants, and performance process.

The works included with this thesis constitute the portfolio and they are the creation of the author.

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Declaration

Concepts, arguments, and discussions presented in this thesis have previously appeared in the following publications:

Renwick, R. (2012). 'SourceNode: A Network Sourced Approach to Network Music Performance', in proceedings of *ICMC 2012*, Ljubljana, Slovenia, pp. 301-308.

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Renwick, R. (2016). 'The Relation of Nodalism to Network Music', *The International Journal of New Media, Technology and the Arts*, 11(2), pp. 21-28.

Renwick, R. (2015). 'Ellipses: Multi-dimensional filter, fracture, and dilution of a nodalistic body'. *Revista Electtronica MAPA D2 - Mapa e Programa de Artes em Danca (e performance)*, 2(2), pp. 176-193.

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Chapter One

1. Introduction

This thesis is a result of the author undertaking the Doctorate of Philosophy programme at the Sonic Arts Research Centre (SARC), Queen's University Belfast. This document comprises the written component of the requirements and forms the theoretical support, contextual analysis, critical evaluation and reflection process accompanying the attached portfolio. The written component of the thesis represents 50% of the overall requirements of doctoral submission, and the attached portfolio and supplemental appendix comprises the remaining 50%. The doctorate was undertaken from January 2012 until February 2017.

1.1. Background and Motivation

Thinking about how and why my interest in the research topic originated, I turn to the moment I formed a relationship between network music, and concepts I am more familiar with, such as electronic music, sampling culture, dj culture, dj performance practice, and internet culture. The initial relationship between these strands of interest and network music was crucial to my initial forays into the research topic. There is one standout example of my own personal interests resonating with my formative notions of what network music is; Ritchie Hawtin, the founder of the M-nus Record Label (see M-nus Inc, 2008) explained the reasoning behind a series of shows his company created to celebrate the ten year anniversary of his record label, *Contakt.*

> "...people like to see us [performers] together. We like to have contact with the people. We like having contact together on stage, how do we...how do we build upon that? Let's get closer to each other, and closer to the crowd, and then we started to build the idea and the technologies, and even the greater concept around that. There has been some technological advancements in dj'ing. I had moved away from turntables. I was using Traktor. So this started to open up a door of being able to have a timecode that would allow me to sync, you know, other people to my records that I was playing." (M-nus Inc, 2008)

The concept and ideology of *Contakt* influenced my understanding of what music could be in the future; a music where multiple performers play together, in unison - synchronised and organised within a technologically developed performance architecture, in constant engagement with the audience, and involved in an inter-connective and interdependent musical experience. This idea influences my notion of what network music is, or could be. The concept of technologically leveraged performance models developed through my MSc Thesis (Renwick, 2011), into my PhD application, and then onto my PhD research - namely the creation of performance architectures and systems that focus, explore, and develop levels of interconnection between musical agents.

1.2. Network Music

I will offer a working definition of a network, drawn initially from a dictionary definition, and then supported by explanations and theoretical concepts found within various academic fields. I will then offer a brief explanation of perspectives drawn from existing literature within the specific field of network music. Finally, I will outline my own definition of network music, which will form the working interpretation of the term within the context of this thesis.

1.2.1. The Network

An attempt to define the term ‘network’ is a difficult task, as the notion is one that defies completely structured specification. Two, or three, dimensional topological formations graphing network structures fail to explain or demarcate the implications of the whole; delineating connection and relation, yet remaining ill-equipped to demonstrate coalescence or synergy. Even considering this, it would be worthwhile to elucidate notions of the term from varied sources. The term ‘network’ is viewed as a dominant concept in the current age (Barabasi, 2002; Barney, 2004; Castells, 2007, Newman *et al.*, 2006; Varnelis, 2008; Vitale, 2014; Wigley, 2004). It is a word that “slides seamlessly from biology, to technology, to society” (Wigley, 2004, p. 94).

The *Oxford Dictionary* presents a definition of the word, detailing its literal and linguistic meaning. The definition reflects how the word describes characteristics of things or systems - networked; or an organisational structure - a network. The definition details certain organisational or behavioural characteristics in which connection, interconnection, and/or intersection of agents are crucial determinants of its nature.

> "network |noun| **1.** An arrangement of intersecting horizontal and vertical lines. A complex system of roads, railroads, or other transportation routes: a network of railroads. **2.** A group or system of interconnected people or things: a trade network." (Oxford Dictionaries, 2015)

Newman *et al*. propose a "New Science of Networks" (Newman *et al.*, 2006, p. 4), with the postulation that "networks are everywhere" (Newman *et al.*, 2006, p. 1). They propose a definition of a network with foundations in graph theory - a field of discrete mathematics - which in "the past three centuries has become the principal mathematical language for describing the properties of networks" (Newman *et al.,* 2006, p. 2).

> "In its simplest form, a network is nothing more than a set of discrete elements (the vertices), and a set of connections (the edges) that link the elements, typically in a pairwise fashion. The elements and their connections can be almost anything." (Newman *et al.*, 2006, pp. 2-3)

Manuel Castells offers a similar definition, derived from politics and sociology, "a network is a set of interconnected nodes" (Castells, 2000, p. 15). Castells stresses the concept of interconnection; evoking a sense of interdependence and interrelation between elements (nodes) in a network system. Though Castells is interested in the sociological and political ramifications of organised societies, he also understands that technological and communicational infrastructure is critical to the development of intricate and cohesive social bonds. Varnelis supports this notion, echoing sentiments on the cruciality of technology and the ubiquity of network culture. He suggests a "new societal condition" (Varnelis, 2008, p. 145) existing within culture dominated by networked logic, "ours is the first modern age in which the network is the dominant organizational paradigm" (Varnelis, 2008, p. 147); a culture that he feels "succeeds postmodernism" (Varnelis, 2008, p. 149).

Barabasi follows a similar line of thought, tracing the history of networks from the creation of graph theory by Loenhard Euler in the 18th century, to the creation of a distributed network of computers by Paul Baron - as he was tasked by the United States government to create a robust communicational network for military purposes (Barabasi, 2002). Barabasi proposes that network logic is fundamental to all strands of human enquiry, enriching knowledge in fields as diverse as politics, sociology, computer science, biology, genetics, economics, transport logistics, physics, and data analytics. He believes that "networks will dominate the new

[21st] century to a much greater degree than most people are yet ready to acknowledge" (Barabasi, 2002, p. 7).

In his book, *Linked: A New Science of Networks*, Barabasi traces the influence of network logic through a host of fields, explaining how the term, and our understanding of it, has driven the creation of new knowledge (Barabasi, 2002). He articulates two strands of thought applicable to this thesis. The first is that networks, no matter how complex, often follow simple rules and laws, with changes in defined structure, or topology, influencing the network's overall effect.

> "Small changes in topology, affecting only a few nodes or links, can open up hidden doors, allowing new possibilities to emerge." (Barabasi, 2002, p. 12)

Barabasi also pays heed to complex networks, stating that one of the most interesting properties to materialise from them is the fact that, in the real world, they are in principle, emergent.

> "Real networks are self-organised. They offer a vivid example of how the interdependent actions of millions of nodes and links lead to a spectacular emergent behaviour." (Barabasi, 2002, p. 221)

This overarching property of emergence allows Barabasi to delineate the importance of understanding networks, as humanity seeks to understand itself. He feels that if we are to uncover the deep-seated underlying nature of emergence within networked systems it will pave the way for understanding humanity on the whole.

> "Networks are by their very nature the fabric of most complex systems, and nodes and links deeply infuse all strategies aimed at approaching our interlocked universe." (Barabasi, 2002, p. 222)

The most appealing definitions, for the purpose of this thesis, are drawn from political science via Darin Barney, and popular philosophy, through Christopher Vitale. Barney analyses the network society, much like Castells, attempting to understand how societal network formations influence change within politics, sociology, and economics.

> " [A network is] comprised of three main elements: nodes, ties and flows. A node is a distinct point connected to at least one other point...a tie connects

> one node to another...flows are what pass between and through nodes along ties." (Barney, 2004, p. 26)

This open-ended definition has similarities with that of Christopher Vitale, who describes a network as "any whole, composed of parts, distinguished from a background, and composed of other parts and wholes, layered into each other at multiple levels of scale" (Vitale, 2014, p. 16). While Barney describes a system of interconnected and interdependent nodes - with a transfer of information between and through them - Vitale describes a multi-layered stratum of interconnection and intersection with distinction between background and foreground. Vitale denotes a more unfastened description; inherently more complex. Yet, both definitions are supportive in their attempt to describe network logic, even though Vitale's all-encompassing definition may be daunting to those hesitant to abandon traditional two or three dimensional physics, as it deals with dynamic multi-dimensional logic; concurrently transparent, translucent, lucid, and opaque (Vitale, 2014). Both share an essence - nodes are points of perspective within the system, with information flowing between them on a number of planes; visible and invisible. Vitale clears up his position by stating that "parts connected in a network can be recast as nodes, which are joined together by links" (Vitale, 2014, p. 17).

Linking the conceptual frames of Barney and Vitale with those already intricately woven within the context of musical performance will aid understanding of how a network fashions network orientated musicality. The most concise description from within network music theory is offered by Rebelo *et al.* "the network is understood as a communication structure allowing information flow across the globe" (Rebelo *et al.*, 2008, p.1). This structure, technologically supported by a communicational medium, allows for a flow of sound, or data, through and between nodes distributed across the planet. The mediums come in varying sizes, depths and intricacies - from the now out-dated telegram, to telephone, radio, computer networking technologies and the *zeitgeist* that is the internet. Rebelo *et al.* (2008) understand that any network music artwork will rely on at least one communicational medium to create a networked structure, but it must be remembered that no single medium defines the network, it merely acts as support, structure, or artistic inspiration.

1.2.2. Perspectives of Network Music

Since the beginning of the 21st century, interest in network music has risen dramatically due to the development and evolution of supporting technology. Artists who have adopted network music as their artistic and experimental foci have

outlined the long history of the practice's relation to technology (Ascott, 1968; Ascott, 1993; Barbosa, 2003; Braasch, 2009; Carot and Werner, 2007; Chadabe, 1999; Fencott and Bryan-Kinns, 2010; Follmer, 2005a; Follmer, 2005b; Jorda, 1999; Joy, 2010; Kane, 2007; Kapur *et al.*, 2005; Kim-Boyle, 2008; Makelberge, 2012; Oliveros, 2009; Packer, 2005; Renaud and Rebelo, 2006; Renaud *et al.*, 2007; Renaud, 2009; Schroeder, 2009; Shanken, 2000; Tanaka, 2001; Tanzi, 2001; Tanzi, 2003; Tanzi, 2005a; Tanzi, 2005b; Traub, 2005; Weinberg, 2003; Whalley, 2012).

The implications of adopting the network as musical medium, artistic spur, and technological support system straddles a wide range of discourses: musicological and philosophical (Ascott 1993; Braasch 2009; Duckworth 2003; Follmer 2005a; Packer, 2005; Rebelo *et al.*, 2008; Schroeder, 2009; Schroeder, 2013; Tanzi, 2005a; Tanzi, 2005b; Tanzi, 2005c; Weinberg, 2003); technologically deterministic (Alexandraki *et al*., 2008; Barbosa, 2003; Carot, 2009 Caceres and Chafe, 2009; Chew *et al*., 2004; Dannenberg and Jameson, 1993; Gurevich *et al*., 2006; Jorda, 1999; Renaud, 2009); and sociological (Bryan-Kinns, 2012; Chadabe, 1999; Makelberge, 2012; Vallis *et al.*, 2012).

The rapid development of the internet, its co-dependent protocols and interface technologies, as well as its widespread adoption as the primary digital communication tool has influenced culture in a myriad of ways: social; technological; economic; and political. From a musical perspective, Widdass asserts how cultural factors influence "the structure of musical performance" (Widdass, 2012, p. 88). With local cultural factors being evermore influenced by the digitised, computer dependent experience, it is no great ideological leap to imagine forms of music adopting the internet, or networking tools and principles, as primary design, composition and/or performance catalysts. Packer imagines a new type of music where the role of the composer is altered - no longer composing in a traditional sense by creating notation and performance instructions - instead involving himself in designing systems.

> "...we enter into new architectures that are invisible, yet tangible, where we envision new forms of music made collaboratively, where the composer no longer asserts control, but rather conducts an environment, invents new systems." (Packer, 2005, p. 524)

It should be recognised that communication mediums such as the internet are not *the* cause of network music, though they have undoubtedly aided exploration of the type. Practitioners have adopted mediums as tools for exploring sociological,

compositional, and performance perspectives of network music, which in turn has led to a number of differing categorisation techniques being used to describe the practice.

Golo Follmer offers the most complete definition of 'Net Music', a term I feel is almost interchangeable with network music. His definition views a core medium of the modern age - the internet - as a crucial element, providing both inspiration and technological support structure.

> "The term 'Net music' comprises all formal and stylistic kinds of music upon which the specifics of electronic networks leave considerable traces, whereby the electronic networks strongly influence the process of musical production, the musical aesthetic, or the way music is received." (Follmer, 2005b, p. 185)

Brian Kane supports this all-encompassing perspective, adding that the definition has ensured that the term 'net music' covers an enormity of musical and sonic art practices - a range that will be further discussed within chapter two of this thesis.

> "[Net Music] covers an enormous range of musical and sound art activity, including but not limited to: web crawlers that hunt down sound files and algorithmically organize them into sound collages; sites that read web pages and translate the data stream into live audio; virtual instruments that users manipulate online; autonomous sound toys; 'jam' sessions in cyberspace; on-line sound installations that continuously broadcast across the web; and live performance situations where players can be half-way across the world, performing together with streaming audio over the internet." (Kane, 2007, p.1)

The concept of a communicational tool fulfilling myriad roles - support structure, explorative medium, and inspirational spur - is supported by theorists such as Pedro Rebelo (Rebelo *et al*., 2008; Rebelo, 2009), Franziska Schroeder (2009), Alexander Carot (2009), and Alain Renaud (Renaud *et al*., 2007; Renaud, 2009). These theorists view network music as being intricately woven with concepts of distributed performance - where musicians are connected across the globe using communication and electronic networking technologies. The notion of distributed performance has led them to theorise on certain strategies - conceptual, logistical, and technological - as they attempt to delineate methods for playing, composing, and performing within a network.

Gil Weinberg offers a slightly altered perspective of network music, focusing on the inter-connective and interdependent characteristics, or properties, of agents

involved in a musical process (Weinberg, 2003). His thesis details a number of differing approaches - Server, Bridge, Shaper, and Construction Kit, which he feels detail "the level of interconnectivity among players and the role of the computer in enhancing the interdependent social relations" (Weinberg, 2003, p. 31). This subtle change in focus from viewing the communicational tool as support structure to one that enhances social relations is worth noting. Social relations often form the human centric cohesive bond within inter-connective and interdependent music - regardless of the embedded scale, state, stature, or role of communication networks.

Roy Ascott focuses complete discussions on the importance of social relations within network art (Ascott, 1968; Ascott, 1990). This line of thinking is furthered by Dante Tanzi as he questions the role of music within decentralised environments, especially the changing behavioural nature of musical agents within networked architectures (Tanzi, 2001; Tanzi, 2003; Tanzi, 2005a; Tanzi, 2005b). Discussions of social relations are found in a number of network music's related fields of enquiry - from discussions surrounding *The League of Automatic Composers'* computer dependant electronic network performances (Bischoff *et al*., 1978), the telematic perspectives offered by Pauline Oliveros *et al*. (Oliveros *et al*., 2009), the discussions of social music making within live-coding practice (Fencott and Bryan-Kinns, 2010; Bryan-Kinns, 2012), and discussions surrounding the design of collaborative live coding environments (McKinney, 2014).

The depth of discourse surrounding social relations leads Follmer to predicate on the existence of dualistic paradigms within network music - the compositional paradigm and the communicational paradigm - which he feels are deserving of interrelated and interdependent research (Follmer, 2005b). The compositional paradigm focuses on systems, architectures, topologies, and the effect networks have on compositional and performance processes, whereas the communicational paradigm concentrates on the inter-connective and interdependent behaviours and characteristics of musical agents within network music and their respective effect on musical outcomes.

Network music encompasses a wide range of practices, but common traits and fields of enquiry exist within them all. Keywords such as network, node, link, tie, interconnectivity, interdependency, and collaboration must be considered in any attempt to realise a working definition, and should be included within any investigation of the practice.

1.2.3. Working Definition of Network Music

Though Follmer offers a relatively complete explanation of network music (see section 1.2.2), I feel that it is beneficial to offer a definition for the purposes of this thesis.

> Network music is a musical practice in which conceptual, technological, ideological, and/or philosophical concepts of the network are included in the design, composition, production, and/or performance process. The network may influence the work's aesthetic, composition, production, or reception. The network may or may not be limited to electronic computerised networks.

I feel that this definition is accepting of many forms of network music practice. It also allows for the inclusion of open-ended descriptions and concepts of the network, as it does not attempt to define exactly what does, or does not, constitute a network.

1.3. Thesis Structure

This chapter has briefly outlined my personal background and motivations, introduced the concept of a network, and network music, and offered a working definition of the practice. In the following section I will explain my methodology: a practice-based research process involving the analysis of three historical examples of network music; the creation of three individual artistic responses to these historical works; a critical reflection, analysis, and evaluation process leading to the creation of an original artwork exploring a central theme unearthed during the research. This chapter will also contain a section discussing the rationale for choice of historical works, a section outlining the thesis' research imperatives, a brief introduction to the portfolio of works, and also a description of the thesis' contributions to the field.

Chapter two is a literature review that introduces current discourses within the field of network music. It concentrates on themes, strategies, concepts, and ideologies as they have been described and discussed by various authors. The chapter will also offer a description of a number of examples of network music, so that my portfolio may be placed alongside a wider body of work.

The third chapter marks the beginning of the reflection, analysis, and critical evaluation process. It will be completed through four distinct chapters (Chapters 3 -

5). Chapters three, four, and five will each discuss one historical example of a network music artwork alongside a companioned artistic response. Chapter three will discuss Max Neuhaus' *Public Supply I* (1966) and the response I created, *Skype Supply*. Chapter four will discuss Maryanne Amacher's *City-Links* series (1967-1980) alongside my response, *Synchrocities*. The fifth chapter evaluates the relationship between John Cage's *Variations VII* (1966) and my own response, *Web Variations*.

In chapter six, I introduce the portfolio's final artwork - *Fields of Feedback*. This work was created as a summation of themes and concepts that were unearthed during the doctoral process. The work explores a specific topology for network music - derived from the field of computer science, and more specifically neural networks. As the research process developed, I explored more complex topologies for network music, aided and inspired by my developing understanding, and increasing technical aptitude, for conceptualising and forming networks within musical practice. The chapter will introduce the work, discussing its origins, motivations, conceptual and artistic themes, and finally critically reflect on the design, performance process, and musical outcome. It will also relate the final work to all previous work contained in the portfolio. It will show clear thematic and technological development of my work over the completed research process - as well as exemplify a complex network topology implemented in a musical performance context.

The final chapter summarises the previous six chapters and details the findings, conclusions and implications of the research process. Future directions for the research are speculated on, linked to existing theory as well as my own critical reflection, evaluation and analysis process.

1.4. Methodology

Linda Candy defines the practice-based research process, "[it] is an original investigation undertaken in order to gain new knowledge partly by means of practice and the outcomes of that practice" (Candy, 2006, p. 1). The methodological process for this thesis consists of:

A) investigate and research three historical network music artworks, deriving direct inspiration from them.

B) create three artistic responses to these historical works that incorporate both contemporary technologies, and my own artistic inspirations.

C) undertake a post-performance/post-installation critical reflection, evaluation, and analysis process to determine a central investigative theme as it emerged from the creative research process.

D) create an original network music artwork that explores this emergent theme.

1.4.1. Practice-based Research (PbR)

Candy makes the distinction, leaning on the theoretical concepts of Scrivener, between pure practitioners engaging with personal research, and researchers in the field who engage in practice. She states that practice-based research "aims to generate culturally novel apprehensions that are not just novel to the creator or individual observers of an artefact" (Candy, 2006, p. 2). This perspective suggests that the goal of a researcher in the academic arts is to create a deeper level of understanding through the reflection and analysis of practice-based methods, regardless of whether the methods, or artefacts, are created by the researcher or not. The new apprehension forms the basis of the contributions to the field of knowledge; a general stipulation for doctoral research (Candy, 2006). Candy states that a key element of research "is the transferability of the understandings reached as a result of the research process" (Candy, 2006, p. 2). The transferability implies that a research document must provide some level of new knowledge, or understanding, that can be interpreted and understood by other researchers, or practitioners, in the field.

> "...creative output can be produced, or practice undertaken, as an integral part of the research process. However, the outcomes of practice must be accompanied by documentation of the research process, as well as some form of textual analysis or explanation to support its position and to demonstrate critical reflection." (Candy, 2006, p. 2)

1.4.2. Research Imperatives

This thesis contains a number of research imperatives which form an intrinsic part of the motivation for the created portfolio, and also guide the structure and content of the supporting documentation. The imperatives are as follows:

1) Research, evaluate and critically analyse three historical artworks. These works should be clear examples of embryonic network music practice. Question whether avenues of discussion exist surrounding these works with respect to the impact they, and their creators, had on the development and understanding of network music from the mid twentieth century onwards.

2) Create three distinct artistic responses to the researched historical works in a pair-wise fashion; each historical work will have a companioned response which seeks to explore and/or extend the artistic concerns of the original. The responses should incorporate contemporary technologies as supplement and/or replacement to those used within the originals.

3) Critically evaluate the artistic responses to assess if desired outcomes were realised, as well as to understand:

    a) what effect, if any, the incorporated contemporary technologies had on conceptual, thematic, and artistic concerns;

    b) how the incorporated technologies elicited behavioural, observational, and perceptual changes in performers and/or audience members;

    c) the ways in which contemporary technologies altered the communication and/or realisation of central themes with respect to performers and/or audience members.

4) Create an original network music artwork which explores a conceptual, thematic, or artistic concern unearthed during the creation and evaluation of the three responses. This original artwork should represent an exploration of a key theme, or concept, that emerged during the research process.

1.4.3. An Organic Process

It must be stated that the research process manifested organically. As I researched and understood the thematic concerns of the historical works, I attempted to incorporate them into my artistic responses, leveraged by contemporary technologies. As I reflected on my creations, I realised that a central theme was emerging, weaving a thread of commonality through my portfolio; namely how contemporary communicational and inter-connective technologies aid exploration

of complex network topologies, architectures, and systems, while simultaneously altering the experiential nature of the artwork for both performers and listeners.

This theme emerged from the practice-based method and the critical reflection process. I realised through the creation of the portfolio, as well as the supplemental artworks included in the appendix, that I was exploring complex network topologies afforded by contemporary technologies and that, in turn, these topologies altered the perception of, and interaction with, the artworks. This led to the creation of *Fields of Feedback*, a work that directly attempts to explore this concern.

Affordance is defined by Gaver as "properties of the world, that make possible some action to an organism equipped to act in certain ways" (Gaver, 1991, p. 80). Gaver acknowledges that affordance consists of the combined actions and interactions of actual and perceived affordance (Gaver, 2000) - a line of thought developed from James Gibson (see Greeno, 1994), as he outlined a theory of affordances based on the "interactionist view of perception and action that focused on information that is available in the environment" (Greeno, 1994, p. 336).

Brian Kane proposes that network music should seek to enact and actualise specific affordances of assigned networks (Kane, 2007). He solicits a blueprint for performances drawn from projects that have been successful in their attempt "to create mappings that will force the listener into an awareness of the contingent nature of the interface with which they are involved" (Kane, 2007, p. 9). He urges 'net musicians' to develop artistic realisations that create "new practices that realise the ideational or essential dimensions of the network" (Kane, 2007, p. 3). The projects within this thesis seek to realise this ideal - interpreting historical concerns and then exploring whether contemporary technologies urge deeper reflection on the affordances of the actualised networks. This led to the creation of a new work, which explored, directly, the affordances that emerged from enacting specific topologies, aided by the use of contemporary technologies.

1.5. Rationale for Historical Works

When I reflect on the choices I made for formulating the artistic responses, there is one obvious reason that surfaces. Through their artworks, the three artists explored the influence technologies had on sound, and the perception of sound. They implemented technological mediums of their day to explore the relationship between performers and technology, audience and technology, and between

performer, audience, and the experiential nature of sound. Neuhaus implemented radio and telephone in *Public Supply I*, Amacher used telephone and radio in *City-Links*, while Cage and his co-performers used a host of technological apparatus in *Variations VII*, including short wave radio, electrocardiography (ECG) equipment, telephone, and sound generating electronics such as synthesisers.

All three historical works are examples of embryonic network artworks (Joy, 2010). Max Neuhaus implemented radio and telephone to create a complex bi-directional and interdependent communication network; Maryanne Amacher implemented high bandwidth telephone lines to create a live, dynamic network of soundscapes; John Cage, and his colleagues, implemented a host of equipment to create a performance in which performers sourced, gathered, and then modulated, a network of sounds that otherwise lived an obscured, etheric existence - hidden from the natural listening ear.

More similarities surface if one continues to investigate. For instance, all three artists were active in the field during the same period, and within a similar geographical area, as part of the avant-garde experimental art scene developing in New York at the time. This scene, in the 1960s and 1970s, is seen as reaction against developing mainstream music culture in accordance with similar movements in the contemporary art worlds of dance, and performance art. Studying the similarities between the three artists in any great depth is outside the remit of this thesis, but it should be noted that the three works I chose directly inspired me in some way. They explored concepts involving technology; as medium and inspiration, vehicle and device, stimulus and spur.

Of course, I might have chosen different works than the ones I did. For instance, Neuhaus completed a whole series of works under the umbrella term, *Broadcast Works*. For example, in *Radio Net*, he set up a complex communications network between approximately two hundred radio stations; each of them being given an automated mixing instrument so that groups of telephone callers at each station could engage in a self governing performance network (Neuhaus, 1994). Though this was a truly audacious and inspiring work, I admit - humbly - that the sheer scope would have been beyond my own limited skills. Attempting to create such a complex, dense and highly populated network of performers would have been a huge undertaking - one that would have taken a considerable amount of effort and technological aptitude. So, I chose *Public Supply I*, another work included in the suite of *Broadcast Works*, and seen as temporal and conceptual pre-cursor to *Radio Net*.

In the case of Amacher, *City-Links* was a series of iterations whose core themes became evident as I reflected on them; the collection of works touched on many artistic concerns - all interesting in their own right - and it took a period of reflection to grasp Amacher's true artistic and conceptual communication. I could have chosen to interpret any of her iterations - merely updating the mediums and altering the locations - but this was not what inspired me. So, the notion of sonic synchronicity became my engagement - a notion that Amacher formed during her long-form listening practices. It intrigued me in a number of ways; the concept, its perception, and the actual listening dedication completed by Amacher for its realisation.

Variations VII was a case similar to that of *City-Links*. I discovered that *Variations VII* investigated indeterminacy, and I wanted to explore that within my response. I also knew that by using the medium of the internet I could take the concept of a 'network of sounds' and place it within a digitally hosted performance stage and shared sonic environment, reducing the barriers of entry for both performers and listeners. I leveraged contemporary internet technologies to create a complex inter-dependant and intersecting network of performers and listeners, while staying true to certain performance instructions written by Cage for the original performance of *Variations VII*.

1.5.1. Inspirations and Guides

Of course, other historical works intrigued me just as much as those mentioned above, and in some cases my knowledge of them informed ideas I had while completing my own projects. The *League of Automatic Composers* (Bischoff *et al*., 1978) were a group of early network music pioneers who developed network performance topologies for shared musical information using interconnected computers. Knowledge of their works influenced the final portfolio work, *Fields of Feedback*, as well as the supplemental works entitled *Amalgam 2012* and *Amalgam 2013* (Appendix E and Appendix F), and *Sourced Cities* (Appendix H), found within the appendix.

Projects such as John Giorno's *Dial-a-Poem* (1968; see Joy, 2010, p. 101) inspired me to view the network as an organisational and communicational medium that enables altered perspectives of traditional performance topologies, while another Neuhaus piece - *Fan Music* (1968; see Joy, 2010, p. 102) urged me to consider an extended notion of a network - delving into realisations of networks formed through hardware. Douglas Hueblar's *Duration Piece #13* (1969, see Joy, 2010, p.

108) allowed me to consider the network as a system of co-operation, as his piece developed a send, receipt, return and reward system based on posted dollar bills; fostering a network of interaction and bi-directional trust - a notion that informed *Fields of Feedback*, as performers had to trust the feedback control system, its moderator, and each other, to not impinge on their performative individuality to detrimental effect (see Chapter 6).

All these projects contained elements I could have directly responded to, and all had concerns that inspired me. However, the three works I chose are iconic, familiar and widely accepted examples of early network music. I felt it would be foolish to pass up the chance to supplant them with contemporary technologies; evaluate their concerns, and to research whether their original artistic explorations withheld 21st century re-interpretation and critical evaluation.

1.6. Portfolio Outline

The attached portfolio consists of the documentation and supporting materials for the three artistic responses, and the final portfolio artwork: *Skype Supply*; *Synchrocities*; *Web Variations*; and *Fields of Feedback*. The full descriptions of the pieces, including the documentation materials, installation software, programming code, technological infrastructures, and installation instructions may be found within the attached USB memory drive. A brief introduction to the pieces is found below - in the form of programme notes - as well as information as regards the time and dates of demonstrations, performances, or installations.

1.6.1. Skype Supply

Friday 19th April, 2013 Open Skype Supply Session
@ PS2 Gallery, Belfast
A Participative Interactive Audio/Visual Installation

Skype Supply is a response to Max Neuhaus' *Public Supply I* (1966), one of a suite of works Neuhaus entitled *Broadcast Works*. *Skype Supply* implements the often used modern day communication mediums *Skype* and *YouTube* to create a virtual stage that affords dialogue between members of the public; both at the gallery space and further afield. Users interact with the work by calling a designated *Skype* address: skypesupply2013, delivering their voice, image, words, actions and creativity into the installation. The system then supplants their offering into a

bespoke software management application; creating a dynamic collage of participant offerings - attempting to forge semantic dialogue and meaning through its efforts. The output of the installation is simultaneously broadcast onto the Internet through the medium of a 'one-to-many' broadcast station: *YouTube*. Members of the public not situated at the gallery space may watch this broadcast and communicate with the installation, through *Skype*, from their own Internet enabled device. The two-way dependency between the installation and the participant creates a dynamic space in which the artwork pertains the ability, if leveraged, to feed back into itself.

1.6.2. Synchrocities

Saturday 27th & Sunday 28th September, 2014
@ Network Music Festival, Birmingham
An Audio/Visual Installation

Synchrocities is a multi-channel audio/visual installation in which a series of live microphone streams are analysed, in pairs, through FFT based spectral analysis. When the governing system, based in *Max/MSP*, determines a synchronous event it performs a specific process. A synchronous event is determined as a period of time in which simultaneous audio activity exists in two concurrent streams above a certain amplitude threshold and within a pre-defined frequency range (FFT bin). Four streams are analysed, in a bi-focal system. When a simultaneous event occurs, specific processes intervene. In the first instance, the governing system replays the specific FFT bin in which the synchronous event transpired. This may be called a 'frozen' moment. In the second instance, the system replays the sonorous activity through a convolution technique. The synchronous events from each stream are convolved with one another, and then replayed through the space - accentuating an interrelation between the two places.

The installation also contains a visual element in which a map is displayed on the front wall. The map remains hidden until a time in which a synchronous moment emerges. The synchronous event then reveals the specific locational origins of the streams. The interplay between the visual representation and the sonic events allow the listener to forge an understanding of the spectral relationship of the paired sites. *Synchrocities* is displayed within a quadrophonic array. The sonic pairings are made from microphone streams sourced through the *Locus Sonus* open microphone platform (www.locusonus.org/soundmap).

1.6.3. Web Variations

Friday August 14th, 2015
@ Sonic Arts Research Centre (SARC), Belfast
An Internet Based Performance Environment.
Located @ http://webvariations.herokuapp.com

Web Variations is an artistic response to John Cage's *Variations VII*, which was performed in 1966. *Web Variations* is an Internet based performance environment that allows performers, and listeners, to explore and navigate interrelation through musicality; creativity never in isolation, but always in relation.

Upon entering the system, a base node appears. This node represents the fundamental sound source; a live microphone stream, sourced from the *Locus Sonus* live microphone platform. A user may create their node by performing with this sound source. If more than one user is performing in the system, they will also appear as nodes. A user may listen to, or perform with, any available node within the environment.

The performance stage resides on the Internet, as a website. All interactions are interfaced by this website. As of now, the system only runs on the *Google Chrome* Internet desktop browser: due to complications with cross browser web-audio standard implementations. It is hoped that as the web standards develop and evolve, the website will be accessible through a multitude of browsers, and a multitude of devices.

1.6.4. Fields of Feedback

Wednesday July 27th, 2016
@ Sonic Arts Research Centre (SARC), Belfast
A Feedback Network Performance.

Fields of Feedback is a live, improvised group performance involving three laptop performers and one moderator. The performance topology is a direct representation of a specific type of machine learning algorithm, called a Hopfield Network. Within the performance each laptop is designated a unique input stream - a remotely located live microphone sourced from the *Locus Sonus* soundmap (www.locusonus.org/soundmap). Each performer's output is sent to a local

feedback moderation platform which connects the output of each performer's workstation to the input of every other performer - creating a complex and manipulable feedback network. The feedback platform is controlled by a fourth performer, who acts as moderator.

The performance is a delicate balancing act between individual and collective creativity, between artistic individuality and systemic governance. Directed relational paths enforce the emergence of aural communicational channels, as performers are urged to understand their individual actions, inspirations and modulations within a collaborative networked context; performer action is interdependent, as outputs directly intercede and intra-act on others' inputs.

1.7. Contributions to the Field

The textual documentation included in the thesis communicates a level of transferable knowledge by engaging with a critical reflection process that encompasses and extends a discussion that is under-represented. I believe there exists two primary contributions to the field, supported by a number of project specific contributions. The primary contributions to the field of network music consist of:

1) An examination of how contemporary technologies afford increasingly complex perceptual and technological understandings of network concepts, ideologies, strategies and topologies to be explored within network music.

2) An investigation into how certain performance topologies within network music alter the perception, interpretation, and impact of the network's role on involved musical agents.

As well as the general contributions to the field, there are a number of project specific contributions that arise through the creation of the individual artworks contained within the portfolio and the supplemental appendix:

1) Design, development and creation of software processes and algorithms for mixed-media file management within collaborative compositional systems - within *Skype Supply* (Chapter 3)

2) Programming and design strategies for simultaneous real-time audio monitoring, analysis, and signal processing techniques - within *Synchrocities* (Chapter 4)

3) Creation and design of multi-agent, internet-based, synchronous, shared sonic environment - within *Web Variations* (Chapter 5)

4) Development of multi-performer interdependent and inter-connective feedback systems and strategies for the implementation of machine learning network topologies - within *Fields of Feedback* (Chapter 6)

5) Development of multi-channel spatialisation performance strategies and technologies for combined network monitoring and sonification performance - within *Amalgam 2013* (Appendix F)

6) Design of technological management strategies and performance tools for multi-site, bi-directional, interactive and co-dependent performance - within *Ellipses* (Appendix G)

7) Management and design of uni-directional, real-time streamed audio, line-based network performance model - within *Sourced Cities* (Appendix H)

The creative element contained within the portfolio supports and reflects the textual analysis; expressing my artistic process and elucidating a degree of expertise with various elements of technologically dependent artistic creation, whether that be creative programming, systems design and architecture, or technical and systems management.

Through the creative works the reader should acknowledge some sense of originality, uniqueness, and personality; even if three of the works are, admittedly, artistic responses to prominent historical works. It would be naive of me to state formally that my own creative works stand on their own as contributions to a field of knowledge. The seemingly ever-expanding database of network art that holds sound, or music, as its creative fulcrum seems to attest to an ever enriching vocabulary; ever widening vernacular; and most importantly an ever extending language from contextual and creative perspectives (Joy, 2010). I hope that this thesis may be seen as a respected part of that evolution.

1.8. Summary

This chapter has introduced the dissertation thesis and accompanied portfolio. I began by explaining my formative interest in the research topic - outlining the relationship that existed between my early understanding of network music and

topics I was familiar with at the time - namely performance models that incorporated inter-connective strategies for performers and audience through the use of contemporary technologies. Following on from this, I introduced the concept of the network, explanations of network music, and also offered a working definition of network music practice. The next section detailed the structure of the thesis through a chapter by chapter outline. I then explained the methodology of the thesis, positioning it as a practice-based research process. I then outlined the thesis' research imperatives which should act as a guideline as to whether the thesis has been a successful undertaking. Following on from this, I detailed the rationale for the choice of historical works and then detailed the portfolio structure, by introducing each of the portfolio projects. Finally, I offered a section detailing the thesis' contributions to the field of network music, from both a holistic and a project specific perspective. It is hoped that this chapter has introduced and outlined the structure and process of the research clearly, while also detailing the imperatives against which the outcome should be judged.

Chapter Two

2. Literature Review

This chapter introduces the network music classification schemes of Alvaro Barbosa (2003), Gil Weinberg (2003), Golo Follmer (2005b), Alexander Carot (2009), and Alain Renaud (2009). Their categorisations describe certain forms, approaches, and strategies for network music. They are not seen as completive and act only as guide while navigating the practice's discography[1]. I will briefly comment on the merits and limitations of each system, describe specific forms in practice, and also place my portfolio works into their appropriate classifications. By completion of the chapter the reader should have an understanding of the existing classification schemes as well as an apprehension of various forms of network music practice.

2.1. Network Music Strategies

Gil Weinberg's thesis, written in 2003, entitled *Interconnected Musical Networks - Bringing Expression and Thoughtfulness to Collaborative Group Playing*, theorises that all interconnected musical networks (IMNs) fall on either side of a motivational divide - process or product (Weinberg, 2003).

> "...focus in process centered IMNs is on players' experience, whether it is social, creative or educational...the musical outcome of the interaction is less important than the process that participants go through while creating this outcome. The music in such systems [process centred IMNs] would therefore tend to be less coherent and structured than in product centered systems." (Weinberg, 2003, p. 41)

Weinberg draws a decision tree to explain the distinction between projects and highlight the motivational tradeoff that exists at the design stage of network music,

1 For a complete discography, please see Joy, J. (2010). *Networked Music & SoundArt Timeline (NMSAT): A Panoramic View of Practices & Techniques Related to Sound Transmission and Distance*. Locus Sonus, 2010.

regarding project focus, determinate or indeterminate behaviour, desired outcomes, and the method through which outcomes are achieved.

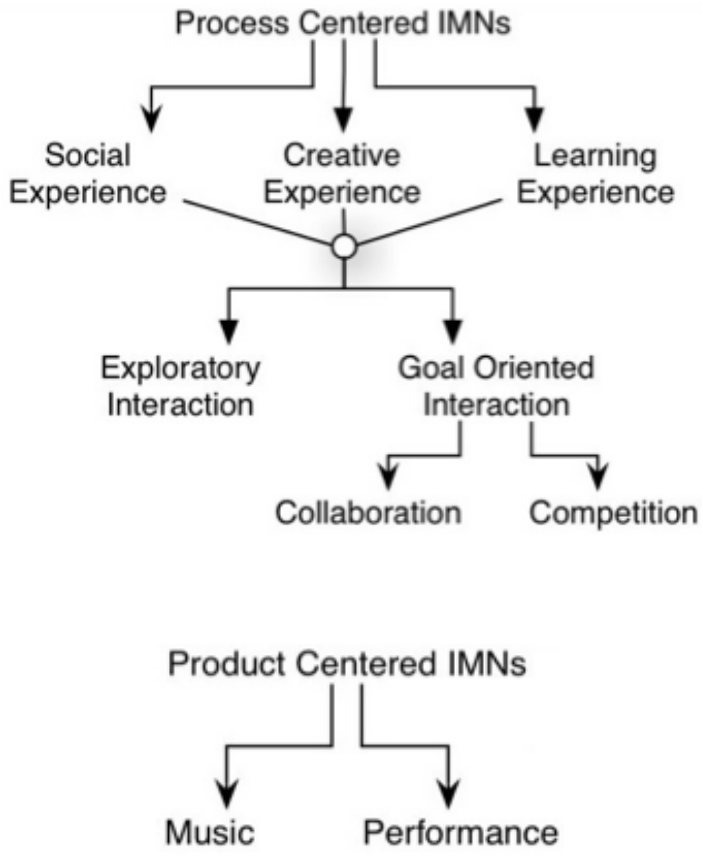

Fig. 1: Weinberg's Motivational Trees for Interconnected Musical Networks (Weinberg, 2003, p. 42)

The inherent complexity of combining different motivational aspects into IMN design is also acknowledged, as Weinberg feels that "many of these motivations are contradictory in nature" (Weinberg, 2003, p. 43). Perspectives of participant organisation are discussed, in recognition of the importance of governance and management of social interactions (Weinberg, 2003). Weinberg imagines a continuum existing between centralised and decentralised organisation, with projects falling somewhere along it, dependant on how the imposed structure defines the mode of participation.

> "The main axes at play here are the level of central control desired and the level equality provided to the different participants in the interaction. Centralized systems would usually be governed by a computerized hub responsible for receiving input from the participants, based on which the musical output will be generated. In decentralized systems players would

> usually communicate directly with each other through instruments that have computational power of their own." (Weinberg, 2003, p. 43)

Weinberg also imagines a spectrum existing within each organisational structure, using governmental descriptors such as democracy, monarchy, anarchy, equality, and inequality to explain "the levels of equality provided to participants in terms of their musical role" (Weinberg, 2003, p. 44).

The definition of roles within IMNs influences actualised architectures and topologies within Weinberg's classification scheme. He outlines a number of topologies that exemplify the described organisational structures - explaining how they might be implemented to suit certain motivational foci. Weinberg's IMN classification scheme is helpful, and goes a long way to explaining the differing motivations that exist within network music, but crucially it fails to consider three important aspects of the practice:

> i) how the medium influences motivations, design decisions, or organisational structures when the network is used to connect participants spread over large geographical distances
>
> ii) how the performance process may influence a change of focus, motivational concern, or organisational structure in a dynamic fashion
>
> iii) how implemented technologies influence motivations, design decisions, or organisational concerns

His classification scheme is a top-down, design based categorisation system with little concern for how the medium, technologies, and practice itself influence design choices. Crucially, his system concentrates on locally instantiated networks, as apposed to those that span large geographical spreads by using internet technologies.

An alternative classification scheme is offered by Golo Follmer, who created a typological ordering of 'net music' - "initiated in 1996 and presented in 2002 as a doctoral dissertation" (Follmer, 2005b, p. 185). Follmer found twelve distinct types, grouped into five 'clusters' (see Fig. 2). This typology classification was completed with respect to three key determinants.

> (i) 'interplay with network characteristics', which describes the extent to which structural characteristics of electronic networks shape the resulting music,

(ii) 'interactivity/openness', which relates to the degree of interactivity offered to the listener, i.e. the extent to which a type of Net music is open to activities by whoever wants to use it, and

(iii) 'complexity/flexibility', which defines the degree of musically effective complexity and variability. (Follmer, 2005b, p. 187)

The five 'clusters' describe core types of network music, with individual examples grouped with respect to their interaction, adoption, or acceptance of the outlined determinants. Despite the ordering being restricted (with respect to the three outlined determinants), it is still helpful to understand that the positioning of projects accepts a cross pollination of ideas, motives, foci, methods, and technologies - as apposed to the more binary infused schematic detailed by Weinberg.

Whereas Weinberg acknowledges that pre-planned design decisions influence the focus of IMNs, Follmer understands that projects can explore varying degrees, aspects, or conditions of the medium - rather than being drawn to either side of a decisional divide. Crucially, Follmer also includes projects that implement the network in a more distributed, geographically spread context - as apposed to the localised implementations of Weinberg's IMNs.

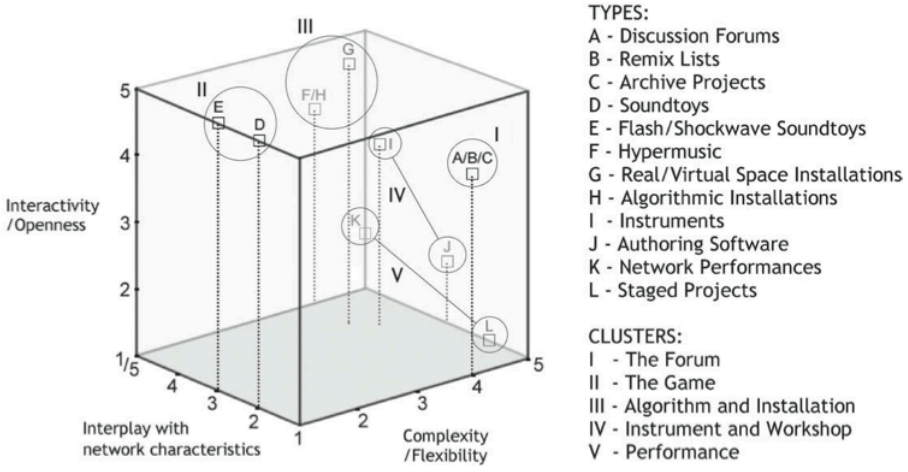

Fig. 2: Follmer's Ordering of Net Music
(Follmer, 2005b, p. 189)

An alternative stance is taken by Alvaro Barbosa (2003), who offers a survey of network music systems - detailing specific projects as direct examples of certain forms of practice. Barbosa understands that networking tools and technologies

drive forms of practice - allowing artists to explore differing avenues of artistic, technological and conceptual focus.

> "The introduction of various collaborative tools, made possible by the expansion of computer network systems and communications technology, has led to new methods of musical composition and improvisation." (Barbosa, 2003, p. 53)

The survey includes a number of different practices, each of which may be held as a defined example of network music. Barbosa understands that unique types of musical practice have emerged as artists and practitioners have incorporated the properties, affordances, concepts, and technologies of the network into their artistic practice. These forms will be discussed in greater detail in the sections from 2.1.1 onwards.

It is important to note that Barbosa understands the deterministic nature of latency within network music - especially within projects centred on collaborative, real-time, acoustic, synchronous performance. He believes that an upper threshold of acceptable latency binds most network performances (Barbosa, 2003). Latency is viewed as the time delay that appears between the transmission of data from one location to the reception at another, due mainly to the technological and physical architecture of the instantiated network (Barbosa, 2003). Barbosa's categorisation system is not determined by this concern, but understands latency as a property befalling most network music projects - unless restrictions are designed into the system with respect to synchronicity, distribution and/or spread of performance locations, and the imposed governance structure (Barbosa 2003).

Alexander Carot and Alain Renaud, both in 2009, offer strategic methods of performance centred around the technological restraints of network music systems - concerned with the management, optimisation, or acceptance of latency for network music involving acoustic instruments and instrument performers. Carot (2009) outlines a taxonomy of approaches that accounts for varying levels of performance of network music architectures - with respect to transmission delay, reception delay, synchronous and asynchronous behaviour, and the implementation of differing data transmission protocols.

Carot offers three core categories with respect to an 'upper acceptable limit' - described as the ensemble delay acceptance limit (EDAL). This upper limit is the

amount of time delay (latency) found acceptable by acoustic ensemble musicians operating within a network orientated performance (Carot, 2009).

> "Category A represents the ideal scenario with delays up to the EDAL. Category B approaches to maintain a rhythmical interplay despite latencies beyond the EDAL by applying four different artistic compromises. Category C introduces two further forms of remote musical interaction." (Carot, 2009, pp. 113-114)

Carot outlines four further sub-divisions within Category B (Carot, 2009) - which represent forms of compromise for those engaging with a network music system - the 'Master Slave Approach' (MSA), 'Laid Back Approach' (LBA), 'Delayed Feedback Approach' (DFA), and the 'Fake Time Approach' (FTA). Each offer strategies for dealing with the inherent delay that musicians find while engaging in network music. These four methods are distinct from the Category A method: 'Realistic Interaction Approach' (RIA) - which assumes a stable one-way latency below the EDAL, and the two category C methods: 'Latency Accepting Approach' (LAA) and 'Remote Recording Approach' (RAA) - which assume a complete acceptance of any delay above the EDAL.

Alain Renaud takes a similarly technologically deterministic stance, offering three categorisations: the Real-Time Playing Approach (RTPA), the Network Centric Approach (NCA), and the Distributed Studio Approach (DSA). The RTPA is seen as being extremely similar to Carot's LLA.

> "...real-time live music interactions are taking place between geographically displaced musicians without any specific strategy, in which they plug and play and naturally adapt to the latency conditions." (Renaud, 2009, pp. 101-102)

Renaud's network centric approach "considers the network as a decentralised and space independent medium. Thus, connecting globally with network delays is part of the performance" (Renaud, 2009, p. 103). The DSA approach "involves producing music using the Internet as a medium for remote recording sessions or remote tracking" (Renaud, 2009, p. 105), and is similar to Carot's RRA.

Even though there are distinct similarities between the two classification systems, Renaud also offers two alternative forms of practice; considering the acoustic properties of the network. The Network in Performance (NIP) and Performance in Network (PIN) approaches are offered to explain project's foci; how a project may

incorporate or implement the characteristics, affordances, or inherent properties of a network. With the NIP approach "performers are taking part in a distributed performance, comparable in networking terms to a peer-to-peer network" (Renaud, 2009, p. 186), as apposed to the PIN approach which

> "...has the potential of making the network an integral part of the performance. As in NIP, all the performers interconnect to each other but use the network as an additional acoustic contribution to the overall acoustic rendition of the combined space. More importantly, the network is used as a central point of reference for the interactions." (Renaud, 2009, pp. 187-188).

This conceptual outlook combines Renaud's technologically deterministic approaches with the more conceptually focused schemes of Barbosa and Follmer - who view the network as an independent medium that influences aspects of network music beyond the sole concern of audio, or data, transfer for ensemble musicians.

The differing classifications, categorisations, strategies, and approaches reflect the attempt by various authors to formalise an emerging form of practice from different perspectives. Weinberg describes his own IMNs - concentrating on the motivational decisions and tradeoffs necessary within the design stage of network music. Follmer creates an ordering of distinct network music types with respect to three specific determinants. Barbosa conducts a survey of existing practices, describing difference and similarity in an attempt to create distinct categorised forms, while both Renaud and Carot prescribe distinct approaches and strategies for ensemble musicians who face performing with the inherent acoustic characteristics of the network. It should be acknowledged that all the categorisation methods understand how instantiations of a network - as concept, system, governance strategy, technology, or metaphor - leaves substantial traces on musical composites.

The following sub-sections (2.1.1 - 2.1.8) detail a number of different forms of network music, describing practice that emerged in the latter stages of the 20th century. It will lean heavily on Barbosa's survey of network music practice (2003). I will also offer contemporary examples of practice, while placing my portfolio of works into their appropriate categorisations.

2.1.1. Local Musical Networks

Barbosa describes Gil Weinberg's (2003) definition of Interconnected Musical Networks (IMNs) as a method of performance that implements the concept of a network in a collaborative, interdependent, but inherently localised context.

> "...groups of performers who interact in real time with a set of musical instruments (or virtual musical instruments) with sonic interdependency provided by a local computer network." (Barbosa, 2003, p. 57)

Connections are usually instantiated between performers through a form of computer interfaced, or mediated, musical device. The method uses network concepts and/or technologies to create interconnected, interactive, inter and co-dependent musical performances by implementing bi-directional communication avenues between musicians (Barbosa, 2003).

Squeezables - a work developed in collaboration with Seum Lim Gan as part of Weinberg's thesis - is discussed by Barbosa. The project is seen as being an exemplification of local network music.

> "...a computer music instrument that allows a group of players to perform and improvise musical compositions by using a set of squeezing and pulling gestures...comprised of six squeezable and retractable gel balls mounted on a small podium." (Weinberg, 2003, p. 72)

Barbosa views the project as an example of a collaborative multi-user instrument in which a network of interdependency is crucial. He acknowledges the criticality of implementing "a real-time network system, due to the interdependency required among performers" (Barbosa, 2003, p. 55).

Local network performances do not necessarily depend on the internet, instead relying on technologies and protocols needed to create a real-time local networked communication system - thus reducing latency impingements. One of the foremost network music pioneers, *The League of Automatic Music Composers* (see Bischoff *et al.*, 1978), implemented electronic, computer-based local network architectures to explore the concept of collaborative, interconnected, and interactive musical performance systems.

> "Each composer had programmed his computer individually with a music program that was by itself able to produce music; however, the programs were also able to input data that would affect the musical content, and output data that would affect another computer's program." (Bischoff *et al.*, 1978, p. 25)

This performance architecture continues to be replicated, or re-modelled, as artists attempt to create interesting ways of performing music using networking concepts and ideas in a collaborative, localised setting - Alain Renaud's *Frequencyliator* (2006) being an example.

> "The concept is to create a framework for laptop improvisers to easily collaborate and exchange musical ideas over a local or remote networked setting." (Rebelo and Renaud, 2006, p. 3)

The focus of *Frequencyliator* is to create a technological infrastructure, designed primarily in *Max/MSP* [2], through which laptop improvisors create collaborative, interactive, and interdependent musical compositions (Rebelo and Renaud, 2006; Renaud, 2009). There are a number of shared parameters which each performer may address as a method for instructing or influencing the behaviour of other participants. The goal is similar to the early experiments by *The League of Automatic Composers* - to create a collaborative and interdependent computer interfaced, network-mediated musical performance.

Michael Gurevich's *JamSpace* (2006) is a slightly extended example of a local musical network being used to aid collaborative and interactive musical creation.

> "An interactive music environment to support real-time jamming by novices and amateur musicians over a network...JamSpace takes advantage of the low latency and connectivity of a local area network (LAN) to allow real-time rhythmic collaboration from isolated locations." (Gurevich, 2006, p. 118)

Gurevich envisions the technological apparatus of local area networks being used to create a performance of slightly larger scope, demonstrating a desire to explore the meaning and implications of isolated connections within a 'semi-localised' context. *JamSpace* participants are connected by a network as they perform in isolated spaces within a distinct location - for example a hotel, office building, or university. The performance is mediated through designed software and hardware interfaces - *JamPads* - specifically built to aid novice network performers

2 *Max/MSP* is a graphical programming language created by *Cycling'74*. More information is available at https://cycling74.com/

(Gurevich, 2006). This project moves closer to the distributed performance ideals discussed later within this chapter (see section 2.1.5), while utilising the inherent advantages - reduced latency, simplified connection and communication, clarity of design, and ease of control - of local networks to achieve its ideal (Gurevich, 2006).

The *Amalgam 2012* and *Amalgam 2013* projects contained within this thesis' appendix (see Appendix E and Appendix F) also instantiate local musical networks. In both performances, a local network is instantiated so that three laptop performers participate in a room, connected in a specific topology. As an added layer of complexity, internet traffic data is interpreted as simple on/off trigger information. Previously prepared audio samples (derived from prepared recordings of the performance space) are triggered with respect to the incoming arrival of network data packets. The triggered audio samples are then simultaneously sent to three processing computers where each of the performers engage in their own audio signal processing. The audio output of these three computers is then sent to the main mixing board which is connected to the speaker system (see Fig. 3).

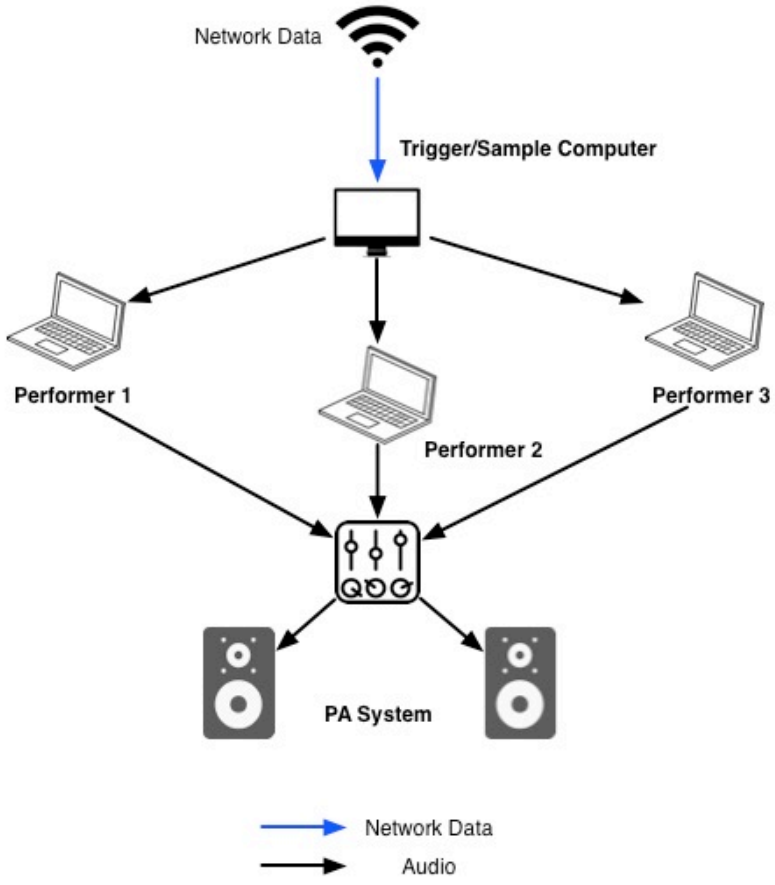

Fig. 3: Topology Diagram for *Amalgam* Projects

This topology may be seen as an extended local network system. The three performers are located in the same performance space for a synchronous performance, with the extension being provided by the internet data traffic, interpreted as sample trigger information. However, it should be noted that performative interdependency and bi-directional communication was not the focus of this project. The local network was instantiated so that one main performance machine (directed by interpreted internet traffic data) shared audio information simultaneously to three user-controlled performance computers.

The final work of the portfolio, *Fields of Feedback*, is also an example of a local music network - though extended somewhat from the formative notions outlined by Barbosa and Weinberg. In *Fields of Feedback* three performers are connected through a feedback network that is controlled by a fourth performer, who acts as a network moderator (see Chapter 6). The project bears close resemblance to Barbosa's local music network, as internet technologies are not implemented to connect the performers' workstations (though the technology is used to source the performances' raw sound material from an internet based live microphone database). *Fields of Feedback* also bears resemblance to the previously mentioned Performance in Network (PIN) approach, as outlined by Renaud (see section 2.1). The instantiated network - in this case a model for a neural network drawn from the field of machine learning - was attributed with affecting the project's outcome in a number of ways: behavioural; musical; and perceptual (see Chapter 6).

Local network systems being adopted in a more mainstream context is seen with the development of *Link* [3] for *Ableton Live* [4]. *Link* is described as "a technology that keeps devices in time over a wireless network" (Ableton, 2016, p. 1). It allows users of the mainstream digital audio workstation (DAW) *Ableton Live* to synchronise their device with any other device that contains *Link* functionality - this may include other instances of *Ableton Live,* as well as specific *iOS* [5] musical applications. It is important to note that *Link* provides software based functionality for network synchronisation, leveraging collaborative possibilities for users who wish to play together using digitally interfaced instruments and workstations - it does not provide an avenue for open sharing of data between connected users, and

3 Link is software based functionality built into Ableton Live v9.5 and later. More information may be found at https://www.ableton.com/en/link/

4 Ableton Live is a software based digital audio workstation. More information may be found at http://ableton.com

5 iOS is the mobile device operating system of device manufacturer, Apple. More information may be found at http://www.apple.com/uk/ios/?cid=wwa-uk-kwg-features

it is unclear if this will be a future development for the *Link* protocol. It must also be noted that *Link's* functionality remains at a localised level, as users who wish to connect their devices must all be connected to the same wireless network. My own previous research (see Renwick, 2012) also engaged with this idea, as I developed a standalone application, programmed in *Max/MSP*, that allowed users of *Ableton Live* to synchronise instances of DAWs over a local network.

2.1.2. Composition Support Systems

The adoption of the internet as a primary medium of information exchange has allowed composers to harness its potential to support collaborative composition systems where the network is used as technological infrastructure for the exchange of compositional ideas, as well as synchronous, and/or asynchronous, collaborative production of music.

> " [They are] used to assist more traditional forms of musical composition and production...by allowing geographical displacement and asynchronous collaboration." (Barbosa, 2003, p. 57)

Barbosa offers Craig R. Latta's *NetJam* (1990) as an early example. Latta's system used email as the primary communication tool for the exchange of MIDI [6] files from composer to composer. It allowed remotely located composers to exchange compositional ideas through a digitally mediated communicational tool.

Barbosa explains how online composition support tools are becoming more ubiquitous "in the form of distributed systems coupled with centralized servers that manage sessions and groups of users" (Barbosa, 2003, p. 55). Since Barbosa's paper these types of systems have become more widespread, with a number of competing variants now existing. *Ohm Studio* [7], created by digital audio effects and synthesiser module creator *Ohmforce,* is one example. In the product documentation the creators state that *Ohm Studio* has "collaboration at the core" (Ohmforce, 2016). They discuss their incorporation of a collaborative feature set directly into the product, viewing the social element as a unique product differentiator.

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6 Musical Instrument Digital Interface (MIDI) is a industry standard musical instrument communication protocol developed by a number of manufacturers in the 1980s. More information may be found at https://www.midi.org/

7 *Ohm Studio* is a traditional computer based digital audio workstation, which had collaborative, online features at its core. More information may be found at https://www.ohmforce.com/OhmStudio.do.

> "As a new feature, it's tempting to see collaboration as an extra line in a list. While designing the Ohm Studio, we were led by the idea that it is more than just that. We've worked to free you from having to establish a connection, keep data synchronized, deal with rights, keep track of who did what, enable you to get privacy when you need it, etc. Every part in Ohm Studio has been thought through so as to be collaboration proof." (Ohmforce, 2016).

Ohm Studio is an example of traditional stand-alone digital audio workstation software featuring a set of in-built collaborative composition tools. The software allows composers to share compositional duty, collaborating directly with remotely located composers, producers and musicians.

The concept of networked composition systems has evolved further with the advent and cross-browser support for *WebAudio* [8]. *Audiotool* [9] and *Soundtrap* [10] are recent examples of internet browser based production tools - as apposed to standalone applications. What differentiates these tools is that they run directly through a standard internet browser (though caveats exist with respect to browser version). They do not require any software to be downloaded by the end-user, reducing the barrier for entry for those interested in engaging in collaborative composition. Compositions may be created, in real-time, as two or more remotely located composers work simultaneously on a shared production - with updates to the current status of the project being delivered across all users' browsers simultaneously.

2.1.3. Collective Creation Systems

Collective creation systems may be seen as an extension of composition support systems, but with the focus shifted towards composition approached from "a community perspective" (Barbosa, 2003, p. 55). Community, in this context, is seen as a group of people that are considered collectively.

> "**community** |noun| *plural* **communities**: The people of a district or country considered collectively, especially in the context of social values and responsibilities; society" (Oxford Dictionary, 2015).

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8 *WebAudio* is a JavaScript API developed primarily for browser-based audio applications. More information may be found at https://www.w3.org/TR/webaudio/

9 More information on *Audiotool* may be found at https://www.audiotool.com/

10 More information on *Soundtrap* may be found at https://www.soundtrap.com/

Within these systems, anonymous users create compositions in a collective manner, taking responsibility for small segments that form part of a larger piece of music. This concept of distributed compositional responsibility was explored in Sergi Jorda's *FMOL* (1997) project. The project, online for approximately three years, saw several hundred composers participate in the creation of excerpts for musical scores for two plays by *La Fura del Baus*, a Catalan theatre company, as well as a compact disc release (Barbosa, 2003).

Within collective creation systems, organisational governance becomes a predominant concern, as does authorship - as composers are attributed with creating a small section of a complete work. In Jorda's project, a centralised server was created into which a number of users contributed their offerings, with the network taking the role of supporting infrastructure. This organisational structure may be conceptualised by turning to network music theory, and specifically the concept of dramaturgy.

The term dramaturgy is borrowed from the performing arts, specifically theatre, where it has been implemented as a conceptual frame for understanding "notions of authorship, collaboration, structure, content and as an umbrella term for a number of aspects that characterise performance practice" (Rebelo *et al.*, 2008, p. 1). Rebelo (Rebelo *et al.*, 2008; Rebelo, 2009), and Schroeder (2009) have discussed the link between concepts of dramaturgy and network music, viewing dramaturgy as an investigative tool that allows exploration of "questions of involvement of multiple sites/nodes and the relation between multiple kinds of artistic input" (Rebelo *et al.*, 2008, p. 1).

Distributed Dramaturgy is apt for describing the ownership and authorship concerns within collective creation systems: "each node retains authorship while contributing specific content and expertise to a shared production" (Rebelo *et al.*, 2008, p. 2). This specific organisational model describes a decentralised formation; allowing a greater degree of creative control to contributing nodes.

A recent example of a collective creation system was completed in 2008 by *The Cathedral Band*, entitled *Say The Music*.

> "[*Say The Music* is] a global sound event in which people from around the world are invited to participate. Here is how: simply call a local phone number in your area; leave us a personalized sound, song, word or phrase; and DJ Tamara or I will mix your sound into the performance. You will even be able

> to hear it in a live webcast. Local phone numbers are available worldwide - from New York to Seattle, and Brisbane to Perth, plus London, Paris, Rome, Tokyo, and Rio." (cited in Joy, 2010, pp. 446-447)

This work allowed participants to offer specific content to a shared production. By phoning into a centralised server - moderated by DJ Tamara - participants contribute to a collective performance. *Say The Music* is similar to two works discussed at length later in this thesis: Max Neuhaus' *Public Supply I*, and my own portfolio work, *Skype Supply* - both discussed in Chapter 3. The two works - classified as collective creation systems - use a network to provide the technological means for participants to offer content into a shared production. A centralised server is used which acts as a moderating locale. Within *Public Supply I*, Neuhaus acted as moderator, while the formation was altered in *Skype Supply* - as a software program was designated this role.

2.1.4. Telematic Performance

Shanken describes telematics as "a broad field of computer-mediated communication" (Shanken, 2000, p. 65). The *Oxford Dictionary* offers a slightly extended definition.

> "**telematics** | plural noun | The branch of information technology which deals with the long-distance transmission of computerized information" (Oxford Dictionaries, 2015).

These descriptions reflect the broad nature of the term. Roy Ascott, one of telematics early celebrants, describes telematic culture as that which involves the creation of a self reflective art form.

> "Telematic culture means, in short, that we do not think, see, or feel in isolation. Creativity is shared, authorship is distributed...telematic culture amplifies the individual's capacity for creative thought and action, for more vivid and intense experience, for more informed perception, by enabling her to participate in the production of global vision through networked interaction with other minds, other sensibilities, other sensing and thinking systems across the planet..." (Ascott, 1990, p. 243)

From the perspective of network music, telematic performance is a specific category where the connection of remotely located persons, places, and spaces is the central investigative avenue. It explores what it is, or means, to be connected -

considering either directly, or indirectly, the implications and idiosyncrasies of the connection. Telematic performance is almost always realised through a combination of aural and visual mediums; combining to create an immersive and enveloping experience for participants and audience.

Telematic performances use audio and video network transmission technologies, based on networking technologies such as the Transmission Control Protocol (TCP) and User Datagram Protocol (UDP) to create performance architectures that explore aspects of network space, place, absence, and presence (Barbosa, 2003). Such tools include, but are not limited to, the Stanford University developed *JackTrip*[11] - for high quality audio communication over the internet - and the McGill University developed *UltraVideo*[12] - for video conferencing.

Oliveros *et al.* (2009) offer six perspectives of telematics, describing it as being "performed live and simultaneously across geographic location" (Oliveros *et al.*, 2009, p. 1). Her project *AB_Time* (2005), completed with Scot Gresham-Lancaster, incorporates a combination of sound, movement and dance.

> "a three-way transmission with dancers and musicians at Mills College in Oakland, CA; Skalen Dance Company Studio in Marseille, FR; and iEAR Studio in Troy, NY. All could see and hear one another. Patrick Laffonte, video artist, arranged projections in Marseille so that the audience sometimes experienced the live dancers on screen with the distant performers creating illusions that were disorienting as to place and time opening a vast potential for the art of virtual space." (Oliveros, 2009, p. 3)

There are similarities between Oliveros' *AB_Time* and the project, *Ellipses,* which I completed in 2013 with Ivani Santana[13]. *Ellipses* explores a sonified, bi-directional, interactive connection between dancers - one located at New York University (NYU), in the United States, and one at the Sonic Arts Research Centre (SARC), Northern Ireland. The project combined both aural and visual media, allowing the

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11 *JackTrip* is currently the best adapted software based tool for audio networking over the Internet. Developed at the Centre for Computer Research in Music and Acoustics (CCRMA) at Stanford University, United States. More information may be found at https://ccrma.stanford.edu/groups/soundwire/software/jacktrip/

12 *UltraVideo* is a conferencing software that was developed at the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT) at McGill University, Canada. More information may be found at http://ultravideo.mcgill.ca/

13 More information may be found at http://ivanisantana.net/en/academic_proj/dramaturgia-de-um-corpo-tele-sonoro-20122013/. More specific information regarding the *Ellipses* performance is located within the Appendix of this thesis.

audience to engage with a temporarily shared, bi-directional and inter-dependent performance connection.

Ivani Santana has explored telematic performance for over ten years, involving herself predominantly in visually orientated works (Santana, 2015). Recently, she discussed telematic art, giving prominence to its conceptual concerns.

> "It is not a matter of just transmitting remote locations over the Internet, but rather it is the dynamic and constant relationship between these locations and the very condition of the network that must be understood as a functional unit, responsible for the art to emerge." (Santana, 2015, p. 330)

In another of Santana's works, *Sound Me* (2013), dancers captured the sounds of New York's 4th Street through radio microphones. This soundscape was then transmitted over a network to a laptop performer located in a performance space in Northern Ireland, for audio signal processing. Here, the sound was merged with the microphone captured breath and vocal utterances of Santana - also located in Northern Ireland - so that a merged, mixed, and digitally processed soundscape was heard. A large visual display located in the Northern Ireland performance space showed the dancers in New York - in real-time - as they mingled among, moved with, and captured the sonic essence of their location. Santana performed in front of this display, merging spaces and places through the telematic apparatus (see Fig. 4). This enveloping and immersive performance attempted to place dancers at two locations simultaneously - their presence felt through communicated sonic and visual representation.

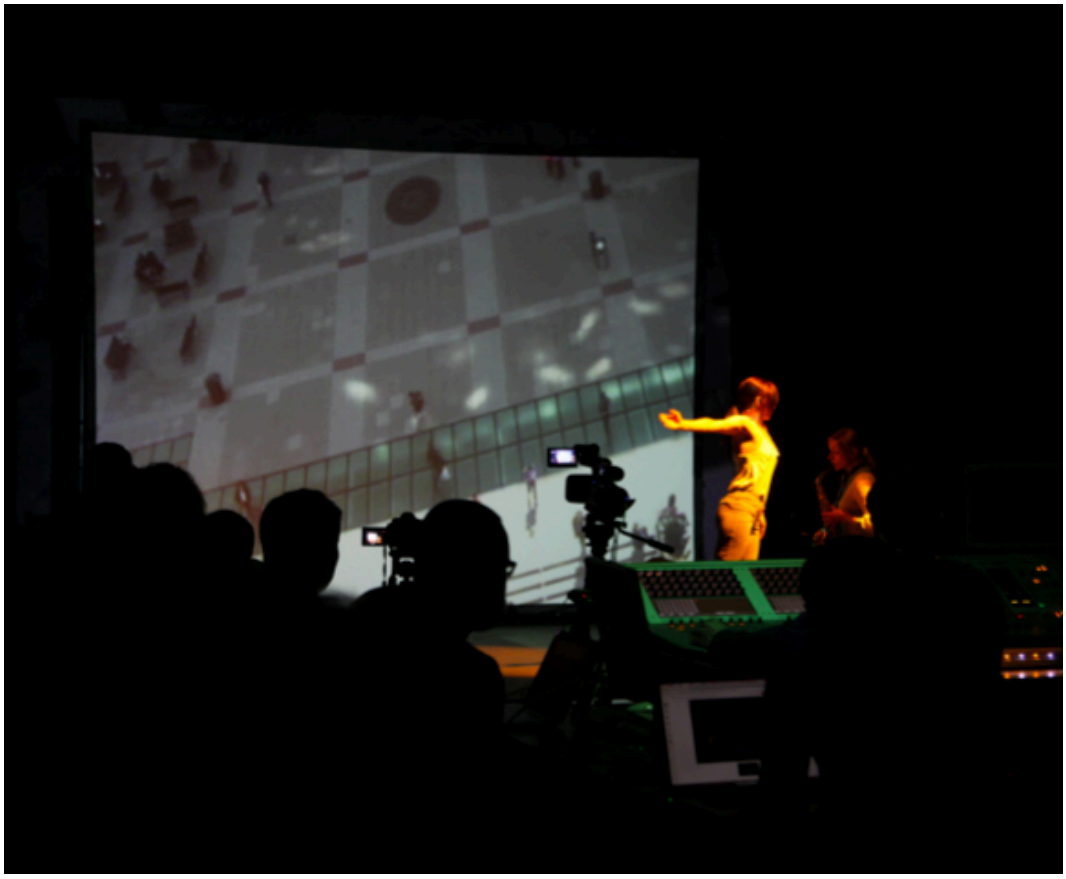

Fig. 4: *Sound Me* performance space in Belfast

Sarah Weaver - based in New York - is a former student of Pauline Oliveros. Weaver has been a proponent of telematic music since she learned about the medium during her time spent at the *Deep Listening Institute* [14] in 2006 (Weaver, 2009). I had the pleasure of working with Weaver during my time at SARC, taking on the role of technical director and network sound engineer on a project entitled, *Time Axiom* (2013). For this performance, three sites were connected through audio and video - New York, Belfast, and Zurich[15]. The performance consisted of a number of new works, composed specifically for the medium, involving acoustic and experimental instruments, laptop performers, and the combination of experimental and graphical scores.

> "Time Axiom is a concert in the telematic music medium - live performance via the internet by musicians in different geographic locations. Featuring premieres of works by composers in New York - Mark Dresser, Elizabeth Hoffman, and Sarah Weaver, Time Axiom utilizes renowned acoustic and

14 More information about the *Deep Listening Institute* may be found at http://deeplistening.org/site/

15 More information may be found at http://www.sarahweaver.org/12_15_13_time_axiom_telematic_music_concert_new_york_belfast_zurich/

> electronic musicians, static and processed video, and the temporal and spatial properties of the telematic medium." (Weaver, 2015, p.1)

Mark Dresser - a performer and composer involved in *Time Axiom* - has described the specific intimacy that emerges in the exacting and demanding, designing, planning, rehearsing and performance stages of telematic performance. He describes a unique kind of collaborative process, one that cannot emerge in any other way; artists and performers are forced to communicate, separated by large distances - attempting to create a shared space of the most involved music and visual connection (Dresser, 2009). He describes his view of telematic music, "Telematic performance isn't a replacement for live performance, but rather an alternative venue that has the potential of artistic intimacy" (Dresser, 2009).

2.1.5. Distributed Performance

Distributed performance is a form of network music where participants are distributed across geographic locations, connected through technological means as they simultaneously perform together. It may be seen as a sub-section of telematic performance, but it is important to note the subtle differences that exist between the two. Firstly, distributed performance does not prioritise visual connection (though performances do often include video for the benefit of the audience). Secondly, the connection is not the focus of exploration. In distributed performance the network is being used as a support structure through which the performance may be actualised, rather than a medium to be investigated or probed. This mirrors the binary schematic of Renaud's NIP and PIN approaches (see section 2.1). Telematic performance represents a network in performance approach, whereas distributed performance leans towards the description of a performance in network approach.

Barbosa terms distributed performance as 'Remote Collaborative Performance Systems', noting that it often involves one site obtaining central control over other participating or collaborative sites - as apposed to the rich interaction, interconnection, and bi-directional co-dependency of telematic performance (Barbosa, 2003). Distributed performances often result in complex architectures and technologies being built - as telematic performances do - but use these architectures as support system, as apposed to artistic playground. Though a wide range of projects may be included under this classification, it is important to note that the concern is centred on the outcome of the performance - the 'product' by Weinberg's definition - rather than 'process' (which would be the focus of telematic performance).

Barbosa details performances that include specially devised instruments purposely built for remote collaboration, such as the 1998 *TransMIDI* system - which allowed performers and listeners to perform together in multiple session groups using the MIDI protocol (Barbosa, 2003) - and *TransJam*, designed in 1997, which allows "synchronous peer-to-peer interaction between several users but goes beyond the MIDI format by supporting low-fidelity digital audio" (Barbosa, 2003, pp. 56-57). A more recent example of this type of performance would be Georg Hajdu's *Quintet.net* project.

> "Quintet.net is a real-time interactive environment for intermedial composition and performance on local networks as well as the Internet...five performers under the control of a conductor, thus dealing with important aspects of symbolic, aural and visual communication among the participants and the network audience" (Hajdu, 2005, p. 23)

Within *Quintet.net*, Hajdu creates four distinct components - Client, Conductor, Listener, and Server, with an added Viewer layer for the audience. Hajdu creates a centralised environment - managed by a server - through which all communication is routed. This performance schematic allows performers to engage in collaborative musical activity ranging from "free improvisation to precise notation" (Hajdu, 2005, p. 26) dependent on the performance type and enacted approach. Hajdu also discusses how network latency - referred to as jitter - is dealt with by the system. A buffering technique is created to account for the temporal differences with respect to the arrival of messages between performers. This reflects Carot's fake time approach (FTA) - as an average shared time is calculated, accounting for the varying latency each performer is subjected to.

Of course, not all distributed performances entail building dedicated network instruments, tools, and components. Distributed performances may also be focused on instrument playing, with performers engaging in improvised, or pre-determined musical performance - accepting any latency that occurs in the transfer of audio data between sites. Distributed performances often incorporate multiple sites, each containing a number of local performers and a local audience. Each site hears every other performance site but only views the local performers (unless video-based presentations are used to augment the spectacle). This standard formation entails performers connecting over a network, with an audience viewing a local performance - simultaneously aware of a remote performance, a remote audience, and the fact that they are witnessing a distributed performance.

An extension of this situation is where performers are distributed remotely, with an audience located at a performance site not containing any performing musicians. The shift in focus is subtle, but important, as it accentuates the distributed nature of the performance. *Sobralasolas*, created in 2007, is a recent example of this specific formation.

> "...a band playing without seeing each other, being located in her/his own context or environments, combining with live selected and composed sound, and the result is listened by an audience in a specific space without present players or on air. The live co-composition and co-improvisation by distributed players is the objective." (Joy, 2010, p. 433)

A situation is described in which performers are distributed across the globe while offering content to a shared production. The audience hears the performances of remotely located musicians, but does not engage in direct visual contact with any of them. *Sobralasolas* may be theoretically framed by the concept of dramaturgy as the topology is close to the concept of Directed Dramaturgy, where "...authorship remains with an individual or group who takes on the role of director" (Rebelo, 2009, p. 390). In this approach, a directorial agent will address and distribute certain tasks or roles to distributed performers, all under one common aesthetic goal (Rebelo, 2009). This implies that distributed performance does not immediately indicate Distributed Dramaturgy (see section 2.1.3).

2.1.6. Live Coding

A classification type under-discussed by Barbosa, but worth mentioning in any summation of contemporary network music practice, is musically focused live coding. Live coding emerged from the domain of computer science and was subsequently adopted by experimental artistic practitioners who sought to combine software based programming languages and improvised live performance (Magnusson, 2014). Thor Magnusson accepts the practice has its roots in live programming, as it exemplifies a situation in which "Algorithmic instructions are written in real time" (Magnusson, 2014, p. 9). In musical contexts, performers use programming languages to create digitally synthesised sound - likening their software and hardware interfaces to performable instruments (McKinney and Collins, 2012; McKinney, 2014; Magnusson, 2014).

Magnusson outlines the diversity of live coding practice, describing examples such as the early experiments with locally networked laptops by the aptly named

PowerBooks.UnPlugged, to the purposely designed, web-browser interfaced programming environment of *Lich.js* [16]. He also acknowledges the rising interest in 'laptop ensembles' - wherein a number of performers, distributed locally or remotely, create music together in synchronised contexts. These ensembles often use nothing more than their computer hardware, networking tools, protocols, techniques, and programming languages capable of generating sound to create music within an improvised performance context.

Networking techniques, concepts, and technologies are incorporated into live coding practices implicitly, or explicitly. Implicitly, through network data protocols for shared algorithmic instructions and purposely designed communication structures, or explicitly, through multi-location performance topologies and/or collaborative coding environments. Sociological concerns such as communication, organisation and governance are often central avenues of exploration, while technological concerns such as data sharing technologies, audio data transferral, and synchronisation techniques and tools are hurdles that most live-coding practitioners must contend with (Bryan-Kinns, 2012; Fencott and Bryan-Kinns, 2010; Magnusson, 2014; McKinney and Collins, 2012; McKinney, 2014).

Magnusson discusses the system entitled *LOLC* - created by Jason Freeman and Akito Van Troyer in 2011 - a standardised platform for networked live coding.

> "[LOLC] simulates a chat client and allows novices in computer programming to live code music in larger ensembles over a wireless network in the same location or in a distributed performance. The system encourages not only conversation and collaboration between performers, but also the borrowing and adoption of code, practically rendering the question of authorship in this collaborative performance setup meaningless." (Magnusson, 2014, p. 12)

The position of authorship becoming 'meaningless' is an interesting stance, as authorship is a key concern within the wider context of network music. The ease at which the live coding community dispose of authorship concerns might be seen as a direct reflection of its 'open source' mentality - coders often engage in code sharing and collaborative projects where a number of programmers offer their expertise to a shared production or programming problem, with programmers accepting collective and community-based responsibility.

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16 *Lich.js* may be accessed at https://www.chromeexperiments.com/experiment/lichjs

Magnusson also details how the development of web technologies has spurned a number of internet based, browser interfaced, live coding environments. These systems are similar to those discussed below in section 2.1.7, and also to the web-based collaborative composition environments discussed in section 2.1.2, but their emphasis is on providing a standardised software programming platform for coders to engage with musical practice in a distributed setting; *Gibber* [17] is an example of this platform in practice.

> " [*Gibber* is] a system that takes live coding into the realm of the Web browser. Using the new Web Audio technologies for JavaScript, the system enables people to visit a Web page and start creating synthesizers or composing music, without needing to download and install any additional software. Multiple users can contribute in the same session in a networked performance manner." (Magnusson, 2014, p. 12)

Lich.js - designed by McKinney in 2014 - is a server/client based programming environment similar to *Gibber*; leveraged by web technologies such as *Node.js* [18] and *Web Audio*. McKinney's goal was to "create a new [programming] language designed from the beginning with quick collaboration in mind" (McKinney, 2014, p. 380). The result is a browser based interface that allows users to code collaboratively, where each user's actions intercede on all other connected clients.

> "...code is executed across the network. Whenever any user executes a function that function is sent across the network and executed for each client." (McKinney, 2014, p. 382)

McKinney accepts that there are some issues with the synchronisation functionality, noting that the environment is still in development. He hopes the platform will mature alongside the technologies used to build it. What must be acknowledged is that the live coding community has adopted networking tools, techniques, concepts and strategies as both technological drive and artistic spur for its own experimentation and exploration - in turn developing and evolving the practice of network music.

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17 *Gibber* may be accessed at http://gibber.mat.ucsb.edu/

18 *Node.js* is a programming framework devised for networking applications. More information may be found at https://nodejs.org/en/about/

2.1.7. Internet Based Systems and Shared Sonic Environments

Barbosa describes internet based platforms for improvised network music where focus shifts away from structured performances towards digital environments that allow for the creation of collaborative music. These environments reside in an online space, offering the chance for expert and novice participants to explore musical applications together.

> "In such openly shared spaces members of the on-line community can participate in a public event by manipulating or transforming sounds and musical structures or by simply listening to music created collectively." (Barbosa, 2003, p. 57)

Barbosa recalls an early example of this classification in practice, Atau Tanaka's *MP3Q*, developed in 2000.

> " [*MP3Q* is] a shared online sound space that streams multiple channels of MP3 audio from different servers. Users can concurrently manipulate these MP3 sources by using a 3D cube to actuate a graphic representation of the system's current behaviour." (Barbosa, 2003, p. 57)

The behaviour of *MP3Q* is similar to my own portfolio work, *Web Variations* (see Chapter 5), in which users manipulate audio streams in an online environment - creating organisational networks derived from enacted connections. The platform allows both simple and intricate network structures to be formed by participants as they engage with the environment through their internet browser. It also allows participants to engage with any performance solely by listening. An independent choice is offered to each connected browser window. In this manner, a listener may navigate the collaborative performance in a completely unique process.

In a similar vein to the networked composition systems described in section 2.1.2, the existence and technological intricateness of shared sonic environments has blossomed in direct relation to the development of internet tools and technologies. A recent example of this is *MultiPlayerPiano* [19], created in 2012, which offers participants an internet based virtual piano that may be played simultaneously with other users. The project explores aspects of collaborative improvisation, performance, and composition - with a specific focus on emergent properties - as it

19 *MultiPlayerPiano* may be viewed at http://multiplayerpiano.com. Further information may be found at https://www.facebook.com/MultiplayerPiano/

offers a collaborative interactive musical instrument as well as a text based group communication tool; allowing users to share instructions, advice, or improvisational and compositional ideas as they interact in the shared online environment.

Plink, created by Dinahmoe [20] , an interaction production company with headquarters based in Sweden, is a multi-player musical environment that allows four simultaneous users to create music in a game-based fashion. The interface resembles a video game - users control horizontally scrolling 'rocket-ships' whose on-screen vertical movement controls the pitch of a individually designated software based instrument.

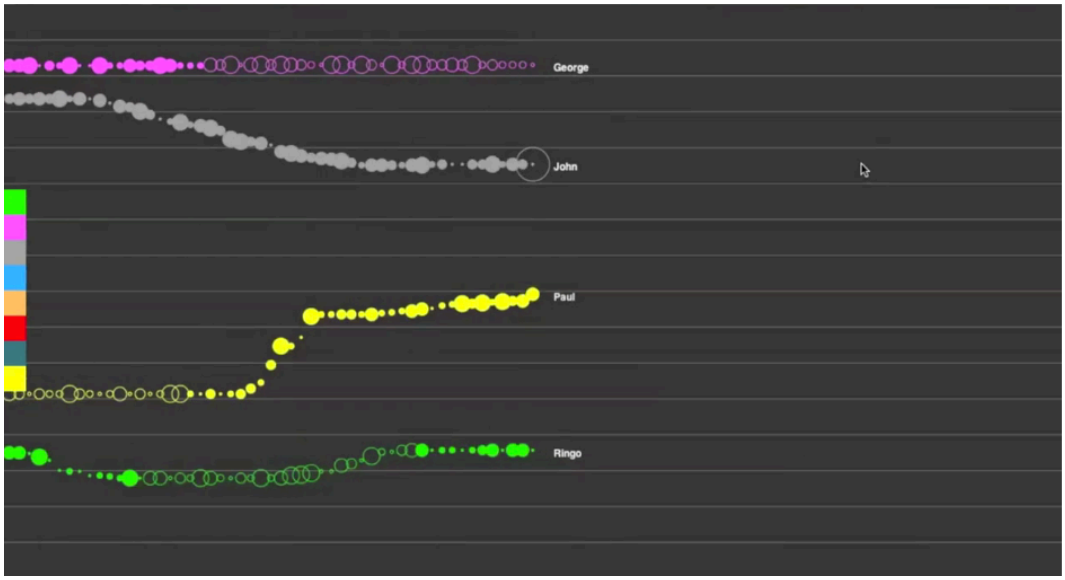

Fig. 5: Plink composition interface

This system exemplifies the development of shared sonic environments beyond the creation of academic researchers and artists, into the domain of interactive production companies. The social nature of network music has spurred digital designers to harness the tools and technologies of the internet to create interactive and collaborative environments; showcasing technological and programming aptitude and/or web based design skills - moving network music away from purely research and musical domains into mainstream ones, as seen in the discussion of *Link* in section 2.1.1.

20 More information about *Dinahmoe* may be found at http://dinahmoe.com with more information, and a video trailer of *Plink* found at http://dinahmoelabs.com/plink

2.1.8. Extended and Emerging Forms

Having discussed a number of classification systems it is important to note that as network music develops - conceptually, idealistically, and technologically - performance systems and environments emerge that do not easily fit into one specific category or classification. Though Barbosa's survey offers an overview of the main forms of practice, it is not complete and needs supplementing even within the context of this chapter - with the addition of live coding discussed in section 2.1.7.

There are a number of projects that straddle categorisations - exploring aspects of one while borrowing ideals, concepts, and strategies from others. For example, the resemblance of *Plink* (see section 2.1.7) to a video-game is representative of the merge between networking concepts and technologies, collaborative ideals, and game-driven motives and design choices - a development also seen within other areas of network music.

Game music has its own rich history - existing before the advent of the internet or networking technologies - traceable to the post-structuralist ideals of composers such as John Cage and Pierre Boulez in the 1950s and 1960s through their experiments with indeterminacy and chance. It is important, though, to acknowledge the merging of strategies and approaches from game based music to network music as it highlights the artistically driven exploration, and continued evolution, of what is a relatively recent form of experimental music practice.

Felipe Hickmann's recent PhD thesis, entitled *Territories of Secrecy: Presence and Play in Networked Music Performance* explores game-derived approaches to network music, "the thesis proposes the use of game systems as a strategy for negotiating musical play in networked settings" (Hickmann, 2013, p. 2). Hickmann devises performance systems and environments; allowing participants and audience members to negotiate game-based musical strategies ranging from competition to collaboration. The portfolio straddles distributed performance and telematic performance, extending the concept of network music into other realms by combining music with art forms such as theatre and dance.

Father-Son (2013) is an experimental performance combining game strategy, theatre, and improvised instrument playing and involves the connection of two geographically separated locations on a University campus.

> "Father-Son subverts most networked performance practice in that the medium, albeit providing a live connection between remote spaces, is made to symbolise dislocation of a different nature. The two participating venues are reframed under the argument set by an underlying dramatic plot - a distributed narrative comprising two parallel storylines. In the diegetic setting of *Father-Son*, the two venues do not represent separate spaces, but separate times..." (Hickmann, 2013, p. 105)

Audience members are asked to engage in a process that alters the narrative of the story, with the connection between two locations representing a "bridge that spans twenty-four years in time" (Hickmann, 2013, p. 107). Though the project resembles a telematic performance, Hickmann's use of game strategy to provide an avenue of interaction to create a non-linear narrative reflects the projects conceptually developed nature. Crucially, the dislocation felt by participants is seen as a reflection of the dramaturgical focus of the piece - disconnection used as a metaphor for temporal span.

> "The non-linear topology of the piece weaves a complex web of relationships between spaces, engendering large blank areas that can only be reconstructed through direct intervention of the public...participants are imbued with the responsibility to make a decision on behalf of the son. The quality of that decision is affected by the ability of audience members to investigate the space, drawing connections between objects and events as presented on stage." (Hickmann, 2013, p. 108)

Live coding has also adopted game based strategies with projects often using the network as a communicational or technological support system for participants to engage in musically orientated compete and/or collaborate formations. Magnusson (2014) discuss Craig Latta's *Quoth* (2012) which "implements a musical performance system in the form of a text adventure game command line interface" (Magnusson, 2014, p. 12), while Collins *et al.* (2003) describe the potential of competitive coding to offer scenarios in which live coders engage in competitive 'battles' through music. At the *Network Music Festival 2014* [21] a number of concerts were structured as a series of knockout 'laptop battles' - akin to hip hop rap battles. An eventual 'winner' being crowned on the last day of the conference, after the performance 'final'.

21 The *Network Music Festival* is an academic conference whose focus is on network music and live coding. More information may be found at http://www.networkmusicfestival.org

Other forms of network music exist outside the remit of Barbosa's survey, borrowing elements of other strategies and classifications, while hinting at others. For example Chris Chafe's *Ping*, created in 2001, is an example of Renaud's network in performance (NIP) approach. *Ping* is a sound installation which views the internet as a geographically distributed set of nodes, each with identifiable and traceable addresses (IP addresses). The unique location of addresses is made audible through the transmission of data packets, with the inherent latency in delivery and retrieval of these packets representing geographical spread - sonically.

> "Ping functions as a sonar-like detector whose echoes sound out the paths traversed by data flowing on the Internet. At any given moment, several sites are concurrently active, and the tones that are heard in Ping make audible the time lag that occurs while moving information from one site to another between networked computers." (Chafe, 2001, p. 1)

Viewing the network, or internet, as a source of information or dynamic data is seen in a work by Tim Kreger, entitled *Firehose* (2014). Kreger's piece merges dynamic network data in the form of *Twitter* [22] feeds, with both pre-composed and improvised electric guitar. It is an audio-visual performance that explores the relationship between musical performer, audience, and mass of communicating individuals. In *Firehose*, dynamic network data is translated into identifiable musical and visual uniqueness - the artist relaying musical agency to the received information via the performance system. The use of network traffic data is a similarity that may be seen between this work, and my own collaborative works *Amalgam 2012* and *Amalgam 2013* (previously discussed in section 2.1.1).

> "Firehose is a real-time improvisation using the Twitter api. Twitter provides access to the live stream head which is known as the firehose. The work uses a filtered form of the firehose to generate a musical stream for the guitar to react to. ASCII characters are mapped to pitch sets and presented in three forms:
>
> 1/ In parallel, the mapped pitches control sine tone generators playing simultaneously. Each tweet generates a new sonority and are played as they come off the head of the stream.
>
> 2/ Sequentially, each tweet encodes a melodic sequence played by three different waveform generators played in alternation.

22 Twitter is a digitally based social network that allows users to broadcast unique messages to an audience of direct or indirect followers. More information may be found at http://www.twitter.com

> 3/ Temporally, each tweet triggers an event. This timing of the tweets provides the rhythmic impetus.
>
> The filters used are simple one word filters such as love, happy, lonely, sad etc. Each filter possesses its own rhythm pace and harmonic patterning as much of traffic can quite often be the same message permeating (ie retweets replies etc)." (Kreger, 2014, p. 1)

Synchrocities (see Chapter 4) is also seen as an extended form. In this work, the internet is used as both technological support for, and source of, information. Live microphone streams are sourced from a remotely located server and relayed into an installation space. A programmed system analyses these streams, searching for pre-defined 'synchronous' moments. These moments are then relayed to the audience through convolved tonal swells, as well as a form of visual representation. Traces of the network are seen in the system, through its use of the internet as a sound source, as well as the additional layer of networked relationships formed between remote locations through a convolution process. This work is not easily placed into any categorisation - it resembles both the PIN approach (by creating a non-linear narrative from four interconnected sites) and the NIP approach (by utilising the network as a source of dynamic information); instantiating and exploring interdependency between remote locations through networking technologies and protocols.

Serendipity [23] (MacDonald, 2015) is a example that straddles definite categorisation and bears resemblance to *Synchrocities*. *Serendipity* is a software based artwork that resides on the internet, monitoring user's *Spotify* [24] music selections requests in real-time. Simultaneous musical selections are visualised and sonified on a dynamic internet webpage. The artwork creates a network of relations between user's requests, drawing connections between listening habits and the geographical spread of musical tastes and trends of users. The artwork may be concurrently viewed as an internet based system (as it resides on an internet webpage) as well as a collective creation system (as users are unknowingly contributing to a collaborative network artwork).

Play The World (Lieberman, 2015) was a sound installation displayed at the Barbican's *Curve Gallery*, in 2015. It is a participatory work that focuses attention

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[23] *Serendipity* may be found at the following internet address, https://www.spotify.com/uk/arts/serendipity/

[24] *Spotify* is a digital music service which allows users to listen to listen to music for a subscription fee. More information may be found at https://www.spotify.com/uk/

on the hidden sound world of the internet, drawing connection between the mass of sound found within internet traffic at any given moment, and a hardware piano.

> "Visitors are invited to perform with a keyboard that finds samples with the same note in realtime from web radio stations from around the world, essentially allowing them to play the world. Pressing a middle C key, for example, will play a matching C note from Nigerian sports radio or a Brazillian Bassa Nova station. The project monitors hundreds of diverse streams, from talk radio to pop to experimental transmission from around the world. The installation will have speakers in round, and sounds will be presented in geographic orientation to the audience, highlighting the voluminous, enchanting and playable global soundscape that surrounds us." (Lieberman, 2015)

This project is another example of an extended form of network music as Lieberman created a mass of technologically networked radio stations; reinterpreting their real-time broadcast content as information for an extended musical instrument. His system imagines correlations between the pressed note of a piano keyboard, and the closest pitch match within a managed database set. This system is difficult to classify under the headings of Barbosa, but it bears closest resemblance to a collective creation system. However, it is an extended form of the category - as radio stations are unknowingly collectively contributing to a musical composition and performance device. It may also bee seen as borrowing elements of Renaud's PIN approach - as a network is formed between the user, the hardware piano, and the mass of online radio streams as monitored by the system. The internet is also viewed as a dynamic database, as Lieberman's hardware based 'augmented piano' sources sound from the internet's vast array of online radio stations.

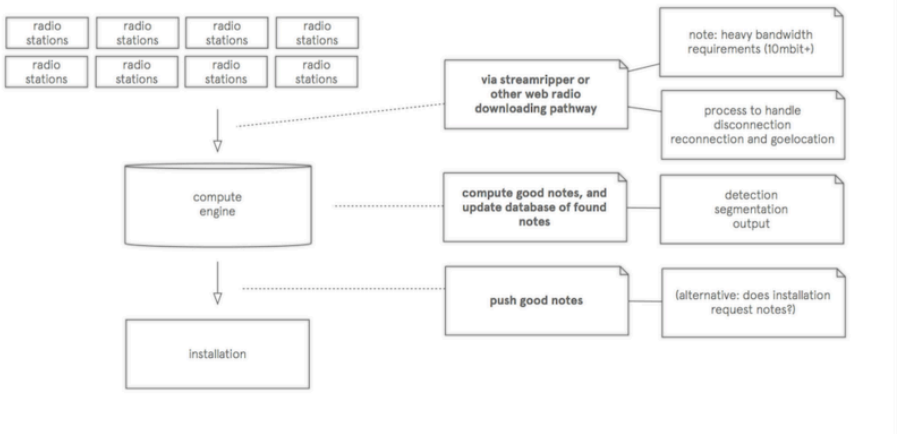

Fig. 6: Software and Hardware Design Schematic for *Play The World*

These examples highlight the continual development and evolution of network music. There seems a growing tendency to create artworks that implement the concept of a network in more evolved, intricate, and interesting ways. The network is no longer seen as just connective tool, or medium - it is viewed as an entity in itself - from which engaging works may be formed through engagement and exploration.

2.2. Summary

This chapter has introduced a number of network music classification schemes. It has described specific forms, strategies, and approaches while outlining distinct examples of them in practice, using Barbosa's survey of network music as a template. The chapter has augmented Barbosa's survey by discussing live coding as a recent, and relatively developed, form of network music. It has also discussed various extended and emerging forms to highlight network music's continual evolution. It has also discussed my own works, in the context of their appropriate classification. It is hoped that the reader has gained an understanding of the various types and forms of network music; gaining clarification of how, and why, certain forms exist in practice.

Chapter Three

3. Skype Supply

This chapter will discuss the artwork entitled *Skype Supply,* contained within the attached portfolio. The work is an artistic response to Max Neuhaus' *Public Supply I* (1966). Firstly, I will introduce the concept and origins of *Public Supply I*, as well as giving some contextual background to its creator. I will then describe my artistic response by outlining the implemented topology and the technologies used. A critical reflection and analysis section will follow, in which similarities and differences between the historical work and my own will be discussed. The analysis will focus on the project's core themes and concepts. The chapter will conclude with a brief summary, in which I will offer an overview of the main discussions.

3.1. Public Supply I

Max Neuhaus was an integral part of the experimental music movement that developed in the United States during the latter half of the 20th century (Cox, 2009; Kotz, 2009; LaBelle, 2006; Licht, 2009; Murph, 2013). Formally an instrumentalist, Neuhaus "abandoned performance completely to work with sound as an 'entity'" (Licht, 2009, p. 5). This elevated perspective of sound actuated Neuhaus' evolution as artist, and he is credited with creating some of the first sound art installations (Cox, 2009; Kotz, 2009; LaBelle, 2006; Murph, 2013). Neuhaus "worked with sound from environment and as environment" (Licht, 2009, p. 5), inferring the myriad roles that sound plays in one's engagement with it. He understood and engaged with the evolving role of the composer in the 20th century; as maker, designer, architect, moderator, and catalyser - dependent on his orientation within any specific work. Neuhaus was "interested in trying to move beyond that (performance) and beyond being a composer" (Neuhaus, 1994, p. 5). His engagement with 'sound activity' was a reflection of a desire to find "ways to escape from our present conceptions of what music is" (Neuhaus, 1994, p. 7), a

treatise that was shared amongst his peers within the avant-garde movement of the 20th century.

Public Supply I - performed in 1966 - was the first in a number of works, classified as *Broadcast Works,* that Neuhaus created specifically for the communicational mediums of the age - radio and telephone. Within *Public Supply I* Neuhaus offered compositional and performance integrity to a distributed ensemble, from which he moulded an engaging, original, and dynamic sonic 'dialogue'. The ensemble was made up of participating audience members situated within a twenty mile transmission radius of *WBAI FM* radio station, located in New York. The idea for the piece came about when *WBAI FM* asked Neuhaus if he would like to give a broadcast interview. He recounts how he "had this idea - instead of talking, why not try to make a work for the radio itself?" (Neuhaus, 1994, p. 5). With the medium of radio in mind, Neuhaus went about designing a bespoke performance system.

> "I built this wonderful pre-answering-machine...Each phone sat on a small platform and had a solenoid-controlled lever which fit under its receiver. A plastic cup with a microphone inside was fitted over the ear piece. The mikes and solenoids were connected to a box with switches controlling the solenoids, and with pots for the mike gains. The output went to an amp and speaker." (Neuhaus, 1994, p. 6)

Neuhaus was able to moderate the sonic input of a host of callers through this system. Contributions would arrive, via a telephone call to the station, where they would then be mixed, merged, and broadcast over the airwaves. A performance architecture emerged in which participants could communicate with each other and the sonic environment as it evolved. Crucially, participants had access to a feedback channel - the radio broadcast. They were aware of their involvement in the piece; how their contributions were collated by Neuhaus, as well as how other participants responded or engaged with their input.

Neuhaus designed art with specific attention to the concepts of environment and space (La Barbara, 1977; La Belle, 2006). In *Public Supply I*, Neuhaus was offered a space that had intangible borders, a space whose edges lay on the outer fringes of radio transmitter coverage. He recalls how he made a "virtual space" (Neuhaus, 1994, p. 7); a space in which "any of the ten million people living there could enter into by dialling a telephone number" (Neuhaus, 1994, p. 7). The relatively low technological barriers to entry ensured Neuhaus offered the potential of 'dialogue'

formation, as participants were presented a two-way communication structure accessed through familiar communication channels.

3.2. Skype Supply

Skype Supply updates *Public Supply I* by replacing the telephone and radio with contemporary technologies. The telephone is replaced by *Skype* - a communicational tool that is used predominantly for combined audio and video communication over the internet. *Skype* is used by participants to contribute content to the performance by calling into a moderator. The moderator is an integrated software system built using a combination of the programming tools *Max/MSP* and *AppleScript* [25]. Replacing the radio is the one-to-many broadcasting tool, *YouTube* - a web-based platform that allows the dissemination of combined audio-video media to the general public. The broadcast was implemented through a *YouTube* 'channel'. This allowed the dissemination of audio-video media in real-time [26].

Skype Supply is an interactive artwork in which participants partake in aural and visual dialogue. The artwork's first installation was at the *PS2 Gallery*, Belfast in 2013. Participants could call a designated *Skype* username: skypesupply2013, either through their own *Skype* enabled device - from their own location - or using one provided at the venue. The broadcast mechanism *YouTube* could be used in two ways: participants could use it to analyse their contributions in a reflective manner, or as guide, inspiration, or spur - viewing the performance before offering their contributions.

Below is a topology diagram for *Skype Supply* (see Fig. 7). It details the arrangement of the installation as shown at *PS2*. The attached portfolio folder contains a video trailer detailing the project (~/Documentation_Material/2.Skype_Supply/Trailer/...), documentation of the individual participant contributions (~/Documentation_Material/2.Skype_Supply/Participation_Videos/...), and the full length *YouTube* broadcast (~/Documentation_Material/2.Skype_Supply/Broadcast/...).

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25 *AppleScript* is a software programming language for Mac OS computer systems that allows programs to be written for the automation of certain tasks and inter-application communication. Please see https://developer.apple.com/library/mac/documentation/AppleScript/Conceptual/AppleScriptX/AppleScriptX.html#//apple_ref/doc/uid/10000156i

26 *YouTube* was used as the live broadcasting mechanism for *Skype Supply*. The designated *YouTube* channel is located at https://www.youtube.com/user/SkypeSupply. Instructions for live streaming on *YouTube* may be found at https://support.google.com/youtube/topic/6136989?hl=en&ref_topic=2853712

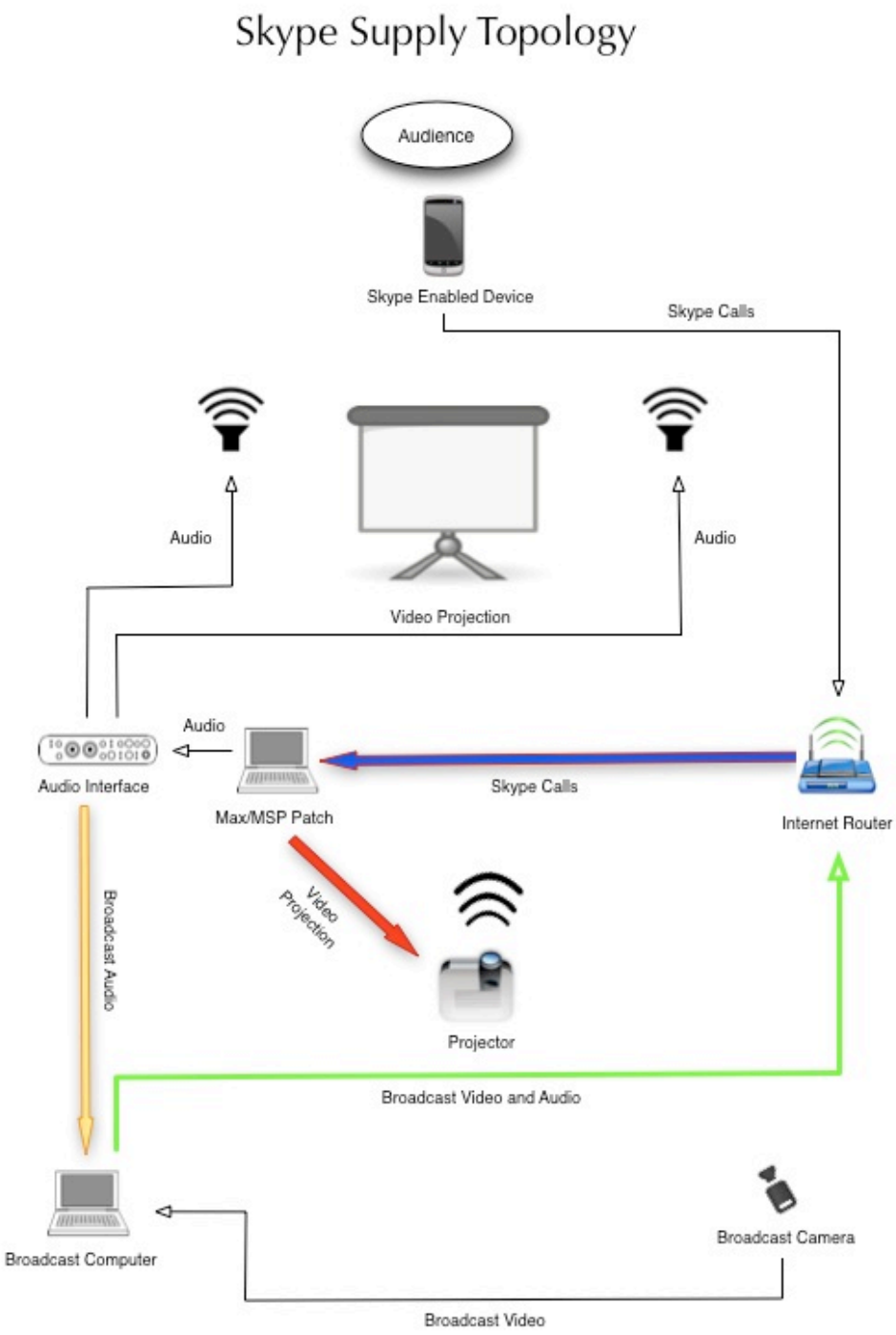


Fig. 7: Skype Supply Topology

A core difference between *Skype Supply* and *Public Supply I* is the existence of a public facing installation gallery space [27]. In *Public Supply I* audience members could listen to the installation in their own homes through their personal radio receivers. In *Skype Supply* listeners engage through their own internet enabled

27 The gallery space was used to house the technological infrastructure of the piece: computers, routers, projectors, cameras, transducers, etc. The *YouTube* broadcast was projected onto the front window of the gallery. The screen displayed the artwork, as it formed, with respect to the contributions of the participants.

device, via *YouTube*, or alternatively, at the gallery location in Belfast's city centre. This gallery space allowed viewers to engage with the artwork in a slightly different manner. Members of the public could watch as participants formulated their offering at the installation space, while also viewing and reflecting on how the programmed system moderated the input once the contribution had entered the system.

3.3. Reflection and Analysis

Critical analysis and reflection reveals conceptual, technological and practical similarities and differences between *Skype Supply* and *Public Supply I*. The implication of technologies used, the change in participant interaction in response to the use of certain technologies, and how the design and moderation process of Neuhaus differed from my own will be discussed. Below is a summary table of the similarities and differences that exist between the two projects.

Characteristic	*Public Supply I*	*Skype Supply*
Input Medium	Telephone	Skype
Broadcast Medium	Radio	YouTube
Performance Structure	Indeterminate	Indeterminate
Instruction to Participants	Provide Music	Provide Dialogue
Community Dialogue	Yes	Yes
Existence of Virtual Space	Yes	Yes
Participant Search for Relation	Yes	Yes
Mode of Interaction	Mixed	Diary Style Entry
Moderating Agent	Max Neuhaus	Software Tool

Fig. 8: Similarity and Difference between *Public Supply I* and *Skype Supply*

3.3.1. Indeterminacy

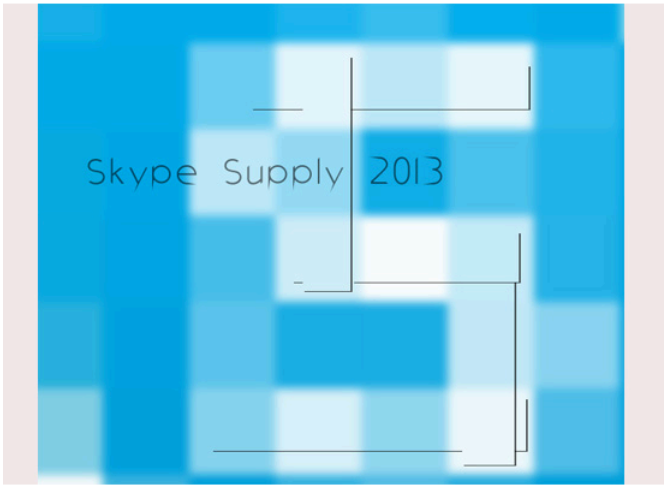
Indeterminacy is a core theme in both *Public Supply I* and *Skype Supply*. Indeterminacy is defined by the *Oxford Dictionary* as "**indeterminate** |adjective|: not exactly known, established, or defined" (Oxford Dictionaries, 2015). John Cage, a peer of Neuhaus, was a composer who explored the relationship between indeterminacy and chance in music. He defines indeterminacy in music as "sonic

processes the outcomes of which are not known in advance." (Cage, 2008b, p. 221). Roger Reynolds asserts that indeterminacy does not mean completely unscripted behaviour (Reynolds, 1965). He describes musical indeterminacy as a process which involves decision making, usually in the form of planned pre-performance decisions. These decisions ensure that musical events happen within agreed limits or bounds, with the exact specificity of events not being known. He asserts that categories of events are determined, but not what will happen within these categorisations; indeterminate musical events hold a degree of "significant independence" (Reynolds, 1965, p. 139). In *Public Supply I*, Neuhaus made little effort to control the input from participants, but he did categorise their contributions - they would contribute through a telephone call, and he would ask them to contribute 'music'. During the radio broadcast, it was reiterated many times that prospective participants should call a telephone number, offering music with which Neuhaus would 'compose' [28].

In the case of *Skype Supply*, I also made pre-performance decisions regarding the categorisation of indeterminate events. I decided that contributions would be made through *Skype*, and that participants would hold a degree of independence over their contributions within bounds that I had set. These bounds were set in the form of a note to performers, located at the installation space. This included the *Skype* username to call, and instructions to participants. I also ensured, through emails and face-to-face conversations with friends and family, that I would have participants engaging from remote locations. Within these conversations I communicated the *Skype* username to call, and some minor instructions as regards call length and content. It was hoped that through the installation space and pre-determined communication with remotely located participants I would garner enough contributions to make the installation successful. The note to the participants located at the gallery space is seen below (see Fig. 9).

28 Please refer to the performance recording of *Public Supply I* (Neuhaus, 1966) for evidence of these repeated requests. *WBAI FM's* broadcast announcer reiterated instructions to performers, communicating to them the name, concept, and the telephone number needed for participation in the performance. The broadcaster would announce at regular intervals throughout the broadcast, such as that heard at 27m 34s. "Oxford, 7, 8 ,5, 0, 6, or Oxford 7, 9, 5, 2, 6. Make music in Public Supply" (cited in Neuhaus, 1966).

Skype Supply 2013
by Robin Renwick --- PhD Student @ Sonic Arts Research Centre Queens University Belfast



Note for Participants:

Please ask the invigilator for access to the mobile device used for this installation.

When ready to contribute, please video call the skypesupply2013 contact.

The video call will answer automatically. When the call is answered, feel free to leave your contribution, whatever that may be. The more creative you are, the more exciting the exhibition will be.

You are the artist in this open dialogue, along with fellow participants who have involved themselves in the project.

Don't forget, that not only are you broadcasting onto the projection screen, but also onto a live YouTube channel.

Queen's University Belfast SONICARTSRESEARCHCENTRE PS2 paragon studios project space

Fig. 9: Note for Participants in *Skype Supply*

The use of the term 'open dialogue' within the note for participants, as apposed to a request for music, determined how participants perceived and interacted with the installation. The word 'dialogue' prescribes a certain type of participation. I felt, personally, that *Skype Supply* was not solely a musical performance - it was designed as a virtual space, created for participants to contribute what they felt they

could, or should. A virtual space in which they could explore and play with an evolving, collaborative, and participative dialogue.

Public Supply I did not impose many rules on the performance, and neither did *Skype Supply*. However, *Skype Supply* did have certain technological restrictions. The maximum number of videos that the *Max/MSP* patch could hold without causing undue stress on the computer hardware was sixteen, so I designed the program to reach full capacity once this many videos were received. The way in which the performance was actualised was wholly dependent on the contributed content from the participants, but unlike *Public Supply I* there was not a continuous evolution of content. In *Skype Supply* the moderating program would engage in a bricolage process, moving from video to video in an arbitrary fashion. As the amount of videos in the system increased, the wider choice the program had in respect to which video to display next. This process may also be seen as indeterminate in nature; I decided the technique by which the *Max/MSP* patch would move from video to video, and the rule structure imposed, but I did not know the exact outcome. *Skype Supply* and *Public Supply I* were both "indeterminate with respect to performance" (O'Grady, 1981, p. 370). Compositional structures were known and decided in advance, but each performance instance was not repeatable "in specific detail" (Reynolds, 1965, p. 371).

3.3.2. Music as Dialogue

Neuhaus discussed the anthropological influences of *Public Supply I*; he found inspiration in the fact that music had been observed to possess a very different function to persons not in contact with 'modern man' - as anthropologists had learned in their study of 'secluded' communities (Neuhaus, 1994). The anthropologists discovered music divergent from the coded 'composer - performer' dichotomy that existed in the 20th century. It was described as "sound dialogue among all members of the community" (Neuhaus, 1994, p. 7). This ethos is echoed by Neuhaus as he discussed the motives for creating the suite of *Broadcast Works*.

> "...these works are really about proposing to reinstate a kind of music which we have forgotten about and which is perhaps the original impulse for music in man: not making a musical product to be listened to, but forming a dialogue, a dialogue without language, a sound dialogue." (Neuhaus, 1994, p. 7)

The concept of 'music as dialogue' has since evolved. Bruce Ellis Benson incorporates the term into his study of improvisatory practice, stating that 'dialogue formation' is fundamental to music making.

> "What is clear to me, though, is that the binary schema 'composing' and 'performing,' which goes along with the construal of music making as being primarily about the production and reproduction of musical works, doesn't describe very well what musicians actually do. In its place, I wish to suggest an improvisational model of music, one that depicts composers, performers, and listeners as partners in dialogue. From this perspective, music is a conversation in which no one partner has exclusive control." (Benson, 2003, p. x)

This description - formed through a model of improvised communication between composer, performer, and listener - has strong relation to the sonic dialogue that Neuhaus sought to create in *Public Supply I*. Neuhaus involved members of the public in a participatory way, opening up avenues of activity by implementing widely accepted communication channels into a musical performance system. The performance was not controlled by any one member, it was influenced by all participants as they formed a mutually inclusive dialogue.

A key technological instrument within the realisation of *Public Supply I* was the telephone, and its indisputable links with the realms of communication, and dialogue, is no coincidence. The telephone system, at the time, connected hundreds of millions of people - both nationally and internationally - affording a depth and scope of communication on an unprecedented level. Coupling the affordances of the telephone with those of radio, Neuhaus designed a performance architecture that encouraged distributed, bi-directional participation. Neuhaus describes his art as moving away from static, one-way relational models towards bi-directional exchange, " 'music did become a process of communication, a loop, rather than a one-way message from performer to audience' " (Neuhaus, cited in Murph, 2013, p. 65). The mediums of radio and telephone leveraged the artistic mode of the participant, affording involvement in a continual, real-time 'sound dialogue':

> "At that moment it became a group activity - a process of people making sound together, listening to it, and adjusting what they did according to what was going on. I think this is the heart of the musical process - this dialogue." (Neuhaus, cited in La Belle, 2006, p. 156).

Skype Supply, at its core, uses the same idea. *Skype* is a familiar tool to the majority of participants, a tool that is ubiquitous in the age of digitally mediated one-to-one communication. Similarly, *YouTube* has an equivalent familiarity today as the radio did in 1966 - but as a one-to-many mode of communication rather than the one-to-one mode of *Skype*. Dialogue forming was seen as the crux of *Skype Supply*, with reflection proposed through both the installation space and the *YouTube* broadcast. The anthropological influence, discussed by Neuhaus, was also a part of the idea to create *Skype Supply*. I felt the performance should attempt to reflect the sociological, personal, and musical spectrum of the participants. On reflection, something should be learned about the group, both in isolation and in amalgamation. The way in which participants interacted with each other, the way they interacted through the interface technologies, or the way in which they did or did not harness the bi-directional nature of the artwork are seen as valid avenues of investigation.

Within *Skype Supply* it is possible to see and hear instances of dialogue forming (see section 3.3.4), as well as participants using the performance system as a direct, public facing lens onto their personal lives (see section 3.3.5). Within the broadcast video it is also possible to see how one participant acknowledged the bi-directional feedback potential of the artwork. The participant realised they had made an error while calling into the installation - instead of ending their *Skype* call they placed the call on hold, which then confused the software system - the audio was correctly incorporated into the performance, but the video was not (it was distorted). The participant realised this and called again - with the latter video being incorporated correctly. Within the documentation of the *YouTube* broadcast (~/Documentation_Material/2.Skype_Supply/Broadcast/...), at 40m 19s, an offering may be heard. This is the distorted, or 'squashed' video. It is not until later in the broadcast, that we see and hear a second offering. This second offering demonstrates that the participant became aware of the mistake. At 1h 39m 54s it is clear that the participant adjusted the error, producing a clearer video, albeit with similar audio content.

3.3.3. Virtual Space

Neuhaus understood that the ephemeral borders created by the *Public Supply I* performance system created a "virtual space" (Neuhaus, cited in Traub, 2005, p. 1). A space into which participants could sonically enter and exit. Neuhaus was intrigued by the concept, describing it as "independent of geography" (Neuhaus, 2005). This virtual space, disassociated with physical limitations, borders, and

topography allowed Neuhaus to create an intangible, ethereal network - connecting participants from otherwise disparate locations.

Joan La Barbara elucidates how Neuhaus' works "focus on that most important function of the composer in society, of retraining ears and minds by utilising original contexts or situations as new forms in which to set pieces" (La Barbara, 1977). Brandon La Belle describes a veiled net - steeped in aurality; percipiently draped across an environment "so as to activate how one moves, occupies, and engages in space" (La Belle, 2006, p. 163) - urging connection, communication, dialogue, participation, and substantiation (Tazzi, 1997).

> " [The work] displaced the culture of new musical practice onto a larger context. Such a project, while making reference to certain musical attributes related to tonality, frequency, and compositional structures, moves more overtly into questions of spatiality, environmental relations, the mixing of found and constructed." (La Belle, 2006, p. 164)

Neuhaus reflected on the creation of a new kind of space in *Public Supply I*, articulating that "the telephone forms a two-way virtual space in the aural dimension; we function in it aurally as if we were in one real space, but this space doesn't physically exist" (Neuhaus, 1994, p. 3). The existence of a space not rooted in physicality, yet holding the propensity to inflect, deflect, and reflect as an extension of 'real space' is described.

> "The fact that there are single dimensional virtual spaces has some interesting aspects...a one-dimensional virtual space doesn't engulf us. It leaves us in our real world, but extends it." (Neuhaus, 1994, p. 4)

This extension of 'real space' is what Neuhaus explored in *Public Supply I.* He created a work that inspired and excited in equal measure; prompting contemplation on what it was to be a pseudo-resident inside the 'virtual', "an aural virtual space reproportions focus and stimulates imagination" (Neuhaus, 1994, p. 4).

The concept of virtual space as an extension of real space has since evolved. Mitra encourages one to think of "a synthetic world made up at the intersection of the real and the virtual" (Mitra, 2003, p. 1), a world steeped in 'digitality'. She views the internet as being an example of a synthetic world, a world in which people temporarily dwell (Mitra, 2003). Neuhaus designed *Public Supply I* as a space in which temporary sonic residence of participants was welcomed - the work allowing

them to create and engage with content as they wished. *Skype Supply* offers the same opportunity, as participants are encouraged to enter a performance in communicative participation with others. Within the broadcast of *Public Supply I* voices intermingle, interweave, appear, disappear, and reappear, remaining in a shadowed space of interconnection. Within *Skype Supply*, voices and images morph from participant to participant, connected through the technological apparatus, but still distant - perhaps a reflection of the temporary nature of their dwelling.

Neuhaus, while discussing *Public Supply I,* describes a space that does not physically exist. It could not be walked into, through, felt, or navigated in a tactile fashion, but it could be experienced through other distinct modes of transmission and reception. *Skype Supply* creates a similar space, where the modes of reception are limited to engagement through hearing and sight. *Skype Supply* further explores the extension of the virtual from the real through the physical installation space. The work's topology ensured that the virtual space could be viewed for the duration of the performance at the window of the gallery in Belfast, as well as through the *YouTube* broadcast channel. In *Public Supply I* participants engage with the virtual space through their aurality - by listening to the radio broadcast. In *Skype Supply*, participants engage and reflect through both aural and visual modes - the real extending into the virtual through both senses; a technologically afforded bi-modal extension.

3.3.4. Relation Within a Virtual Space

Listening to a recording of the original broadcast of *Public Supply I*, a distinct search for relation can be heard. At 29m 08s, a voice says "Hello, can I speak to my mommy?" (cited in Neuhaus, 1966). This may be viewed as merely a humorous extrovert voicing a comical anecdote, but it may also be seen as a participant's search for concrete communicational, empathetic, or sympathetic relation within the medium of a virtual space - perhaps a reflection of the feeling of mis-direction or mis-location felt while navigating the space Neuhaus had created. If one continues to listen, it becomes even more absorbing at 29m 20s when the voice continues in a much more distressed tone: "Is my mommy there? I want to speak to my mommy" (cited in Neuhaus, 1966). Immediately after this interlude the same voice continues its search.

> "Paul Schriver, Paul Schriver, Paul Schriver, Paul Schriver, Paul Schriver, Paul Schriver, Paul Schriver, Paul Schriver. Paul, can you hear me? Paul, can you

> hear me? Paul, can you hear me? Paul, can you hear me? Paul, can you hear me?...” (cited in Neuhaus, 1966)

It would seem that the voice, a male, is searching for some form of communication within the performance. He is asking a direct question of somebody and, we assume, hoping for a corresponding reply. It is never clear whether this reply is forthcoming. However, it is clear that the participant was searching for direct, personal communication within the performance.

In the documentation trailer for *Skype Supply* (~/Documentation_Material/ 2.Skype_Supply/Trailer/...) there is a distinct example of a participant becoming aware of a relation within the virtual space. At 2m 03s, a participant is located at the installation location. He is engaging with the installation through a mobile device, positioned in such a way that he can view the performance as it is being broadcast. He announces “This is John”. As the broadcast is being displayed behind him, projected onto the window of the installation space, he is aware of its current state. It is at this moment he becomes aware of other participants within the performance. He realises that other videos were created by participants he has some relationship with, outside of the context of the installation. John comments: “...and that’s Rob. Oh no, that’s Tullis now”. John actively engages with the installation, relating his own experience with what has come before. In *Public Supply I* we hear participants attempting to create distinct connection between themselves and others within the virtual space. In *Skype Supply* we see a manifestation and documentation of the same desire.

3.3.5. Modes of Interaction

Neuhaus recounts the apprehension the studio engineer at *WBAI FM* had of *Public Supply I* - the engineer doubting Neuhaus’ ability to devise a working phone answering system: “The engineer laughed and asked me how I was going to answer them all” (Neuhaus, 1994, p. 5). He also discusses the trepidation the studio engineer had with broadcasting live, fearing the station would lose its licence as there was no such thing as a live ‘call-in’ show at the time (Neuhaus, 1994). The solution “was to put a mike in the studio and pretend it was a strange kind of interview show” (Neuhaus, 1994, p. 5). The definition of the performance as an ‘interview’ is quite revealing. The performance may be seen as that in which members of the audience ‘interviewed’ each other, or themselves, in a very free, indeterminate, and unscripted manner. This same mode of interaction can be seen manifesting within *Skype Supply*.

Within the individual participant offerings of *Skype Supply* (~/Documentation_Material/2.Skype_Supply/Participation_Videos/...), it becomes apparent that the participants did not view themselves as musical objects, certainly not in a traditional sense. This may have been because the mode of interaction could be interpreted as over-determined; *Skype* and *YouTube* are two popular communication tools, with established modes of interaction. Neither are associated directly with music making, even if *YouTube* does have associations with music consumption. As *Skype* was the core tool through which participants engaged with the system, it was no surprise that they used the medium as a lens, focused on their personal lives - much in the way that a person may use *Skype* to communicate in a normal situation. Reflecting on this further, it is possible to question whether the behaviour is representative of a general trend towards the death of privacy and subsequent growth of public facing individuality, as is seen with the rise of social networks such as *Twitter* [29], *Facebook* [30], and the more recent visual modalities of social network extensions *Periscope* and *Meerkat* [31].

In the documentation of the *YouTube* broadcast (see ~/Documentation_Material/2.Skype_Supply/Broadcast/...) there are instances of participants using the system as a documentation tool, offering up miniaturised portraits of the current status of their lives. At 10m 39s we see a video of a male participant talking: “In my...uh...adopted city of Belfast at this current point in time...”, it continues at 10m 48s “...possibly the most pleasant evening thus far in Belfast’s illustrious year in that it’s sunny and I am not being rained on which is a great victory in the grand scheme of things...”. Another example is seen at 45m 06s when a female participant relates “Bye Belfast, I am going back to Brazil...see you there...bye bye”. A third example is seen at 54m 52s, with a male participant saying “ [I have to give] a speech in city hall on Tuesday and I don’t really really want to, so, I still have to write it...”, continuing at 55m 13s “...you know, dutch courage and all that. So uh...if anyone has any advice...umm...thanks”.

The theme of public facing documentation seems to be found throughout. At 1h 33m 43s we see and hear another voice: “...but...uh...that’s all that I have to say at the moment, but...uh...we’ll talk to you soon again. Take care, bye bye.”. What is

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29 *Twitter* is a digitally enabled, community based micro-blogging site. More information may be found at http://twitter.com

30 *Facebook* is an internet based social network. More information may be found at http://facebook.com

31 *Periscope* and *Meerkat* are social media platforms that allow users to create real-time streamed video content from their mobile device’s video camera. More information may be found at https://www.periscope.tv/ or https://meerkatapp.co/

perhaps most interesting about this last example is the specificity with which the participant uses the word 'you'. The participant, my sister, is used to talking directly to me on *Skype* outside of the context of the performance, and so does not separate this association from the performance itself. She uses the word 'you' as if she might actually be talking to me, as distinct from forming a dialogue with the number of other participants that are in the performance at that time. Of course, it may also be the case that she was unsure that dialogue forming with a host of distributed voices was the project's concern - this may not have been communicated effectively - or perhaps she did not feel it necessary to watch the current status of the performance through the *YouTube* broadcast before engaging with the system.

By studying the individual participant offerings (~/Documentation_Material/ 2.Skype_Supply/Participation_Videos/...) it becomes clear that the familiarity of *Skype* as a personal communication tool may have actuated a certain style of interaction, and type of content. Within these videos participants offer details, stories, feelings, emotions and memories of their own personal lives, even though, I assume, they were aware of the public facing nature of the artwork.

3.3.6. Moderating Contributions

Alfred Gell's definition of agency as "the source, the origin, of causal events, independently of the state of the physical universe" (Gell, 1998, p. 16) is helpful for describing the assertion of any entities designated role within a performance. Ian Whalley asserts that agency can be attributed to software, or a software system, stating that "an agent is generally understood as somebody or something that acts on behalf of another in a process. A software agent, put simply, is a computer program that works on tasks specified by a user" (Whalley, 2009, p. 156).

In *Public Supply I* Neuhaus implemented and controlled a custom built "pre-answering machine" (Neuhaus, 1994, p. 6). Within *Skype Supply*, I used a software program to moderate the calls of the participants. In effect, this programmed piece of software acted as the 'answering machine' on my behalf. In *Public Supply I* Neuhaus' agency was attributed to the artwork through the design and building of the architecture, topology, and the moderating enabling 'pre-answering machine'. In *Skype Supply*, the moderating agent is a digital system. My agency is attributed to the performance through the programming of the moderating software, as well as the design of the installation's architecture and topology. Decisions I made during the design and programming stage of the project affected the outcome of the

performance, even though I had little or no influence on the performance as it was being actualised.

I faced numerous design and architectural decisions during the design and planning stages of *Skype Supply*. The main decision was how to incorporate contributions into the performance given the technologies at my disposal, their affordances, limitations, and the knowledge I had of them. As the participant contributions were being collected by the software system it made decisions concerning which video to display next. This decision was made arbitrarily. I set rules for the behaviour of the software with respect to how the next video would be chosen, the time taken to move between videos, and the length of time a video would remain foregrounded. The order of displayed videos, however, was decided entirely by the software. This is different to how Neuhaus moderated the input of participants within *Public Supply I*. Although Neuhaus would have faced the same indeterminacy with respect to call content, he would have had direct control over how the calls were moderated. I did not have the same level of control. The software program, once initiated, controlled how videos were mixed and merged - though I did decide, and programme, the rules by which the software would actualise this moderation process. I enacted technology as an agent on my behalf, moderating content with respect to a distinct rule structure. The rule structure was pre-determined, but also included an indeterminate process. The combination of the determined and indeterminate processes affected the artworks outcome.

3.4. Summary

I have discussed the core similarities and differences between *Public Supply I* and *Skype Supply*. I have also detailed common themes within the two projects - indeterminacy and virtual space. I have demonstrated how these themes are still evident, given the differences in technologies used. I have also briefly discussed how my artistic agency is attributed to *Skype Supply* through the design and implementation of the system, technology, and the programming of the moderating software. It is important to note the way in which technologies altered interaction, with *Skype* modifying participant behaviour, due to its familiarity. It is also important to note how my own instructions to performers altered behaviour - the request for dialogue being attributable, in some way, to the offered content.

Even though *Skype Supply* is an artistic response to *Public Supply I* completed five decades after the original, it is clear that the core artistic themes of indeterminacy and virtual space are still explored. Similar tools are available today as there were

in 1966, demonstrating communicational and technological equivalence, even in an age of radical technological advancement. Most importantly, it would seem that the conceptual, explorative, and thematic core of Neuhaus' artwork is durable enough to be supplanted into the 21st century, through contemporary means.

Chapter Four

4. Synchrocities

This chapter will discuss *Synchrocities* - a sound installation created as an artistic response to a series of works entitled *City-Links* (1967-1980), by Maryanne Amacher. I will first introduce Amacher, offering some contextual background to her artistic and conceptual motivations, before describing a selection of works within the series. *Synchrocities* will then be introduced as I explain design decisions, technologies used, and the topological and dramaturgical implications of the work. A critical analysis and reflection process will follow, in which I discuss the similarities and differences between *Synchrocities* and *City-Links*.

4.1. City-Links

Maryanne Amacher is seen, by some, as one of the foremost experimental composers of the 20th Century (Borchet, 1997; Curran, 2009; Dietz, 2009; Kaiser, 2014). Her exploration of the spatial, perceptual, and physiological aspects of sound distinguished her from other notable luminaries of the time. Amacher's interest in perception - how we as humans perceive aspects of sound - was borne from her long-form listening habits. She "learned about the perception of dimension in sound" (Amacher, 1991, p. 4) by spending weeks, months, and years listening, playing, morphing, and enveloping her life with sounds of remote places transmitted to her over high bandwidth telephone lines (Amacher, 1991).

One of the more established and documented catalogue of works by Amacher is the sequence of concerts, performances, radio broadcasts, and sound installations, entitled *City-Links*. This series contained approximately twenty two iterations, or events; constructed, planned, and performed at intervals over approximately a decade and a half, beginning in 1967. *City-Links* was a cornerstone of Amacher's development as a sound artist; a predominant series of exemplifications of her artistic principles. In *City-Links* microphones were placed at various locations,

connected to dedicated high-bandwidth telephone lines, so that the sounds of one location could be transmitted over a communication network and sounded at another.

> " [Amacher was intent on exploring the] noise-related qualities of sites, such as their fundamental or resonant tones, and their dependence on conditions such as climate, weather, time of day and other, sometimes extremely subtle, changing aspects..." (Maier *et al.*, 2010, p.1).

Amacher's dedication to understanding the transmitted environmental sounds set her apart; at times her concentration and focus bordering on obsession. A "pure, uncompromising commitment" (Curran, 2009, p. 1) coupled with a love for "drawn-out duration" (Curran, 2009, p. 1) is recalled as she describes her process.

> "...the mike had been placed in Boston Harbor, using a dedicated telelink that was hooked into my studio for three years, going into my mixer. I could play the space. That is how i learned..." (Amacher, 1991, p. 4)

The ability to transport a sound, or series of sounds, from one location to another was a core developmental exercise for Amacher. She began to acknowledge her desire to discover and learn about the sounds, to understand them; to build an 'instrument' from them (Amacher, 1989). This desire was reflected in the learning process that involved her 'playing' the transmitted sounds that arrived to her. The *City-Links* series was an exploration of ways in which Amacher could build a "live sound environment" (Maier *et al.*, 2010, p. 2), understanding how to design and produce a musical tool that employed sound sources from remote locations.

By analysing the *City-Links* series, a developmental path may be traced that reveals how Amacher's conceptual outlook of her "live sound environment" (Maier *et al.*, 2010, p. 2) changed over time. *City-Links #1 (Buffalo)*, performed in 1967, was a work in which eight different locations were transmitted to the studio of *WBFO FM*, in Buffalo, New York - where they were subsequently mixed by Amacher over the course of a 28 hour broadcast performance (Maier *et al.*, 2010). This durational performance illustrated Amacher's desire to translate remote locations' environmental characteristics to an audience through sound, combining them through mixing techniques to create a conglomerate soundscape; a reflection of Buffalo city.

City-Links #6 (Hearing the Space Day by Day "Live"), performed at MIT during the *Interventions in Landscape* exhibition in 1974, focused her concept of a "live sound environment" (Maier *et al.*, 2010, p. 2) further. During this exhibition Amacher 'performed' live transmissions - received from a microphone overlooking the water at Pier 6 in the Boston harbour - by re-directing the original harbour sound through her studio. She called these performances 'interventions'.

> "...produced through mixing techniques, processing, synthesis, and additional combinations of tone structures. The performance actions were made freely in the course of each day in the studio, while Amacher lived with the live Harbor sounding space, listening and responding to its changing pattern." (Maier *et al.*, 2010, p. 7)

This concept developed further in later iterations - live instrumentalists played at designated locations, immersing themselves and their instruments into the sonic environment of their situated place. This was the case in *City-Links #10 (Everything in Air)*, where "musicians were 'on location' with tuba and banjo at the East River Flats, a site on the Mississippi [River]" (Maier *et al.*, 2010, p. 8), as well as *City-Links #13 (Incoming Night, Blum at Pier 6)* - which involved flautist Eberhard Blum located at Pier 6 of Boston harbour.

During the creation of the *City-Links* series, Amacher became interested in extending and developing the works to include more artists - differentiating roles, configurations and topologies, and experimenting with altered ideas. This series evolution is crucial to understanding the development of Amacher as artist. One of the most developed incarnations of the "live sound environment" (Maier *et al.*, 2010, p. 2) was demonstrated during one of *City-Links* latter iterations - *City-Links #18 (Intelligent Life)*. In this work, Amacher was joined by John Cage and George Lewis - both respected musicians in their own right. Cage and Lewis performed at designated locations, sending their performances to Amacher in a relayed fashion. Lewis was located at Boston Harbour, while Cage was located in Amacher's New York studio. Lewis' microphone stream was sent to Cage, who intervened on the stream, sending the output to Amacher - located at a performance venue in New York - where she would 'play' the final output through her own performance process.

City-Links may be interpreted as an example of early network art, as Amacher used communication networks formed from the combination of telephone lines, microphones, and radio to create works that focused audience attention on concepts

such as distance, absence, presence, place, space, location, and remoteness. The use of telephone lines to reduce perceived distance for both performers and audience is an example of Amacher using technology to communicate conceptual and artistic concerns regarding sound, environment, perception, dimension, and technology.

4.2. Synchrocities

As an artistic response to *City-Links*, *Synchrocities* turns listener attention towards the moments of sonic synchronicity that emerge from concurrent listening of multiple microphone streams sourced from a number of disparate locations. Internet technologies, software programming tools, and real-time microphone streams, hosted by *Locus Sonus* [32], form a work similar to iterations *#11*, *#16* and *#17* of the *City-Links* series - where emphasis is drawn to natural sound environments and their respective sonic characteristics.

In *City-Links* Amacher wanted to create an instrument; a "live sound environment" (Maier *et al.*, 2010, p. 2) for manipulation and modulation. *Synchrocities* moves in a similar direction, but removes the humanistic element of 'playing' the environments; allowing streams to interact on each other through a bi-focal signal processing method - based on convolution and time-stretching techniques. The system monitors microphone streams - searching for simultaneous sonic events [33]. When an event occurs, the system engages in a designed operation - ultimately causing swells and undulations of sonic activity within the installation space.

In *Synchrocities*, high bandwidth telephone lines are replaced by the communicational infrastructure of the internet, including *Ogg-Vorbis* [34] audio compression techniques for real-time transmission of digital audio information.

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32 The *Locus Sonus* Soundmap Project are the source for all microphone streams within the project. More information may be found at http://www.locusonus.org/soundmap. The full list of available streams on the *Locus Sonus* server is available at http://locus.creacast.com:9001/

33 The *Max/MSP* patch, included in the documentation folder, was the governing program for the installation. The patch sourced four streams, in real-time, from the *Locus Sonus* sound map. The choice of streams was dependant on availability, but for the first realisation were: Berlin, Nantes, London and Aix-en- Provence. The system laid out the chosen streams in two pairs. The streams were then subjected to FFT analysis wherein the program analysed the FFT windows for simultaneous activity with respect to audio amplitude. Concurrent activity in a paired set of bins, within a threshold of 12db, activated two distinct processes: The first would be a replaying of the window (1024 sample size) in the installation space for a period of 10 seconds. Secondly, time delayed audio streams would be convolved with each other. This convolution would also be replayed within the installation space for a period of approximately 10 sec, including a gentle fade in and fade out process. Examples of these swells may be heard throughout the documentation video.

34 *Ogg Vorbis* is an open source audio compression format used to store and play digital music files. More information may be found at http://www.vorbis.com/faq/#what

Cycling 74's Max/MSP software is used to analyse incoming audio data, as well as to create a visual representation of the analysis process. In *City-Links*, Amacher used the technologies available at the time to understand and reflect on sounds of places and spaces. *Synchrocities* uses contemporary technologies to elicit understanding of the relationships between places. The installation space urges reflection on an amalgamation of four distinct sonic environments as well as the subtle similarities and differences of their sonic characteristics through the awareness of detected simultaneous sonorous events.

The work reflects a projected dramaturgy; the installation space a central node (or location), gathering content from remote nodes - as the topology diagram below shows (see Fig. 10). Rebelo *et al.* (2008) describe projected dramaturgy as "one node as author and the others as contributors, i.e. media from other sites, are 'projected'" (Rebelo *et al.*, 2008, p. 2). Within *Synchrocities*, the dramaturgy is viewed from the perspective of the installation space - the central node. The streamed media content is projected into the installation space where it is both moderated and authored by the *Max/MSP* patch. Design and programming decisions I made during the creative process affected the installation's outcome, such as the threshold level for synchronous events, or the way in which the system visualised simultaneous activity in the analysed streams. It is also important to note that the moderation of the installation is completed by an automated software script in a similar manner to that seen in my *Skype Supply* project (see section 3.3.6).

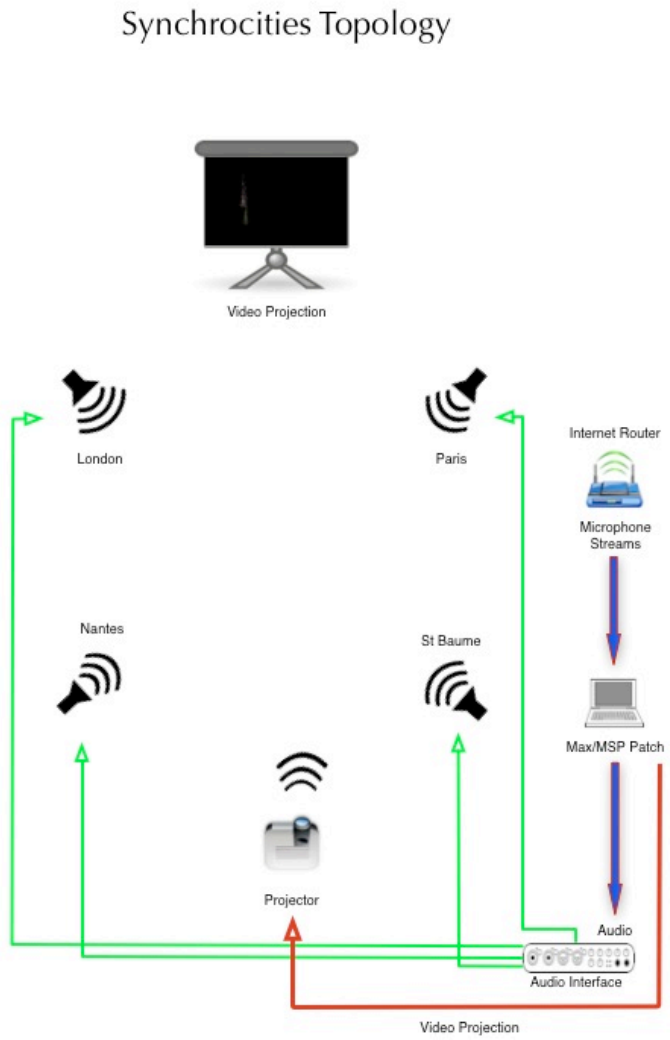

Fig. 10: S*ynchrocities* Topology

4.3. Reflection and Analysis

Analysing the similarities and differences between iterations of *City-Links* and the *Synchrocities* installation at the *Network Music Festival 2014*, reveals engaging perspectives of both works. The core differentiation between the two works is the subtle shift in focus from 'telelinked' sound towards synchronicity. The table below summarises the key similarities and differences between each project.

Characteristic	*City-Links*	*Synchrocities*
Audio Transmission Technology	High-Bandwidth Telephone Lines	Internet and Ogg-Vorbis
Visual Representation	Sculpture, Image and Video (*City-Links #9* and *City-Links #12*)	Digital Video Projection
Number of Iterations	27	1
Conceptual Focus	Telepresence	Synchronicity
Conceptual Support	Perception and Dimension	Perception and Dimension
Moderation and Intervention	Human	Technology

Fig. 11: Similarity and Difference between *City-Links* and S*ynchrocities*

4.3.1. Visual Representation

An immediate difference between the *City-Links* series and *Synchrocities* is the use of a visual element in the installation space. Though some iterations of the *City-Links* series contained supporting visual elements - like the video projection, sculpture, and images used within *City-Links #9 (No More Miles - an Acoustic Twin)* and *City-Links #12 (No More Miles)* - it was certainly not a central artistic theme through the whole series. In *Synchrocities* the visual element is placed front and centre of the installation space (see Fig. 10). It consists of a darkened layer, hiding a coloured map of Europe. Each time a synchronous moment occurs, the locations of the microphone streams in which the transported sound originated is subtly revealed; a small digitised burst of activity in an otherwise still environment[35]. A dynamic image is projected onto the front wall of the installation space (see Fig. 12). The brief, yet consistent, glimpses of coloured activity intersect a dark canvas - illuminating my own artistic notion of the moderation system remaining dormant until a synchronous moment activates a designed process - in a reactive manner.

35 The approximate geographical co-ordinates of the streams were pin-pointed on a digitised version of a map of Europe (located within the installation folder). This map would be hidden by a dark overlay within the *Max/MSP* patch. When a synchronous moment occurred, the software patch would reveal these locations in a particle by particle fashion. This process would last for the same duration as the two audio processes heard within the installation space. The display would return to its dormant state once the synchronous moment had passed. This process may be seen at various points within the documentation trailer (../Documentation_Material/3.Synchrocities/Trailer/...).

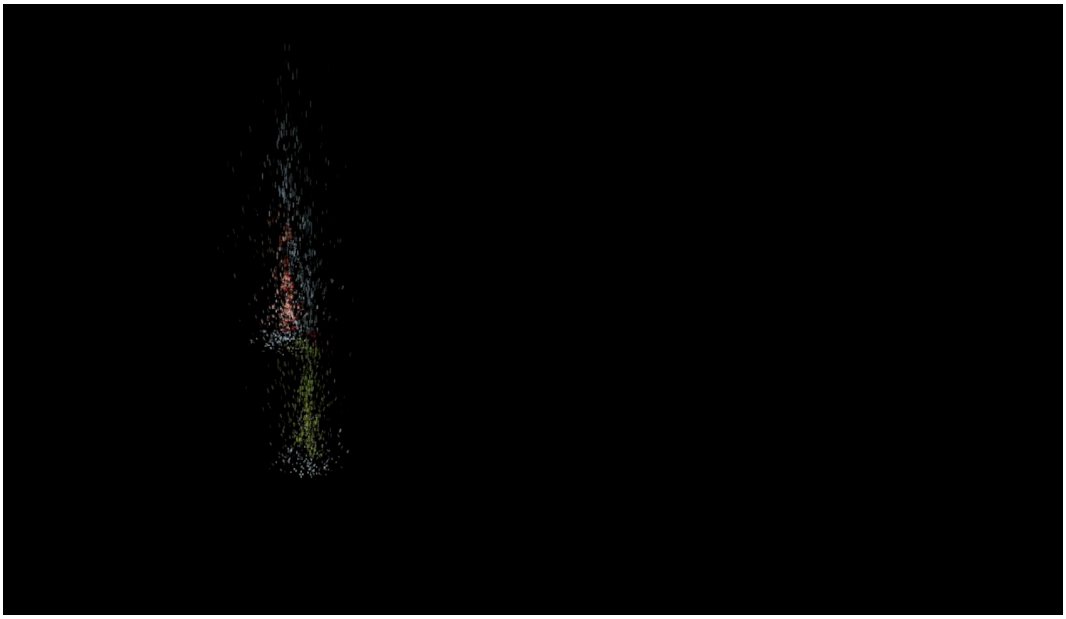

Fig. 12: Visual Representation in *Synchrocities*

4.3.2. Telepresence and Synchronicity

City-Links investigates and explores Amacher's concept of "sonic telepresence" (Kaiser, 2014, p. 19), Amacher's term to describe the impact of the "transmission of sounds between divergent locations" (Kaiser, 2014, p. 19) - especially the transported sense of presence at the transmission destination. This description, along with the implemented topologies, allows the series of works to be interpreted as early examples of network art; technologically instantiated networks are formed between sending and receiving locations. *City-Links* merged sound from one space, or place, with others - exploring the qualities and implications of the technologically leveraged communication between sites (Kaiser, 2014).

Through iterations of *City-Links*, Amacher evolved her exploration of 'telepresence' - changing topologies, formations, and focus as the series developed. A relatively simple topology may be seen in *City-Links #11 (Hearing The Space, Day by Day 'Live')*, where the explorative nature of the transported sound is foregrounded in an extended duration work.

> "Two outdoor sounding environments - a site on the Mississippi River called the East River Flats and the surrounding space of the old General Mills silo landscape - were transmitted live each day for the five weeks of the exhibition" (Maier *et al.*, 2010, p. 8)

Amacher involved the listener with the transported environments - their natural, 'living' narrative; urging reflection on the listener/location relationship and encouraging the extended duration listening that she had involved herself with previously. A listener could form a picture of the daily and nightly rhythms of a remote location, relating them to the rhythms of the gallery space, or their own internal rhythms like heartbeat or breath; allowing a perspective to form of the 'life' of a place as it existed naturally, and its relationship to them.

A more complex topology is seen in *City-Links #18 (Intelligent Life)*, which incorporates three performers and three sites in a strict line formation (see Fig. 13).

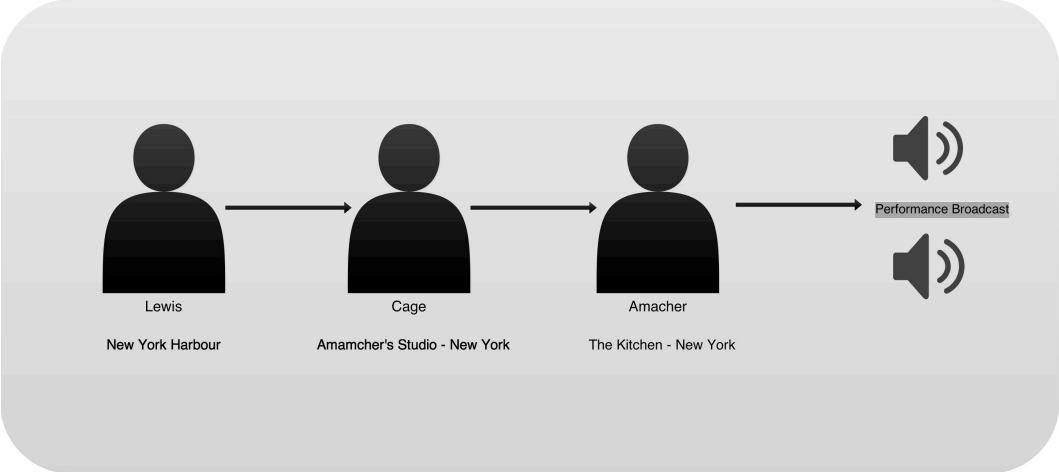

Fig. 13 : Topology of *City-Links #18 (Intelligent Life)*

This work reflects Amacher's realisation that certain spaces, environments, and 'psychological overtones' play distinguishable roles in how sound, or music, is heard. Remote locations were explorative avenues - John Cage was located at Amacher's studio while George Lewis was located at Pier 4 of New York Harbour. The trombone of Lewis was purposefully placed in the "humid, late night, water atmosphere" (Maier *et al.*, 2010, p. 14) and this "specialized situation, and the acoustic atmosphere of the harbor, were mixed with Cage's private adding of texts at Amacher's studio" (Maier *et al.*, 2010, p. 14).

> "[In the work] musicians were staged in different locations to create colors and psychological overtones that would not be possible if they performed in one public environment, with the same acoustic and environmental conditions" (Maier *et al.*, 2010, p. 13).

Amacher hoped the listener would hear the reflection of the locations. She felt that the relationship between the harbour atmosphere and the trombone would be clearly

conveyed, as well as any psychological inflections that the situation would create. These may have been related to meteorological aspects such as the humid weather and warm air, environmental concerns such as the close proximity of water, birds, or people - or situational aspects such as the solitary nature of Lewis' performance and the lack of monitoring capabilities at the remote performance sites. Amacher also felt that the relationship between her studio space in New York and John Cage would be conveyed through the piece. Again, these may have been technological - Cage's familiarity with Amacher's studio equipment; psychological - Cage's performative solitude; or environmental - the acoustic characteristics of the room in which Cage would voice himself.

In *Synchrocities*, conceptual focus shifts away from 'telepresence', to synchronicity. The work is designed to implicitly communicate moments of sonic synchronicity that exist between two remote locations - using a combined hardware and software system to convey simultaneous moments to an audience. Synchronous events are distilled and purified down to their lowest 'digital common denominator' - which is represented in this case as the FFT analysis window size - replayed to the audience so that a distilled moment of time envelops the installation space. The idea for the work was borne from Amacher's own interest in synchronicity - as she meditated on the sounds of remote locations. Living with the 'telelinked' sound for months and years at a time, Amacher constructed a deep apprehension of sonic locality. She possessed the strength of mind to reflect on her perception of the sonic landscape as she lived with it, in both artistic and pseudo-scientific communion.

> "[She wanted to] get inside the 'hum'...The hum that underpins all the mid- and foreground sound of life, the hum of all vibrating substance that holds our damned planet on keel...Maryanne knew that inside that macro envelope of noise in the All: nascent melodies, harmonies, beats, and rhythms, starlike in their birth." (Curran, 2009, p. 1)

This meditation on environmental sound allowed Amacher to move beyond and above "narrative sonic drama" (Curran, 2009, p. 1); seeking out a multi-dimensional perceptual experience, one that traversed through the outer layer of 'first order hearing' to "places and things unknown" (Curran, 2009, p. 1). It was in this traversal that Amacher developed an understanding for cause, effect, and synchronicity - and especially the distinction between these concepts. This became the conceptual cornerstone of my own artistic response.

Continuing her long, deep relationship with remote sound, Amacher sought understanding of pure, distilled, synchronous time - attempting to decipher how humans perceive synchronous temporal moments - as she formed an interest in hearing "synchronicity 'live' as it is" (Amacher, cited in Maier *et al.*, 2010, p. 5). Amacher describes her learning process as she discusses *City-Links #4 (Tone and Place, Work I)*, wherein "a five year live transmission of the Boston harbor was transmitted to Amacher's studio" (Maier *et al.*, 2010, p. 3). The relationship Amacher developed between herself and the sound environment enabled her to understand the relation of cause and effect within the vibratory world of sound.

> "Vibration in air is heard 3 minutes before the actual sound of a plane is heard. Changes in air vibration as different boats approach. Seagulls sensing these changes in air - their anticipation, announcement of arrivals and disappearances, before the sound of the change is heard at the site. Patterns in air." (Amacher, cited in Maier *et al.*, 2010, p. 3)

Amacher's understanding of cause and effect enabled her to develop an awareness of synchronicity in the environmental sound world. This interest can be linked to John Cage's concern with the relationships between indeterminacy, nature, and sound. Charles Hamm discusses notions of synchronicity within Cage's work, most notably, *Imaginary Landscape No. 4*. Hamm relates Cage's concept of synchronicity to Carl Jung's philosophy. This allows similarities to be drawn between Cage's notions of synchronicity and Amacher's. Amacher discusses how listener awareness of certain 'governing principles' are altered as they simultaneously hear remote places; leveraged affordance through the implementation of technology.

> "...birds suddenly begin to sing at one location, music begins at another. Hearing simultaneously spaces distant from each other, experiencing over time, more than one space at same time, coincidental rhythms, patterns of synchronicity, emerge. Awareness suddenly altered by over-view – perception recognizing beyond the boundary of my walls..." (Amacher, cited in Maier *et al.*, 2010, p. 5)

This pattern recognition may be related to Cage's notions of simultaneity and synchronisation, which Hamm feels is rooted in philosophy.

> "Cage had woven together the threads of Jung's concept of synchronicity, with its denial of causality and its focus on the relationship of simultaneously-occurring events..." (Hamm, 1997, p. 288).

Just as Cage explored these concepts through his work in *Imaginary Landscape No. 4* (1951), Amacher understood that the perception of synchronicity transformed one's awareness of the environment, altering the shade, or lens, through which one viewed the reality of existence, just as Jung had philosophised.

> "...take the coincidence of events in space and time as meaning something more than chance, namely, a peculiar interdependence of objective events among themselves as well as with the subjective (psychic) states of the observer or observers..." (Jung, cited in Hamm, 1997, p. 286).

Amacher understood that the long-form habitual listening of 'telelinked' locations had the effect of collapsing distance through technological means - altering listener perception and understanding of the nature of reality. *Synchrocities* emerged from my own understanding of this concept. I believe that certain technologies allow an alteration of listening; offering a window onto perceived synchronicity. Using digital signal processing techniques it is possible to draw out the subtle synchronicities below the level of human perception. Synchronous moments unbeknown to a listener can be foregrounded, coercing the listener into a technologically leveraged understanding of the existent relationships between geographically displaced locations - an overview that Nathan Thomas, a reviewer of the *Network Music Festival 2014*, describes.

> "For the most part it wasn't clear what events were triggering the swell response, which led to a beautiful impression of the senses being extended to grasp coincidences and correspondences that wouldn't normally be perceptible — the world as heard by a patiently listening network." (Thomas, 2014, p. 1)

4.3.3. Perception and Dimension

Amacher envisioned an understanding of sound and music where "the split which now exists between these two worlds - that of musical language and of environmental sound - one day will be closed" (Amacher, cited in Maier *et al.*, 2010, p. 8). Her desire to see this manifest saw her experiment and explore environmental sound for over a decade, learning as she went. Amacher discusses her discovery, and then continued acknowledgement and development, of spatial dimension, physical dimension, and dimension in sound - recalling the assimilated knowledge of these concepts into her practice. She formed landscapes in her mind, of the far; near; high; low; strong; weak; leading to a multi-dimensional occupation

with sound, physical space, and the acoustic and architectural properties of both place and space (Amacher, 1989).

Discussing her artistic practice - at *Ars Electronica 1989* - specifically her long-form listening habits - Amacher describes the importance of staging "sound architecturally" (Amacher, 1989). This preoccupation with architectural dimension informed the staging of various projects in the *City-Links* series. For example in *City-Links #8 (Chicago)*, performed on May 8, 1974 at the *Museum of Contemporary Art*, Chicago, Amacher sourced sound environments from various locations around the city. Amacher manipulated characteristics of sound according to specific properties of spaces; shaping and sculpting sonic characteristics so that she could explore different dimensions within her work.

> "[The performance consisted of her] interrupting the live sound...by the resonance of a tower, for example, recorded first in 1968 and later transformed for special characteristics internal to those of other indoor and outdoor spaces." (Amacher, cited in Maier *et al.*, 2010)

In *City-Links #9 (No More Miles - an Acoustic Twin)*, Amacher sought out an "acoustic twin" (Maier *et al.*, 2010, p. 10) of an installation space. She found this 'twin' in "a Budget Rent a Car Store in the La Salle Court, an indoor Arcade in downtown Minneapolis, where voices, footsteps, and other sounds matched those heard in the gallery" (Maier *et al.*, 2010, p. 10). Amacher reduced both distance and difference, as sounds perceived by the listener would appear to originate from within the installation space due to the similar architectural characteristics of the two environments. The "acoustic double" (Amacher, cited in Maier *et al.*, 2010, p. 10) offered the listener a reduced sense of distinction. Amacher merged the spaces, folding the acoustic and architectural dimensions unto themselves.

Marvin Lee Minsky entitles Amacher's skill at transporting listeners to 'other' places "Subjective Transportation" (Minsky, 1988, p. 1), describing her technical aptitude - "Amacher has become a master at controlling sounds..." enabling "...new senses of location and orientation" (Minsky, 1988, p. 1). *City-Links #1 (Buffalo)* saw the transmission of eight different locations to the studio of *WBFO FM*, where they were subsequently mixed by Amacher over the course of a 28 hour broadcast performance (Maier *et al.*, 2010) (see Fig. 14). This extended duration performance illustrated Amacher's desire to combine multiple locations' environmental sonic characteristics through mixing techniques - transporting the listener to a fictional

conglomerate sonic landscape; a reflection of Buffalo city otherwise beyond the capabilities of their own hearing.

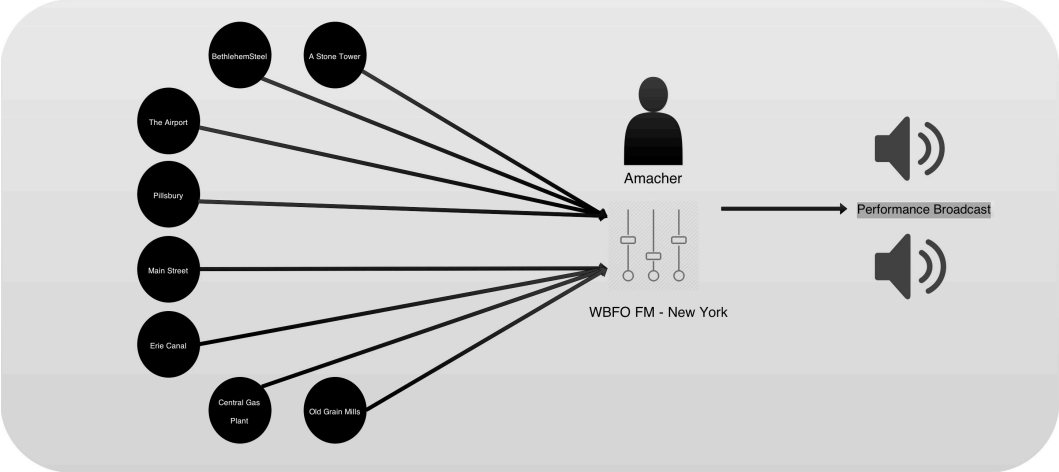

Fig. 14: Topology of *City-Links #1* (Buffalo)

Synchrocities magnifies and amplifies similarity and difference; moving sonorous events from the unknown to the known in an alluring, consistent, and recurrent fashion. The manner in which the programmed system creates distinct relational pairs between microphone streams allows the listener to understand the subtle relationships that exist between sites. For example, in the documentation trailer (~/Documentation_Material/3.Synchrocities/Trailer/...) at 7m 42s, the sound of bells may be heard. The bell sounds originate from a microphone located on an Aix-en-Provence hillside, in France. The sounds trigger an active process, as they match the activity from a stream sourced from another location, heard as the gentle tapping in the garden of a London residence. Even though the tonal qualities of the sounds seem quite distinct, the system views them as synchronous. This activates two designed processes (see footnote 31) that ultimately produce a swell of sonic activity within the installation space. This tonal swell, formed from a combination of the frozen FFT window that activates the intervention process, and a convolution of two matched segments of audio from the microphone streams, forces the listener into an engagement with the similarity that exists between the two streams. It also creates a distinct event within the installation space which the listener understands as a technologically afforded intervention on the otherwise natural sounding sourced environments.

The speakers are arranged in the installation space in a quadrophonic array (see Fig. 15). A listener positioned in the centre of the configuration hears four distinct sound environments from four corners of the room. Just as Amacher urged

reflection on the sounds of places in *City-Links* - building relationships through aural experience - *Synchrocities* urges listeners to explore the juxtaposition of similarity and difference between places in the physical space. Lucid individuality and blended collectiveness are interspersed with moments of distinct kinship and synchronicity, as a listener may focus attention onto different speakers and thus different places at any given moment in time.

Fig. 15: Quadrophonic Array in *Synchrocities*

In the design process, I considered the idea of placing speakers as a scaled geographical representation of the actual microphone locations; with speaker placements mirroring the scaled cartographical co-ordinates of the locations they amplified. A listener could then navigate the space as they would a scaled version of Europe. Conceptually this would have been ideal, but logistical issues made this unfeasible [36]. Due to the restrictions, a quadrophonic arrangement was chosen. A listener could navigate the space, focusing on streams in pseudo-isolation or from a position of centrality - urging a relational listening perspective. In this way the dimensional acoustic windows are merged with the perceptional window of synchronicity; urging the listener to reflect simultaneously on the other place, the relation between places, and most importantly, the moments of distilled synchronous time that appear as sonorous swells and undulations.

36 The installation space did not contain support structures suitable for placing speakers in the desired areas and at the required height, and nor could the organisers provide such structures. Secondly, due to the directional characteristics of the amplification process, it would have been difficult for the speakers to amplify the sounds in 360 degrees. I felt that this lack of omni-directionality would mean it would have been difficult to accurately reflect the mirrored analogy of placement.

4.3.4. Moderation and Intervention

Amacher viewed herself as a crucial element within the majority of *City-Links'* iterations - whether by direct intervention on performances through signal processing and mixing techniques, or the design of installation spaces. Amacher also involved herself in the "neurotic process of listening to and then tuning a specific space...[a process] never entrusted entirely to anyone else" (Kaiser, 2014, p. 21). The fact that the word 'tuned' is used reflects how Amacher viewed installation spaces. She felt that rooms could communicate sonic narrative if they were 'tuned' correctly (Dietz, 2010). She understood the crucial relationship between a sourced location's sonic environment and the way it interacted with the space to which it was being transported.

> "Maryanne Amacher used to rail against the typical study and understanding of music that was blind to the reciprocal spaces of music - the space that determines the quality of sound and the space that a sound defines" (Kaiser, 2014, p. 12).

Amacher's desire for artistic control enables an interpretation of her as a 'governing' agent within the series - seen in the implemented topologies. In *City-Links #1 (Buffalo)*, Amacher was in control of how eight separate streams were merged, mixed, and ultimately broadcast. The previous discussion of *City Links #18 (Intelligent Life)* demonstrates a topology in which she remained in sole control of the final output - this time moderating the creativity of other performers (see section 4.3.2). In this instance she acted as a node through which the creative output of Lewis and Cage was mediated.

As the series developed, attention turned towards the natural living rhythm of environmental sound. In *City-Links #4 (Tone and Place, Work I)* and *City-Links #14,* microphone streams were continuously transmitted to Amacher's studio for years (Maier *et al.*, 2010), and the previously mentioned *City-Links #11 (Hearing the Space Day by Day "Live")* where two environments were transmitted for five days to an installation space. These iterations bear close resemblance to *Synchrocities* - where the natural sounding environments are at the forefront of the installation space - but in the case of *Synchrocities* the sound is complemented with a technologically leveraged intervention process. From the perspective of the audience member a resemblance of human intervention is not apparent, as I am not located in the installation space, and play no active role that can be immediately perceived by an audience member.

City-Links altered the listening perspective; extending the aural sense by reducing distance through technological avenues, deepening comprehension of remote locations. In *Synchrocities* the software system gathers content, analysing and monitoring against a set of prescribed conditions, with a monitoring system mediating the received microphone sources. Once certain conditions are met, the system engages in a process that draws attention onto the moment of technologically perceived synchronicity. The temporal suspension of the synchronous fragment allows the listener to reflect on the nature of the relationship between two soundscapes, as the software is more sensitive to the minute differences, simultaneities, and synchronicities found while monitoring and analysing the data. *City-Links* allowed reflection through concurrent listening perspectives, but *Synchrocities* integrates technology so that moments of synchronicity become foregrounded. Minsky discusses Amacher's intervention technique, describing how she was "a master of controlling sounds that are comparatively 'faint' yet produce new senses of location and orientation" (Minsky, 1988, p. 1). *Synchrocities* produces a similar altered sense of location, but through an automated intervention method, as apposed to the humanistic one of Amacher.

From an aesthetic perspective, Iris Murdoch acknowledges that beauty is found in the "appreciation of something else, something particular, as existing outside us" (Murdoch, 1959, p. 52), with Elaine Scarry furthering this line of enquiry.

> "There are many things in life that give us an acute state of pleasure, that opiate us, and there are many things in life that make us feel marginal or lateral or on the sidelines. But what is deeply and abidingly extraordinary about beautiful things is that they do those two things at once" (Scarry, 2014, p. 2).

Synchrocities allows listener engagement with the world outside; the external, remote and distant. It coerces reflection of the 'other' place, drawing out the minute synchronicities between locations; elongating them by creating tonal drones from what is, in reality, digital data. In Scarry's view, the beautiful thing is one that simultaneously includes and marginalises; obliging an awareness of something else at work. *Synchrocities* opiates through the tonal qualities of the temporal suspension of spectral information; but more importantly it affords awareness of the gentle play of synchronicity that surrounds us. By implementing a connective and communicative software and hardware based system the project leverages and extends our senses so that we may become aware of relationships that would otherwise have remained hidden.

4.4. Summary

This chapter has discussed the similarities and differences between a series of works created by Maryanne Amacher, entitled *City-Links*, and my own portfolio work *Synchrocities*. It has introduced both projects, and outlined bilateral themes. I have also briefly discussed the subtle shift in focus from the 'telelinked' sound of *City-Links* to the perceived, and apparent, sonic synchronicity of my own work. The change was afforded by the technologies available to me, most notably the software system that engages in the analysis and moderation process.

The *City-Links* series was created over a period of approximately fifteen years, starting in 1967 - exploring themes such as presence, absence, remoteness, and connectedness - concepts which still resonate within many modern examples of network art. Similarly, *Synchrocities* engages in the transportation of sound from one location to another, but leverages listener perception through the use of digital technologies - creating an altered awareness. Contemporary technologies have allowed exploration of a concept, drawing attention to a theme that was of crucial concern to Amacher, but not easily or immediately explorable - that of sonic synchronicity.

Chapter Five

5. Web Variations

This chapter will discuss the portfolio artwork entitled *Web Variations* [37], an artistic response to *Variations VII* (1966) by John Cage. I will introduce *Variations VII* by explaining its core concepts and outlining the motivations Cage had whilst designing the work. I will then turn attention to *Web Variations*, explaining the artistic drive, technologies used, and the implications of designing the work as an internet based performance environment. A critical analysis and reflection section follows in which the similarities and differences between the two works are discussed. The chapter concludes with a brief summary.

5.1. Variations VII

Variations VII is one work contained within a suite of eight - entitled *Variations* - created by Cage between 1958 and 1967 (Hope *et al.*, 2012). *Variations VII* was "an experiment in mak(ing) the inaudible audible and transferring the results via electronic sound processing" (Miller, 2009, p. 74). The work comprised of a number of performers using a suite of instruments to generate, or source, sounds. David Miller recognises that the *Variations* suite was perhaps the "most radical and esoteric subset of Cage's work" (Miller, 2009, p. 66), with *Variations VII* interpreted as an explicit exploration of indeterminacy (Hope *et al.*, 2012; Miller, 2009). The notion of indeterminacy relates heavily to Cage's ideal of letting "sounds be themselves" (Cage, 1968, p. 10) wherein Cage developed "notations that circumscribed a field of musical possibility out of which an unrepeatable stream of unique sounds and actions could emerge" (Hope *et al.*, 2012, p. 5).

37 *Web Variations* exists as an internet based performance environment. It may be viewed at https://webvariations.herokuapp.com/

It is worth acknowledging that no published score exists for *Variations VII*, merely a set of performance instructions - written by Cage prior to the debut performance in 1966 - with an updated set prepared in 1972 (Miller, 2009). The instructions "consistently indicate that systems for discovering and gathering sound are the focus" (Miller, 2009, p. 74). Performers are instructed to develop systems which contain "no previously prepared sounds" (Miller, 2009, p. 76) but which allow for the "free manipulation of available receivers and generators" (Miller, 2009, p. 76). Cage instructed "no interposition of intention" (Miller, 2009, p. 76), indicating that the piece's core focus was for facilitating reception (Miller, 2009).

Miller recounts an early brainstorming note written by Cage as he addressed his compositional and performance colleague, David Tudor. Contained within the writing were Cage's ideals; how and where he imagined the sounds be gathered.

> "...things happening at the performance time (not prepared tapes) via TV, radio, telephone?, mike, police...from us...; from audience; from city; from zoo...; from outer space if possible..." (Cage, cited in Miller, 2009, p. 74).

This brainstorm is a treatise on the work's central idea; sounds being sourced, manipulated and coerced into a coherent structure by the performers, and performance itself. Cage noted in the later modification of the original instructions that the performers should not attempt to discourage aesthetically questionable sounds, discouraging any riddance of "unlistenable ones" (Cage, cited in Miller, 2009, p. 74). Cage allowed performers create instruments that offered listeners avenues of discovery into the hidden or inaudible sound world that existed around them. He envisioned performers as mediums - through which sounds could traverse into the realms of perceptibility with the implementation of technology.

Cage felt that indeterminacy was one of the most appealing features of the work (Hope *et al.*, 2012; Miller, 2009). He realised that each and every performance would be unique and unrepeatable. This indeterminacy held an unquestionable beauty for Cage; he saw the delivered music being true to the nature of sound. This fidelity between Cage's view of indeterminacy, and his view of the nature of sound, urges Miller to recommend a deeper delve into the latter *Variations*, as he believes the days of viewing the works "as historical curiosities has passed" (Miller, 2009, p. 84).

5.2. Web Variations

Web Variations is an internet based artwork - designed as an online environment that allows a number of users to engage with an interactive, and navigable, musical performance. General themes, as well as specific directions, contained within the performance instructions of *Variations VII* were carried through to the design and programming of *Web Variations* - such as "free manipulation of available receivers and generators" (Cage, cited in Miller, 2009, p. 76), "catching sounds in the air as though with nets", "Inside composers picking up outside sounds", and "facilitating reception" (Cage, cited in Miller, 2007, p.1). The work is designed and programmed with a combination of internet technologies: *HTML* [38] and *CSS* [39] for the user interface, and *Javascript* [40], *Node.js* [41], and the *Web Audio API* for the server side audio processing, environment management, and digital audio signal routing.

In *Web Variations* a user navigates to an appointed web address which, upon entry, displays a short introductory text. The user is then presented with a graphic representation of a performance space. Drawn within this space is a node, which represents the fundamental sound source of the entire work (see Fig. 16). This sound is a live microphone stream sourced from the *Locus Sonus* [42] database. This fundamental source will be referred to as the 'base node', as it represents the root sound source for the artwork - of which all other sounds in the performance derive.

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38 *HTML* is a markup language used for the creation of Internet based content. More information may be found at https://www.w3.org/html/

39 *CSS* is a markup language that allows for styling of Internet based content. It is used in conjunction with other languages, such as HTML. More information may be found at https://www.w3.org/Style/CSS/

40 *Javascript* is a programming language used to create interactive and dynamic Internet based content. More information may be found at https://www.javascript.com/

41 *Node.js* is a programming framework that is primarily designed for network applications. More information may be found at https://nodejs.org/en/about/

42 The list of available microphone streams at any given time may be found at http://locus.creacast.com:9001/

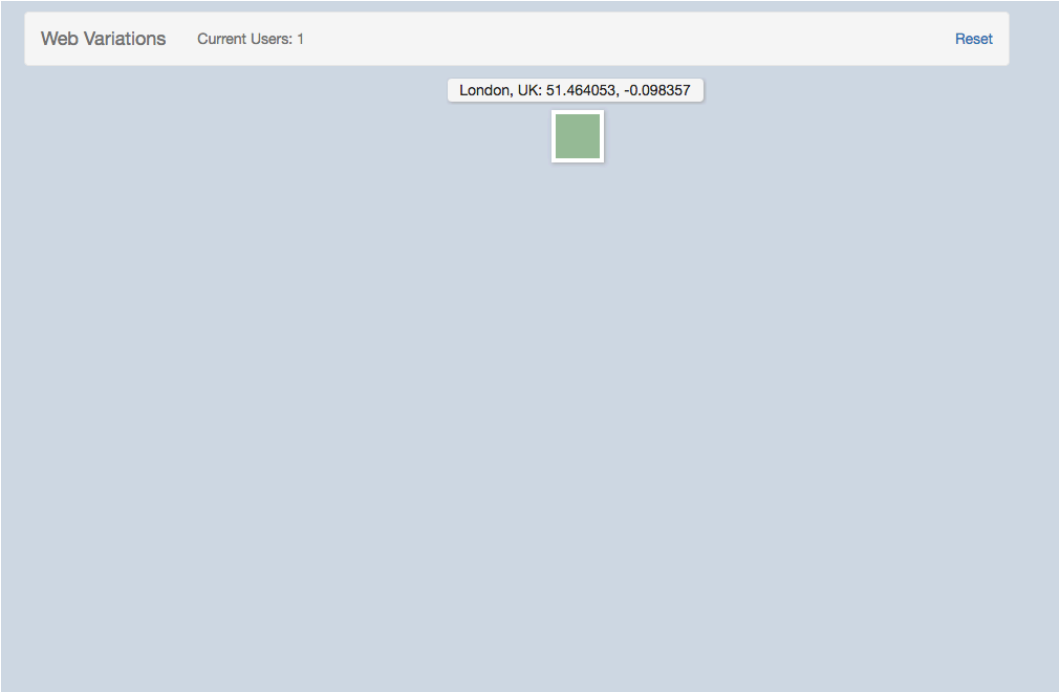

Fig. 16: Initial Interface of *Web Variations*

If a user clicks on the base node, they are offered two choices: listen, or perform. If perform is chosen, the user's activity within the performance space is represented by the appearance of a new node (see Fig. 17). The direction of audio as it travels from the base node to the user node is represented by a line. A window also appears which contains the control parameters of the user's audio signal processing unit. Any subsequent user that enters the environment will encounter the performance environment in the same state as the initial user, minus the effects window. The second user will have the choice to listen to, or perform with, any of the existing nodes - of which there will now be two (the base node, and the first performing user's node). This process continues for any subsequent user. All actions and environment states are shared across all computers accessing the performance environment simultaneously, regardless of their location [43].

43 This is dependent on every user using the required browser for *Web Variations*, which is *Chrome*. This is primarily due to the lack of dependable cross-browser support for the *Web Audio API*. At the moment the environment only allows *Chrome* users to enter. *Chrome* is a popular internet browser, developed by *Alphabet*. More information may be found at https://www.google.com/chrome/

Fig. 17: Interface of *Web Variations* for Performing User

Web Variations explores three distinct conceptual and artistic concerns: "relayed creativity" (Born, 2005, p. 26), "intra-action" (Moore and Place, cited in Follmer, 2005b, p. 186), and "navigable music" (Novak, 1997, p. 1). Relayed creativity is introduced by Born as she discusses her understanding of music, and musical mediation.

> "...distributed across space, time and persons, music can become an object of recurrent decomposition, composition and re-composition by a series of creative agents. We need a new term for this capacity: I suggest relayed creativity." (Born, 2005, p. 26)

The term 'relayed creativity' - where creative agents participate in continual musical reprocessing - defines the actions and interactions of users within *Web Variations*. The term is an apt descriptor of how sound is relayed from one node to another in a constant state of re-composition. In *Web Variations* any node's actions are dependent on the preceding node's actions, in a continual and recurrent fashion.

An elevated concept of action and interaction is outlined by Follmer, as he introduces the term "intra-action" (Moore and Place, cited in Follmer, 2005b, p. 186). The term describes "the processes in musical systems wherein single players' actions intercede onto those of other players" (Follmer, 2005b, p. 186). This perspective is borrowed from a more traditional notion of performing agents, but is beneficial for framing the way in which behaviours intercede onto others within network music. In *Web Variations* a user is allowed to explore the notion of 'intra-

action' explicitly. The work reflects an environment in which music moves away from an absolute, or fixed, state; a space where music is repeatedly changed, modulated, morphed - transformed across distance, time, and persons through the use of technology. The explicit role of technology with respect to experimental artistic endeavours is discussed by Born; "electronic and digital technologies afford and enhance a dispersed and collaborative creativity" (Born, 2005, p. 25). This technologically afforded collaborative creativity frames *Web Variations* - an environment in which constant decomposition and re-composition of sound events occur, as sound travels from user to user within the performance space.

The concept of 'navigable music' is developed by Marcus Novak (1997). He describes the potentiality of music to inhabit 'metamorphological' spaces and liquid architectures. 'Metamorphological' architectures are first described in *Cyberspace: First Steps* (Benedikt, 1991) as animated, animistic, metamorphic, continuous and discontinuous structures - crossing categorical boundaries, and evolving in both space and time; cyberspace being the perfect support mechanism (Novak, 1991). Novak describes what is found within such structures, including what he details as a new kind of music.

> "...it is possible to stop seeing music as singular, as a street between point a and point b, and to start seeing music as multiple, as landscape, as atmosphere, as an n-dimensional field of opportunities. If music is a landscape then it is possible to extract as many types of conventional music as there are trajectories through that landscape. The new problem for composition is to create that landscape." (Novak, 1997, p. 1)

The three concepts outline the conceptual and thematic backbone of *Web Variations*. Technology offers an avenue of artistic progression from *Variations VII.* The internet based environment offers the potential to merge concepts from Cage's work - indeterminacy, the facilitation of reception, and the gathering, catching, or sourcing of otherwise inaudible sounds through sonically focused apparatus - with concerns such as those outlined by Follmer, Born, and Novak. The internet based environment of *Web Variations* is an appropriate space to situate these concerns; a structure that allows exploration of 'relayed creativity' and 'intra-action' - while listeners to engage in a direct form of musical navigation as they move about, and through, the performance environment. The internet based environment and the designed performance space facilitates an autonomous, navigable, and unique listening experience.

5.3. Reflection and Analysis

The previous two chapters include analysis and reflection sections which attempt to uncover how modern technologies alter, progress, or evolve the way in which performers and listeners engage with artworks, especially with regard to the similarities and differences between my artistic responses and the historical works on which they were based. This chapter will follow a similar format. The table below (see Fig. 18) summarises the core differences and similarities between *Variations VII* and *Web Variations*. It is followed by a discussion of the main topics.

Characteristic	*Variations VII*	*Web Variations*
Location of Performance Space	69th Regiment Armory, New York. October 15-16, 1966	Internet Based Environment. June 2015 - current
Core Concept	Indeterminacy	Indeterminacy
Instrument Design	Performer Led	Environment Led
Performance Topology	Static	Dynamic
Sound Sources	Many	Fundamental Source - Branched
Modes of Interaction	Performer Led	Democratised

Fig. 18: Similarity and Difference between *Variations VII* and *Web Variations*

5.3.1. Performance Location

In *Variations VII* the performance is a tangible, three dimensional performance space that includes a local audience and local performers. The performers each have their own personally designed instrument. In *Web Variations* the performance space is replaced by an internet based performance environment, designed to reduce performer individuality, but increase listener autonomy.

Variations VII was shown as part of a multi-artist programme, entitled *9 Evenings: Theatre and Engineering*, at the 69th Regiment Armory, New York on October 15-16, 1966 (Bonin, 2006). The performance space consisted of a stage on which performers were located (see Fig. 19). The performers' motivations were to gather

otherwise inaudible sounds and to coerce the audience into an engagement with the technological apparatus used in the sourcing process.

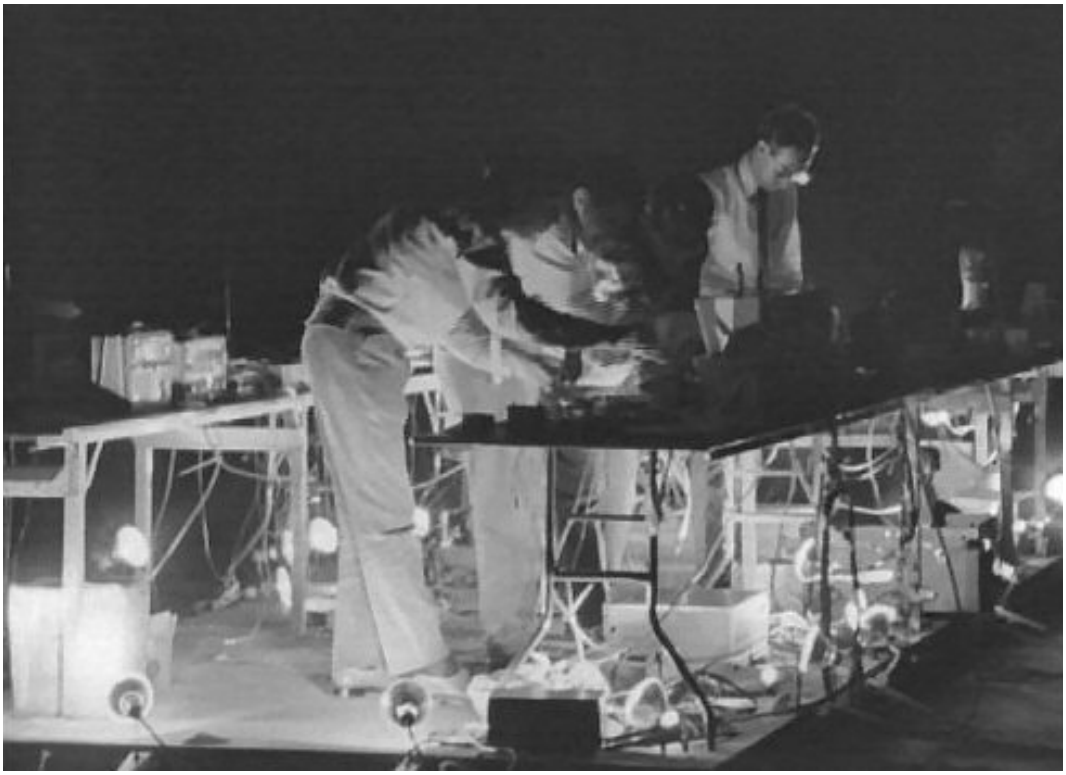

Fig. 19: Performers Located on Stage in *Variations VII*

Web Variations shifts focus by locating the performance inside a digital environment - accessed through internet enabled computers. All performers are remotely located, connected with each other through the multi-user navigable interface the environment affords. I view this environment as a meeting place for interested parties in a similar manner to how concepts of 'virtual space', 'cyberplace', and 'cyberspace' have been adopted by theorists interested in understanding the implications of the internet on music.

The ability of modern communication technologies like the internet to create bridges between places, allowing for a 'virtual space' to be populated has been, and still is, a central investigative concern of network music.

> "...networked media and its peer-to-peer relations subvert the traditional constraints of musical and artistic practice leading to new forms of media composition that embrace the evolving architecture of virtual space." (Packer, 2005, p. 510)

Whalley embraces the discussion by distinguishing between abstract notions of 'cyberspace' and 'cyberplace' with respect to network music's communication and production paradigms (Whalley, 2012). He outlines 'cyberspace' as being concerned with production values - especially the informational paths that operate within a network, "a web of connections between people at nodes" (Whalley, 2012, p. 5) and 'cyberplace' as "the meeting points between parties in cyberspace" (Whalley, 2012, p. 5). This allows me to view the performance environment of *Web Variations* as a 'cyberplace', where interested parties meet to engage in connection and interconnection in a musical context.

5.3.2. Indeterminacy

The concept of indeterminacy played an important role in Cage's career as composer, influencing his thinking beyond just his own musical ideals (Cage, 2008a; Cage, 2008b). Cage described experimental music as that which "initiates sonic processes the outcomes of which are not known in advance" (Cage, 2008b, p. 221). Miller discusses Pritchett's analysis of Cage - especially his preoccupation with the concept of indeterminacy, deliberating on two strands relevant to Cage's music - indeterminacy with respect to composition and indeterminacy with respect to performance - outlining that the two processes elicit different outcomes.

Variations VII was indeterminate with respect to both performance and composition. Cage instructed performers to 'gather' sounds through technologically inclined means, and then to amplify these sounds within the performance space. Cage ensured that the indeterminate nature of the gathered sounds was mediated by the performers, not instructing them to behave, act, or perform in any designated way. He wished for the indeterminate nature of the sounds to be translated to the audience, and for this 'free' nature to be mediated by the performers. Cage further detailed his musical ideals in 1968, two years after the debut of *Variations VII*. He stated "in musical terms, any sounds may occur in any combination in any continuity" (Cage, 1968, p. 8). He also noted his feelings at the time "we are, in fact, technologically equipped to transform our contemporary awareness of nature's manner of operation into art" (Cage, 1968, p. 9). *Variations VII* is as an example of Cage practicing these ideals.

Web Variations contains a semblance of indeterminacy; a by-product of the compositional and performative goals of the work. My objective was to create a performance environment that used a live microphone stream - ungoverned aside

from the compression techniques used in the audio data transportation - as a source for all performers to engage with in a collaborative and interactive musical performance. The microphone source is represented in the environment by the base node, with all performing users connecting to this node directly - by connecting their performing node to the base node; or indirectly - by connecting to another node that is itself directly or indirectly connected to the base node. It is important to remember that the sonic output of the base node flows through the system by passing through all attached nodes. If there are birds singing at the microphone location, this sound event courses through the work - moderated, sculpted, and manipulated by the connected nodes. If planes pass overhead, a swell flows into, and through, the input and output of each connected node; a sonorous cascade.

The concept of indeterminacy is also reflected in the 'relayed creativity' and 'intra-active' processes found within the environment (see section 5.2). From the perspective of any individual performer, the lack of control they have over their node's input ensures their own artistic creativity is directly influenced by whatever is happening at their node's input connection point (which is the output of the node they are connected to). This relayed process is an embedded design feature. The environment attempts to explore the nature of 'intra-action'; manifest through an internet based network music system.

From the perspective of a listener - defined as one that listens to the output of any node but does not take any role in enacting a performance by creating a node - indeterminacy is found in a number of aspects. Firstly, the fundamental sound source is indeterminate - it is a live, unmoderated microphone stream. Secondly, there is no score for the piece - each performance is unique and dependent on factors such as the number of performers, the vantage point of the listener, and the topological formation that the performers create. Performances will sound similar as the microphone stream has an identifiable timbre, tone, and character - as does the effects unit - but individual parameter setting permutations and configurations remain distinct. Thirdly, the listener is able to choose the vantage point from which they listen, changing their listening perspective as they engage with the work. Each individual listener (there is no upper limit on the number of concurrent listeners) has the opportunity to hear a different piece of music as they navigate through the topology the performers have created. A listener may seek similarities and differences at each node; viewing the performance through an altered aesthetic - concerned with the quality of navigation, robustness of the performance environment, or the degree of 'intra-action' between performers.

5.3.3. Instrument Design

In *Variations VII,* Cage did not determine what types of instruments should be implemented within the performance environment. There were no rules or techniques imposed as to how instruments should be designed, programmed, controlled, or configured. Indeed "free manipulation" (Miller, 2009, p. 76) was a behavioural objective outlined in the performance instructions and seemed to be of importance to Cage. This unscripted nature is reflected in the original presentation of the piece, as relationships between the performers and their designed instruments surface. One of the performers, David Behrman, placed a set of electrodes on his forehead - interpreting, converting, and then mapping the biological data to a suite of sine wave oscillators which varied in amplitude with respect to values received (Bonin, 2006). This highlights an interest by Behrman in early brain communication interfaces. Cage implemented a similar technique, but instead of mapping electrodes to his own forehead he mapped them to the foreheads of his collaborators. This provides evidence of Cage's fascination with cybernetic principles - as he attempted to engage with a communicational feedback path between performance environment, amplified output, performer interpretation, and the return of information to the performance environment.

Wenhart describes the series of performances as those that "made the body into a sort of bridge between the stage and the technological environment" (Wenhart, 2006, p.1). She views the relationship between the listener and the performance environment as being a central avenue of exploration, even if indirectly - noting how the industrialists of the day were interested in "changes in the user's perception produced by the new technologies developed in the 1950s and 1960s" (Wenhart, 2006, p.1). Cage recognised that the use of technologies within the performance space allowed the audience to question their relationship with them (Wenhart, 2006). His instructions to gather sounds from the air through various means ensured the audience reflected on how sounds appeared, as well as the techniques used to make them audible. The performance process is seen as a reflection of the technologies as well as a mediated expression of the sounds themselves (Bonin, 2006).

The relationship between audience and technology has been reiterated in Tom Plsek's reworking of the original - as part of the *Mobius Artist Group*, in 2007, at the *New Art Center*, Newtownville, Massachusetts (Miller, 2007). In this reworking the group implemented different techniques to those used in the original

performance in 1966. Plsek incorporated two laptop computers, each with differing foci.

> "One [laptop] was used to search for mostly live sounds, e.g. radio stations, [Air Traffic Control] transmissions, online microphones...The other computer was my 'Skype' machine which was used to establish contact with folks who would then insert sounds into the system." (Plsek, cited in Miller, 2009, p. 76)

The implementation of the different technologies reflects a certain degree of cultural and technological evolution. Miller states that Plsek is "interested in a 21st-century presentation which tries to locate the essence or most salient aspects of the original..." (Miller, 2007, p. 1). The audience in 2007 was urged to reflect on the use and implementation of *Skype* in a musical setting, or consider more deeply the relationship between sound and the vast dynamic store of information and data on the internet.

In *Web Variations*, the choice of instrument is restricted; performers are only offered use of the browser based *Web Audio* effects unit [44]. This custom built audio processing module is the same for every performer. I made this decision so that focus would move away from reflection on the implications of individualised instruments and their designers - as was the case in *Variations VII* - onto the performance environment as a whole, especially in the context of the themes outlined in section 5.2: 'relayed creativity'; 'intra-action'; and 'navigable music'. By turning attention onto the environment, and the technologies that allowed its creation, it is hoped the users (both listeners and performers) engage with the affordances of the internet and its technologies in a more reflective manner. Users may make simple acknowledgements regarding the burgeoning audio generating and processing capabilities of their internet browser, or become aware of the internet as a creative medium for simultaneous multi-user navigable spaces designed for musical composition and consumption. They may also, more importantly, become aware of the internet as the most compelling manifestation of the 'network' in the modern age - where concepts of connectivity evolve our understanding of society - especially in regard to notions of individuality.

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44 The design of the effect is based on a simple slider based interface. The effects window displays a series of sliders that have recognisable names, and sonic results: similar to the way in which a DAW plug-in works. The interface is designed to allow a wide range of users to access the work, as a complex design may have alienated certain age groups or experience levels. *Web Audio* based signal processing functions form the back-end operative of the instrument.

The decomposition of individualised behaviour is a core concern of *Web Variations*, as audio processing parameter modifications have direct implications for other nodes within the system - they are all part of a system state which is shared across all instantiations of the performance environment. Conceptually, I link this concern to Deleuze's notion of the 'dividual' which Varnelis (2008) describes as individual identity dispersed through a community; where one is "less an autonomous individual and more of a construct of the relations it has with others" (Varnelis, 2008, p. 152). This construct of 'dividuals' is represented in *Web Variations*, as the environment allows a system of 'intra-acting' performers to engage in the collective creation of musical material. While the concept of collective creation has been seen previously (see sections 2.1.3 and 2.1.7), *Web Variations* turns attention directly onto the technological reduction of individuality - especially with regards to the manner in which the internet and its related technologies can enable - as well as govern - actions, interactions, and 'intra-actions' in a multi-user environment.

5.3.4. Performance Topology

In *Variations VII* the performance topology remained predominantly static. The performance space consisted of a number of performers, located on a stage, gathering sound through specifically designed instruments - relaying this sound to an audience through an amplification process. Examples of the technologies used are electrocardiography (ECG) machines, short-wave radios, telephone lines, sine-wave generators, Geiger counters, and contact microphones [45]. The instruments were located on a raised platform, with performers able to move around - freely manipulating the available receivers and generators. The instruments were arranged in a static fashion, with performers locating themselves at any instrument at any given time during the performance.

> "Two parallel platforms were set up in the centre of the Armory. On them were placed the technological components, along with several sound generators." (Bonin, 2006, p. 1)

The topology of *Web Variations* is dynamic. Within any given performance, the arrangement of nodes is decided by users. Performers are free to enter and exit the stage, altering the formation as they do - with the graphed formation of nodes readjusting as and when needed. The base node remains static, but the location and

45 A full list of the used technologies may be found at http://www.fondation-langlois.org/html/e/page.php?NumPage=611

connection of each subsequent node is completely unscripted and indeterminate. This freedom ensures a vast number of topological formations may be formulated. For example, performers may arrange themselves in a standard star formation - with each outlying node connecting to the base node (see Fig. 20). This formation ensures that each performer remains predominantly autonomous, with their creativity not being impinged on directly by any other performer.

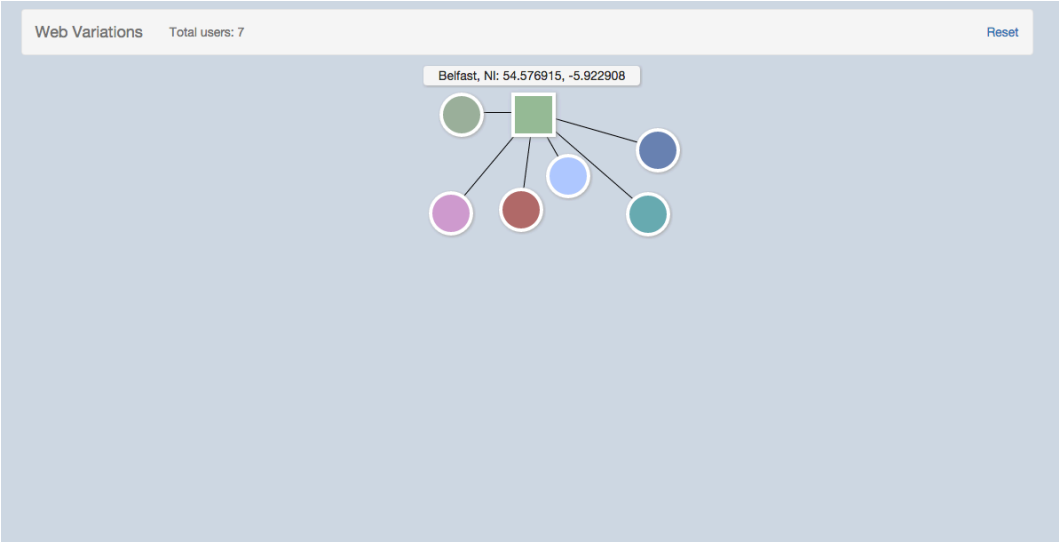

Fig. 20: Six Performers in Star Formation in *Web Variations*

Alternatively, performers may arrange themselves in a line formation (see Fig. 21). In this formation each node is interceded on by the preceding node in the chain, with the final node being dependent on the relayed actions of every other node. The fluidity of arrangement allows a great degree of freedom to performers in the environment, especially with regards to their position and the level of relayed behaviour they wish to enact. If a performer is not entirely happy with the current topology, or their place in it, they are free to exit the performance space, returning to alter their position, and thus altering the topology.

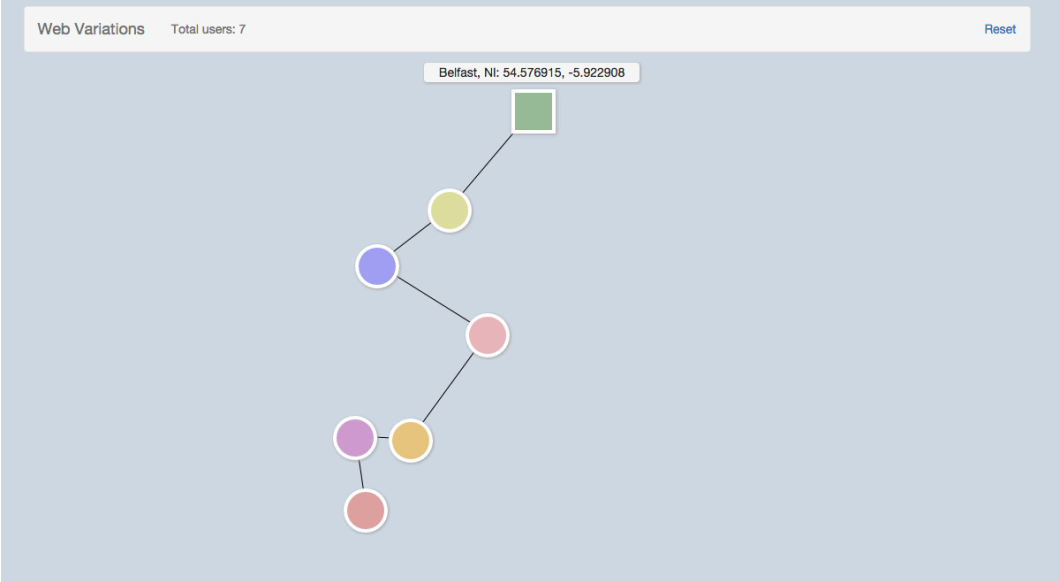

Fig. 21: Six Performers in Line Formation in *Web Variations*

It is possible to calculate the number of topological formations by understanding the potential number of permutations and configurations of eight performing nodes (the maximum number of connected performing nodes allowed by the system). The formula below (see Fig. 22), representing **F(n)**, details the number of total possible unique formations that can exist - with **n** representing the number of performing nodes (not including the base node). For **n=8**, the total number of possible ways in which the performers may arrange themselves is **1,935,361**. That is, there are almost 2 million possible configurations, given eight unique performers.

$$F(n) = (n-1)^2 n! - (n!) + 1$$

Fig. 22: Number of Possible Configurations within *Web Variations*

The upper limit of eight was chosen as I did not want to cause undue stress on the performance system at any given time. The indeterminate nature of entering users meant a case may arise in which a user enters the performance environment with a browser installed on a computer with relatively low hardware specifications. In *Web Variations* all signal processing must be completed on the client side, so limiting the amount of possible calculations ensures that the majority of users will perceive the performance environment as a smooth functioning experience. Of course, as technology continues to develop, and more powerful hardware configurations

become commonplace, the possibility of offering a higher upper limit of concurrent performing users increases.

5.3.5. Sound Sources

The fundamental concern of *Variations VII* is how listener attention is drawn onto the sounds themselves, and the ways in which sounds are made audible through technology. A perceptual shift occurs as listeners engage with sounds and sound generating equipment in unfamiliar musical and performance contexts. This focus is also seen in more recent re-workings of the piece. In 2008, *Variations VII* was performed in the United Kingdom for the first time - at the *Baltic Centre for Contemporary Art* as part of the *AV Festival*, Gateshead (Brown, 2008). The festival director, Honor Harger, describes the work.

> "...to be true to the spirit of Cage we've got to update...we can now use mobile phones, we can now use Skype...It was first performed at an event that was about using new technology. They were breaking new ground and in order to be in the spirit of the piece we have to have the chance of discovering something new to leave the audience with the same frisson." (Harger, cited in Brown, 2008, p. 1)

Though *Web Variations* uses only one sound source, a similar perceptual shift occurs, as users are encouraged to acknowledge the affordances of the performance environment. One microphone stream - sourced from a remote location - is shared across a number of performers, with the collaborative capabilities of the digital space focusing attention onto the performance's enacted interceding and relayed relationships. Even though only one sound source is used, the environment offers discrete connection points (nodes) which a user may connect or disconnect with as they choose.

5.3.6. Modes of Interaction

Variations VII contained no direct elements of audience interaction, as performers were separated from audience members through raised platforms and a dedicated performance stage (Bonin, 2006). In section 5.3.3 the manner in which electrodes were mapped to the heads of persons within the performance space - by Berhmann on himself and Cage on a number of other performers was discussed. Interaction between members of the public and the performance was restricted to unknowing

and unscripted contributions - sources gathered from short-wave radio interceptions, public radio broadcasts, or dedicated telephone lines.

Web Variations alters this schematic, as the performance environment offers any user the choice of becoming a listener, or performer. This ensures that all audience members have the potential to include themselves in the performance. I see this as a democratisation of performance - a democratisation afforded by the environment. This is a reflection of a general trend towards democratisation of musical decision-making seen within shared sonic environments and collective creation systems - as outlined in Chapter 2 (see sections 2.1.3 and 2.1.7). Allowing the audience to interact with the performance in an unscripted manner also allows discussion to arise regarding the emergent characteristics of the performance system.

Emergence has been described by Johnson as "a higher-level pattern arising out of parallel complex interactions between local agents" (Johnson, 2001, p. 19). In *Web Variations*, the actions and interactions of agents lead to collaborative and co-operative musical performances. Whalley outlines how process centred systems in network music have moved away from hierarchically modelled, centralised structures, towards horizontal "co-ordinate and co-operate paradigms where multiple entities self-assemble" (Whalley, 2012, p. 5), creating musical works "beyond the product of a single creator" (Whalley, 2012, p. 10). This behaviour is afforded by the *Web Variations* system. Goldstein describes emergence in a similar manner, concentrating on the structures, properties, or patterns that arise "during the process of self-organization in complex systems" (Goldstein, 1999, p. 49). He defines emergence as the macro-level phenomena arising from simple micro-level processes (Goldstein, 1999). By observing the behaviour of agents within *Web Variations*, the potential for emergent behaviour to arise within the performance environment may be seen.

For example, if a topology was formed as seen in Fig. 23 there may be two distinct musical paths. The path on the right may be focused on the original sound source, with performers using subtle transformations on their node's incoming audio. The path on the left, in comparison, may be populated by more experimentally focused performers who want to explore the feedback and filter properties of the audio effect. The musical output of each path would be different - even though the same information was the source for both. The performance environment allows agents with differing motives and foci to self-organise, which highlights the affordances of the system, and the emergent characteristics that may arise from simple connections between nodes in the performance space.

It must be remembered that the internet technology facilitating the online based performance environment has simultaneously leveraged the modes of interaction. The design of the system and the enabling technologies ensures that any participant has the choice of two roles; performer, or listener - moving between them as they see fit. This dualism is afforded by the technology and design of the system. A participant may engage with the environment, either listening directly to individual nodes, creating a unique listening experience, or moving about the system attaching their own node to other nodes - altering their role in the performance, the topology of the performance, as well as the performance itself.

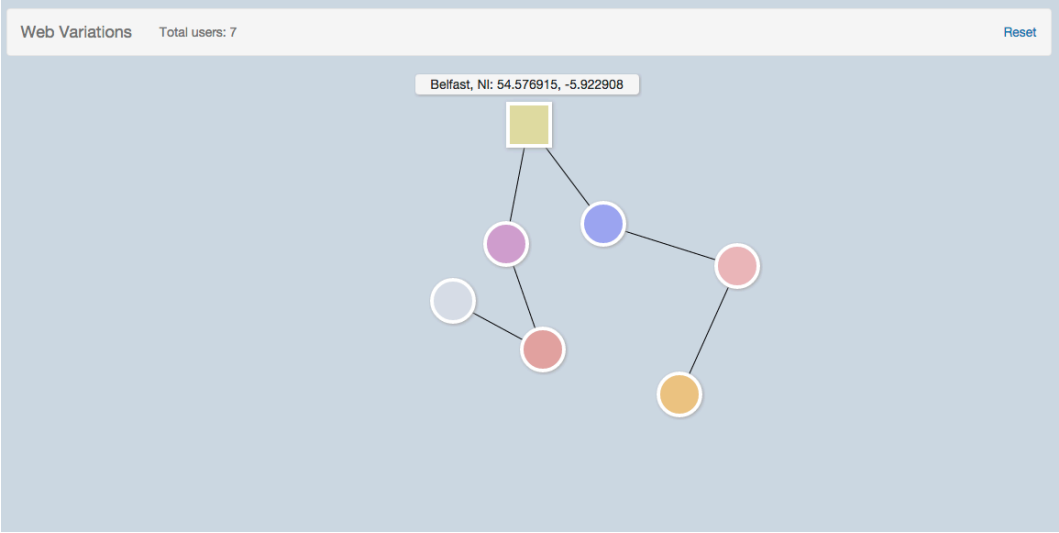

Fig. 23: Comparative Paths in *Web Variations*

5.4. Summary

This chapter introduced Cage's *Variations VII* alongside my own artistic response, *Web Variations*, demonstrating the similarity of the two works through discussion of the core conceptual motive - indeterminacy. I have outlined how indeterminacy remains a concern in the artistic response, even though the methods through which the two projects are realised are different. I have detailed how themes are augmented in *Web Variations*, by urging participants to acknowledge the affordances of internet technologies, and online multi-user environments, in the context of how they leverage the potential for emergence and indeterminacy to appear. I have also discussed the reductionist nature of *Web Variations* - only one type of performance instrument is allowed, as apposed to the many seen in *Variations VII,* whilst describing the manner in which *Web Variations* draws attention to specific sound orientated internet technologies, rather than an array of sound making equipment - as is the case in *Variations VII*. Relevant performance

topologies were detailed, drawing attention to the fact that *Web Variations* allows a great degree of freedom with respect to enacted topology, allowing users to explore and reflect conceptual concerns such as 'intra-action', 'relayed creativity', and 'navigable music' - by foregrounding interactive performance processes where actions of users intercede directly onto others. Finally, I have drawn attention to the way in which the technology and design of the online performance environment affords a democratisation of performance, as the system allows any participant to become a performer or listener.

Web Variations pays respect to concepts from the initial performance instructions of *Variations VII* such as "no previously prepared sounds" (Miller, 2009, p. 76), "free manipulation of available receivers and generators" (Miller, 2009, p. 76), and "facilitating reception" (Cage, cited in Miller, 2007, p. 1) and placed them into an internet based performance environment. The online performance space allows users to explore specific affordances of the internet and its inherent technologies - extending user engagement, and exploring conceptual and artistic concerns that may not have been so easily identifiable or communicable when Cage's original was performed, in 1966. The technology used in the artistic response has reaffirmed the core artistic concern of *Variations VII* - indeterminacy - while leveraging and extending others: instrument design, performance topology, and modes of participant interaction.

Chapter Six

6. Fields of Feedback

The final work of the portfolio, *Fields of Feedback*, is a musical performance involving three laptop performers and one network moderator. The three laptop performers are connected through an audio feedback network. The moderator governs both the levels and direction of audio feedback within the performance, controlled through an interface developed in *Max/MSP*. This chapter will discuss the motivational and conceptual origins of the work, relating it to other projects included in the portfolio, the thesis' appendices, and examples of practice and research from a wider body of work. The chapter will also reflect on the performance's artistic outcomes, namely the musical performance and the creation of the audio-visual digital artefact found in the supporting documentation folder (~/Documentation_Material/5.Fields_Of_Feedback/Digital_Artefacts/...). Technological concerns will be detailed, especially with respect to the neural network model used as the topological template for the feedback system. The ways in which the piece explores concepts such as 'intra-action', relayed, and collaborative creativity will be communicated. The impact the systemic governance had on the work will be detailed, along with directed and emergent outcomes, artistic decisions, and the perception of performer individuality.

The work developed as my concepts and ideas of network music evolved, expanding to include investigation into a wider body of experimental music, inspired by the fields of machine learning and neural networks. Conceptual and artistic concerns of the work derived from this thesis' critical reflection process; namely an acknowledgment that advancements in audio, networking, and communications technology afford explicit explorations of relayed and bi-directional musical creativity amongst 'intra-acting' musical agents to be completed, coupled with a leveraged ability to communicate network effects,

strategies, implications, and outcomes to an audience through explorative and experimental music practice.

6.1. Inspiration through Reflection

Critical reflection and analysis is noted as being a crucial part of the practice-based research process (see section 1.4). The performance model for *Fields of Feedback* emerged as themes and concepts unearthed during the research process developed into coherent inspiration and strategy for a final work. *Fields of Feedback* is an original project, acting as a summation of what I have learned and understood about network music, network music technologies, and the implementation of specific network topologies as models for music performance systems.

Tracing a linear progression of my art helps frame the artistic and technological concerns of *Fields of Feedback*. Performance models exploring relayed creative behaviour initially emerged in the research I completed for my MSc dissertation (Renwick, 2011; Renwick, 2012). This line of thought developed further in the *Amalgam* (Appendix E and Appendix F) and *Sourced Cities* (Appendix H) projects, before it was fully elucidated in the internet based project *Web Variations* (see section 5.2). The concept of 'relayed creativity' became a central avenue of investigation as my thesis developed, and my desire to explore it directly inspired the final work; researching the concern in a performative context, while simultaneously adding a secondary performative layer - a moderator who governs and manipulates the levels at which a series of performers interact, intercede, and relay their creativity to and from one another.

My ability and aptitude for enacting topologies within network music projects can similarly be traced through my research. The process began with the simple local network music topology for three performers, applied in my MSc research (Renwick, 2011; Renwick, 2012), which developed into a more coherent structure for three performers in the *Amalgam* projects, onto the more direct line topology for two performers enacted in *Sourced Cities*. Alongside these relatively simple topologies, I developed an intricate, distributed and technologically dependent topological structure in *Skype Supply* (see Chapter 3), and initiated an interest in audio source interaction in *Synchrocities* (see Chapter 4) - developing a musical system with co-dependent sonic processes. *Ellipses* (see Appendix G) reinforced my ability to create and manage a complex, bi-directional, interactive performance topology, and opened a distinct line of enquiry into interactive, and 'intra-active' performance behaviour.

Fields of Feedback directly reflects interests first outlined in Chapter 1 (see section 1.1) - how conceptual understandings of network music aid the development of musical performance models - and this was supported by my technological aptitude for designing and creating models for performance through networking concepts. Conceptual understanding inspired exploration of certain avenues, and my developing technological abilities supported this investigation - allowing me to create specific systems like the one discussed in this chapter.

6.2. Technology: Support, Structure, Stimulus, Spur

While outlining the rationale for the historical works in Chapter 1 (see section 1.5), I acknowledged that Neuhaus, Amacher, and Cage all shared a common artistic goal - to explore the relationship between sound and technology through their art. They understood that technology opens up avenues of investigation, exploration, and experimentation; inspiring and supporting artistic concerns. In Chapter 1 (see section 1.2.2) and throughout Chapter 2, I detail the existing relationship between network music and the concurrent development, and implementation, of specific technologies. I note that types, strategies, concepts, and explorative themes found within network music adopt technologies as crucial support structures, determinants of behaviour, and as self-representing conceptual reflection.

Web Variations explores key concerns that emerged in the research process whilst leaning on the ideas of Cage. It uses an internet based collective creation environment, developed with internet technologies, to explore certain investigative avenues. In *Fields of Feedback*, I explore similar thematic concerns, but in a more traditional musical performance. *Web Variations* allows multiple, remotely located users to explore themes such as ‘relayed creativity’ and ‘intra-action’, but does so within an internet based performance environment. The medium allows me to explore the concept of navigable music as a method of audience engagement; creating performative and interactive behavioural affordances for participants, but it does not allow music to be easily performed in a traditional ‘concert hall’ context.

In *Web Variations* any node within the system receives relayed audio from one other node - a similar topological formation as found within the *Sourced Cities* and *Amalgam* projects. In this manner it is restrictive. *Fields of Feedback* addresses this issue, whilst moving the practice into more traditional performance realms - three performers located within a concert hall, performing for a local audience. It also involves the creation of a moderation layer. A role whose function is to manage,

direct, and perform the implemented network feedback system. Turning to Barbosa's survey of network music practice, *Fields of Feedback* is viewed as a local music network (see section 2.1.1). In a manner similar to *Skype Supply*, and *Synchrocities*, there is a moderation role, but unlike those projects the role is undertaken by a human, as in Neuhaus' *Public Supply I*. For the performance of *Fields of Feedback*, I undertook the role of moderator.

6.3. Fields of Feedback

Fields of Feedback's main concern is the musical implementation of an artificial neural network model derived from the field of computer science - more specifically the field of machine learning [46].

> "A neural network is an interconnected assembly of simple processing elements, units or nodes, whose functionality is loosely based on the animal neuron. The processing ability of the network is stored in the interunit connection strengths, or weights, obtained by a process of adaptation to, or learning from, a set of training patterns." (Gurney, 1997, p. 13)

Within *Fields of Feedback*, a specific type of model is implemented, called a Hopfield Network [47] . The learning model is integrated into the artwork by interpreting its organisational structure as the topology for a network music performance system - with each node in the neural network model represented by a performing node in the musical performance topology. It is a direct translation, as processes occur at the nodes in both implementations. In the original neural network learning model these processes are represented by discrete mathematical algorithms - in the musical model they are represented by artistic decisions coupled to computational digital signal processes.

During the rehearsal phase of the project a choice to use alternate neural network models was offered to the performing group. I designed the system in such a way so that a choice of three neural network models could be implemented at any given time: a layered model, a recurrent model, and a Hopfield Network model. These

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46 Machine learning is a subfield of computer science that researches models for computer based learning as artificial intelligence. For a complete explanation of both machine learning and artificial intelligence, from the perspective of neural networks, the author offers the following reference: Haykin, S. (1999). *Neural Networks: A Comprehensive Foundation*, Singapore: Pearson Prentice Hall.

47 A Hopfield Network is a feedback orientated learning model that was described by John Hopfield in 1982 (Gurney, 1997). Further explanation of this topological model will be detailed in section 6.3.3.1 of this thesis. For the moment, it is helpful to understand that the model is a topological formation of units and nodes, and contains a description of the rules by which the units or nodes interact with each other.

three distinct topologies are similar, but contain subtle differences. The decision to use a Hopfield Network model was taken, by the group, on rehearsal day one. From my observation, it seemed clear that the decision was made as the model offered the highest degree of perceived individuality to each performing node. This will be discussed later in this chapter (see section 6.3.2.1).

6.3.1. Motivations

In Chapter 2 (see section 2.1.8), I discussed extended and emerging concepts of network music. *Fields of Feedback* is an example of an extended form. Through the research process, my interest into varied concepts, understandings and implementations of networks led me to investigate the term as used within the realms of computer science and artificial intelligence. The concept of neural networks was introduced to me through my own interest in digital art and emerging technologies. *Alphabet* [48] - formally *Google* [49] - use neural network learning models as a method for image recognition and manipulation through the implementation of their *TensarFlow* [50] open-source software library. In the latter half of 2015, a slew of images were released as software developers, and artists, explored the affordances of the neural network based software library (see Fig. 24). The term "Inceptionism" (Google, 2015) was borne, as *Google* developed an artificial intelligence image recognition and manipulation method using neural networks as their algorithmic base (Google, 2015). The continued development and adoption of this technique has seen a mobile phone application be developed, entitled *Prisma* [51] - highlighting how the method has been adopted by consumer culture after a period of initial experimentation and prototyping - much like how network music strategies and concepts that have been adopted into mainstream music production, as discussed in Chapter 2 (see section 2.1.1 and 2.1.2). The images interested me artistically, not only because of their aesthetic quality, but also because I saw the emergent properties of the learning models being actualised through the systems' outputs. I immediately began to investigate how I might be able to implement similar models into music performance.

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48 *Alphabet* is a holding company, formed in 2015, that manages a portfolio of enterprises formally held by Google Inc. More information may be found at https://abc.xyz/

49 *Google* is a Internet based search engine and information organisation firm. It forms one part of the holding company *Alphabet*. More information may be found at https://www.google.ie/intl/en/about/

50 *TensarFlow* is an open-source software library for numerical computation using data flow graphs. It has many applications in the fields of computer science, mathematics, and data science, with neural networks only being one. More information may be found at https://www.tensorflow.org/

51 *Prisma* is an iPhone application developed using neural network based models for image recognition, and image manipulation. More information may be found at http://prisma-ai.com/

Fig. 24: Example Image as created by *Google's* "Inceptionism" Application

6.3.2. Neural Networks

To understand how I have instantiated neural networks into concepts of network music, it would be beneficial to detail some fundamentals of neural networks - as drawn from the field of computer science. Both Gurney (1997) and Haykin (1999) acknowledge that the term 'neural network' has been adopted by the field as the network models are loosely based on the biological structure of animal brains (Gurney, 1997; Haykin, 1999). Haykin explains how interest into neural networks began as scientists sought to understand how, and why, "the human brain computes in an entirely different way from the conventional digital computer" (Haykin, 1999, p. 23).

> "In its most general form, a neural network is a machine that is designed to model the way in which the brain performs a particular task or function of interest; the network is usually implemented by using electronic components or is simulated in software on a digital computer" (Haykin, 1999, p. 24)

Though Gurney offers a simple definition of a neural network (see section 6.3), Haykin expands it, offering a complex and robust acknowledgement of the adaptive behaviour of the 'machine' - built as a model of the human brain. He explains that any neural network implementation is attempting to define, or model, a suitable structure for learning (Haykin, 1999). The learning process is governed by the network model, and also by the way in which the model interprets, qualifies, or quantifies its own experience - as input is received through the processing units, or nodes.

> "A neural network is a massively parallel distributed processor made up of simple processing units, which has the natural propensity for storing experiential knowledge and making it available for use. It resembles the brain in two respects:
>
> 1. Knowledge is acquired by the network from its environment through a learning process.
> 2. Interneuron connection strengths, known as synaptic weights, are used to store the acquired knowledge." (Haykin, 1999, p. 24)

In the context of *Fields of Feedback* I have taken some artistic licence, by re-interpreting definitions and topological formations of neural networks as a basis for network music topologies. I previously mentioned that there was a direct one-to-one translation of Gurney's definition of neural networks to the topological formation implemented in *Fields of Feedback* (see section 6.3). If we acknowledge Haykin's definition, then some attention must be paid to the learning process of the neural network, and its analogous process within the network music model.

I view the learning process of the neural network model being represented by the rehearsal and planning process of the performance. Trained behaviour is implicit within the process - as the performers iteratively understand what is required to produce a 'successful' performance - they also have a pre-formed understanding of what a 'successful' concert should sound like, drawn from their own experience of musical performance. The experiential feedback process is represented by the iterative process of rehearsal, critical listening, critical evaluation, discussion, feedback, rehearsal - a method that is integral to most musical performances that

involve some level of rehearsed creative process. The process is supervised, as is the case in the training process of neural networks, as all involved agents learn incrementally how the system works, their musical role, and the effect that their individual actions have on the musical output.

6.3.2.1. Neural Networks and Music

Neural networks have been adopted into musical practice and research in a variety of ways - speech recognition, gesture recognition, music classification, musical score analysis, and automated music performance (Leben, 2012). Mark Dolson explains that neural networks' processing and algorithmic functionality has been applied to many computationally demanding tasks (Dolson, 1989). He notes that most applications have been performed within the digital domain - offering "significant advantages over conventional approaches to computer programming" (Dolson, 1989, p. 29). He outlines two musical applications, the first of which is a rhythm evaluation system which makes judgements of rhythmic audio examples based on prior training; ultimately classifying post-training inputs as either 'good' or 'bad'. In this context, the neural network is working as a form of learned intelligence - making musical judgements based on characteristics determined from a supervised learning process. Dolson (1989) also outlines a second application of neural networks - computer-assisted composition - in which a neural network is fed examples of 'good' rhythms, and then attempts to create similar content based on what it learned from the training process. This method of computer-aided musical composition is still a research and development concern, with a recent *Alphabet* open-source software library, *Magenta* [52], being released to cater specifically for this type of application.

Coutinho and Cangelosi implement a neural network computational process to analyse, and classify, human musical emotional response (Coutinho and Cangelosi, 2010).

> "A detailed analysis of the simulation models' results demonstrates that a significant part of the of the listener's affective response can be predicted from a set of psychoacoustic features of sound - tempo, loudness, multiplicity (texture), power spectrum centroid (mean pitch), sharpness (timbre), and mean STFT flux (pitch variation) and one physiological cue - heart rate." (Coutinho and Cangelosi, 2010, p. 331).

52 *Magenta* is an open source software library specifically designed for art and music applications. It is based on *Alphabet's TensorFlow* library. More information may be found at https://magenta.tensorflow.org/welcome-to-magenta

Coutinho and Cangelosi describe a 'spatio-temporal connectionist model' "that is capable of dealing with input data presented across time as well as space" (Coutinho and Cangelosi, 2010, p. 341). They stress the cruciality of recurrence in neural networks, as "through these [recurrent networks] some of the information at each time step is kept as part of the input to the following computational cycle" (Coutinho and Cangelosi, 2010, p. 341). Though discussing the validity of this research is beyond the scope of this section, the effect of recurrent networks with respect to computational cycles should be noted, as this propensity will be detailed later in this chapter whilst discussing the emergent outcomes of the *Fields of Feedback* performance (see section 6.3.4.2).

Gesture recognition is another example of an application of neural networks for musical purposes. Implementing a trained neural network to recognise and/or categorise gestural events mapped through a physical, or digital, interface has been researched by those wishing to delegate the computational load of gesture recognition to specifically designed software. *Wekinator* [53], originally created by Rebecca Fiebrink in 2009, is a standalone, open-source software application that has the capacity for implementing a number of machine learning algorithms for creative purposes - one of which is a neural network algorithm.

> "The Wekinator enables users to rapidly and interactively control ML [machine learning] algorithms by choosing inputs and their features, selecting a learning algorithm and its parameters, creating training example feature/ parameter pairs, training the learner, and subjectively and objectively evaluating its performance, all in real-time and in a possibly non-linear sequence of actions." (Fiebrink *et al*, 2009, p. 1)

Caramiaux and Tanaka also detail how machine learning algorithms have potential for gestural recognition - detailing a number of existing machine learning 'toolkits' for artists (Caramiaux and Tanaka, 2013). They also acknowledge that neural network algorithms play a central role within this field.

> "Through the use of adaptive basis functions, neural networks offer powerful means to create intermediary representations of complex data. This functionality can be encapsulated and used as black boxes, making these models available to composers and musicians in the form of end-user toolkits." (Caramiaux and Tanaka, 2013, p. 5)

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53 *Wekinator* is a software application for implementing a host of machine learning algorithms - including neural networks. More information may be found at http://www.wekinator.org/

The above examples demonstrate neural networks as elaborate algorithmic processors, but more diverse interpretations of neural networks also exist within the wider body of experimental music practice. For example, artist Steve Symons (2002) has created a number of works that use neural network models as a basis for artistic experimentation.

> "I have been fascinated with sonifying neural output and simulations of neural behaviour for over 15 years...But rather than create a large scale artificial neural network I am more interested in the wide range of patterns that emerge from a small (8 to 12) series of simulated neurons." (Symons, 2002, p. 1)

Symons explores neural networks through his art in differing manners - 'Neuronal Network Synthesis' in his *Neural Plexus* project, a four-screen, outdoor, interactive installation entitled *Viral Synthesia* [54], and the *NeuralMix* engine which "is a system for breeding genetically encoded sonic entities...where each entity is comprised of a network of simulated cells based on neurons" (Symons, 2002, p. 1). His work explores the relationship between human and machine through computer based models of neurons and neural networks.

AANN, created by Philip Stearns in 2007, is an "interactive, handmade electronic sculpture that responds to environmental stimuli with a display of light and sound" (Stearns, 2007, p. 15).

> "The sculpture is a 45-neuron network whose topology was largely influenced by multilayered connectionist network models used in neural network computing." (Stearns, 2007, p. 15)

Stearns' work investigates the role of science and technology within art - creating an interactive sculpture able to produce harmonic music by interpreting input information (sound and light) from its environment (Stearns, 2007). His work explores the role of network science in the creation of new artwork through a physical, public facing artefact. This exploration of network science, drawn mainly from biological sciences, leads him to conclude that "neural networks will yield some astonishing discoveries, expanding possibilities for both scientists and artists alike" (Stearns, 2007, p. 21). His expansive interpretation of the potential for neural

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54 A more detailed explanation of this project may be found both on Steve Symons own portfolio website: http://muio.org/viral_synthesia, or in Joy, J. (2010). *Networked Music & SoundArt Timeline (NMSAT): A Panoramic View of Practices & Techniques Related to Sound Transmission and Distance: Archeology, Genealogy and Sound Anthropology of Distance Listening and Internet Auditoriums*. Aix-en-Provence: Locus Sonus, 2010, p. 362.

networks is tempered by his own admission that *AANN* represented only a very basic understanding of the field.

The heuristic process that Stearn went through as he created *AANN* is similar to my own. I delved into the field of machine learning through my interest in emerging technologies, and network art, ultimately seeking to create an artwork based on topologies I discovered. Having obtained a comfortable grasp of differing performance topologies through my previous practice, along with the skills required to implement them, I was introduced to certain organisational models that, I felt, were ripe for exploration and investigation through the performance and creation of music.

6.3.2.2. Neural Network Topologies

The *Fields of Feedback* performance system offers the choice of three neural networks: a layered model, a recurrent model, and a Hopfield Network model. The three models are instantiated through the *Max/MSP* patch - selectable by the moderator through the use of a drop down menu. In this section, I will discuss the three neural network models, explain the differences between them in the context of their implementation in *Fields of Feedback*, and detail the decision taken by the three laptop performers to choose the Hopfield Network model. I will not comment on the advantages or disadvantages of any model over another - but as a simple generalisation the differences exist primarily because of the efficiency and/or accuracy of the models to complete procedural tasks - the measure of which depends on the intended application (Gurney, 1997; Haykin, 1999).

A layered neural network model is one in which feedback occurs in stages - dependant on the amount of nodes, or units, in the system. The diagram below (see Fig. 25) details how this model is instantiated in *Fields of Feedback*. There is one input stream, which travels through three performing nodes organised in a line formation - formally known in the field of neural networks as layering. The output of each node is fed back through the system in stages - with each node receiving the feedback from any succeeding node. In this instance, performer A receives the feedback from every node in the system, including itself - whilst performer C only receives the feedback from its own output. There exists only one output path for the system as a whole - derived from performer C (the last layer in the topology). Every other node in the system acts as a process and feedback layer.

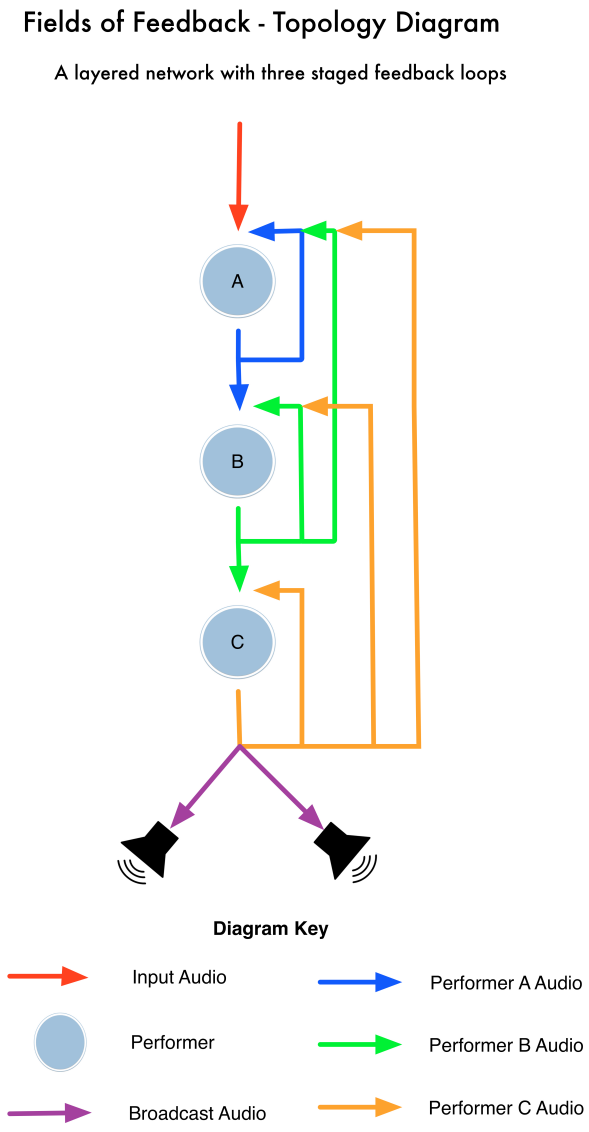

Fig. 25: *Fields of Feedback* - A Layered Network

A recurrent network model is different from a layered network in a number of ways. The most critical difference - especially in the context of its musical application within *Fields of Feedback* - is that each node has its own designated input stream, with the nodes no longer being organised in a linear formation. However, the input at each node originates from the same source [55]. Each node contains discrete processes, and the output of each node is recycled as feedback for every other node. In the case of *Fields of Feedback*, I also implemented self-feedback loops (see Fig. 26). Another differentiator is the fact that every node also contains its own output path - with the output of the system being the summed

55 In the case of the rehearsal process that occurred using this topology, a microphone stream from Aix-en_provence was used, sourced from the *Locus Sonus* soundmap. The difference in this topology and the Hopfield topology chosen as the performance model, will be discussed later in this subsection.

output of all individual nodes. This can be interpreted as each node having a distinct output role - the composition of which is dependent on the input source at every node, the processes that occur at each node, and the output of every other node due to the imposed feedback paths.

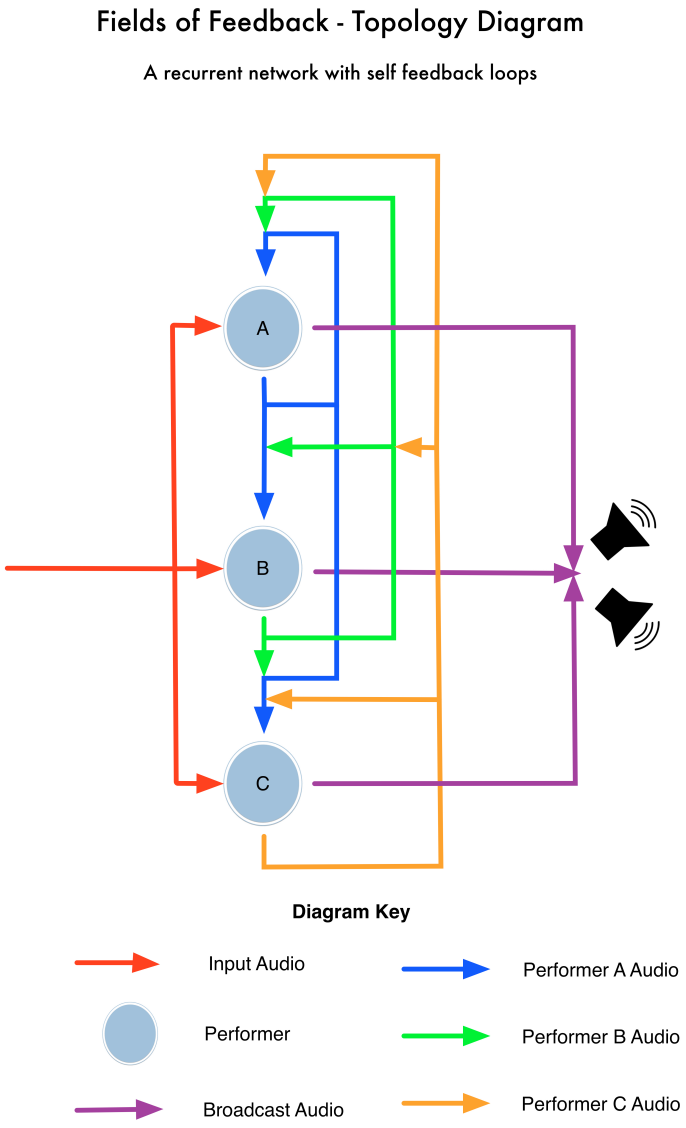

Fig. 26: *Fields of Feedback* - A Recurrent Network

The neural network chosen by the performers was the Hopfield Network model (see Fig. 27). A Hopfield Network is a specific type of neural network model, similar to a recurrent network. Both Gurney (1997) and Haykin (1999) acknowledge that Hopfield Networks are primarily used within learning and memory applications due to their capacity for creating content-addressable memory [56] . Their application

56 Haykin details content-addressable memory with respect to Hopfield Networks more aptly than I can. For a detailed overview of this application, I suggest turning to the section entitled "The Discrete Hopfield Model as a Content-Addressable Memory" (Haykin, 1999, p. 709).

within computer science is of secondary importance to how I have interpreted and applied the topology within *Fields of Feedback*, though it is beneficial to know the origin. Within a Hopfield Network, every node receives a designated and individualised input stream, sending its output to every other node in the system to be recycled in the next computational cycle as feedback input. It is important to note that there are no direct self-feedback loops, even though Gurney (1997) indicates that a Hopfield Network is a type of recurrent network - one which may contain self-feedback loops, as the output of one node can be fed back to itself through another node without any processes occurring in between. In *Fields of Feedback* this did not occur - mainly as this behaviour was not explored by the performers.

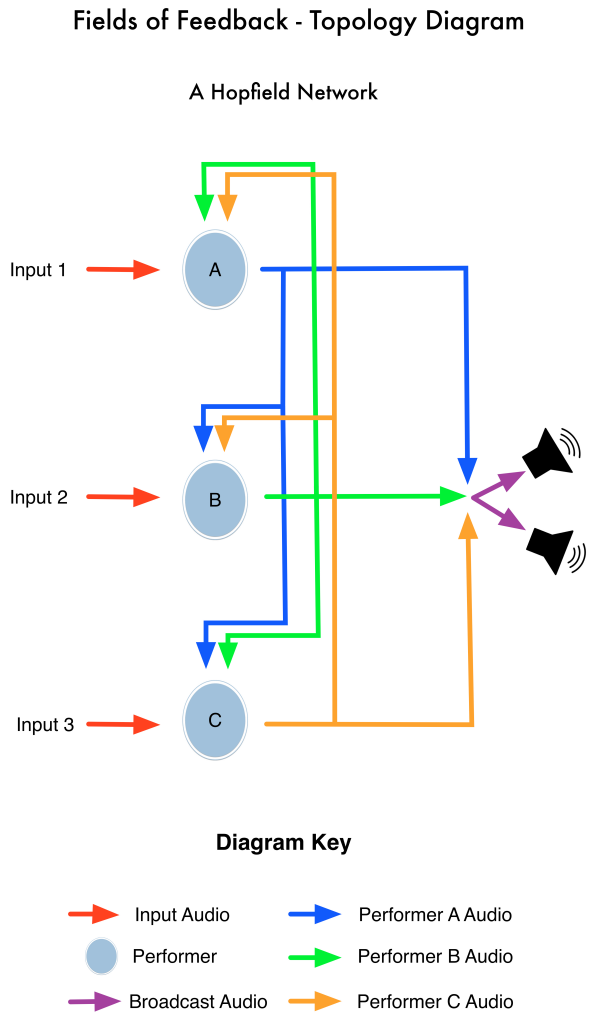

Fig. 27: *Fields of Feedback* - A Hopfield Network

The first rehearsal process was completed using the recurrent network shown in Fig. 25. After this first rehearsal, the choice of topology was explained to the three

laptop performers. It was decided by the group that the Hopfield Network topology was preferred. This was due to one key determinant; the Hopfield Network offers each performer a discrete and unique input stream. This input stream is seen as the main source material for each performer - and is in effect the core differentiator between nodes. As the input streams for the performance were live microphone streams, sourced from the *Locus Sonus* soundmap, the performers decided that they would each like their own stream - individualising the content on which they would perform [57]. This ensured that each performer had an identifiable and unique source onto which they could perform their musical processes.

6.3.3. Fields of Feedback: Relayed Creativity and Intra-action

There are two central conceptual concerns explored within *Fields of Feedback* - "relayed creativity" (Born, 2005, p. 26) and "intra-action" (Moore and Place, cited in Follmer, 2005b, p. 186). The recurrent feedback loops of the Hopfield Network topology aid exploration of both concerns, as every node has the potential to be directly influenced, and acted on, by every other node. The creation of a moderation role affords exploration of 'relayed creative behaviour' in a performative context - something which I have not done in any portfolio project up until this point. In *Skype Supply* I created a moderating role, but designated it to an automated computer program. Even though my agency was attributed to this program, I was not able to explore the role in a real-time performance context. In *Sourced Cities*, and the *Amalgam* projects, I undertook the role of performer, but neither offered me the over-arching governance I was afforded within *Fields of Feedback*.

The moderator role in *Fields of Feedback* ensures that I, as performer and artist, can explore a topology - manipulating the system, and imposing artistic direction on performers subject to my overarching artistic and aesthetic view. The role may be viewed as deterministic - but no more so than a composer's role in a traditional performance of a composed piece of music. As moderator, I can explore affordances of the system, such as the intersection of performer creativity, 'relayed creativity', and perhaps most importantly, the 'intra-action' of performance behaviour - points of interest that have become central to my research. It should be noted that I moderated the 'intra-action' between performers and the amount and direction of 'relayed creativity' in the system at any given time, but I was never in

57 For the performance, three discrete input streams were chosen - one based in London, England, a second in Aix-en-Provence, France, and a third located in Suffolk, England.

complete control of the performance output. The individual laptop performers always maintained control of their own creative ideas, and musical digital signal processing, while being subject to live indeterminate microphone streams.

Critically reflecting on the creative process reveals traits common to most collaborative performances: collective and co-operative action; democratic decision making; critical discussion and feedback; and rehearsed synchronisation of performance processes. These traits exist alongside characteristics that originate directly from the implementation of the network topology, such as the emergent outcomes heard within the musical result, and the reduction of individuality enforced by the directed 'intra-active' processes.

Viewing the performance holistically as an input-output system, incorporating design, moderation, performance, listening and environmental aspects, it is possible to view it as a performance eco-system. This eco-systemic perspective allows an interpretation of interactions, characteristics, environs, and performance behaviours to be forthcoming. This line of enquiry may also incorporate technologies into the discussion, such as designed interactions and hardware and software affordances.

Simon Waters describes three core elements of music - performer, instrument, and environment - discussing how the interaction between them defines a performance system as a whole (Waters, 2007).

> " [Music is] a dynamical complex of interacted situated embodied behaviours. These behaviours may be physical or virtual, composed or emergent, or of a time scale such that they figure as constraints or constructs. All interact in the same space by a process of mutual modelling, redescription, and emergent restructuring" (Impett, cited in Waters, 2007, p. 1)

In the following section I will discuss how the neural network model elicited certain characteristics to emerge within the musical outcome, as the feedback system caused audible sonic artefacts to be created, distinct from any individual performer processes. I will also discuss how the decision to spatialise audio within the performance space with respect to the corresponding unit positions of the performers in the Hopfield Network topology meant that the performance system allowed dynamic spatialisation to occur. Feedback was sent from node to node within the topology, and thus from speaker to speaker within the performance space; a by-product of the enactment of the topological model.

Reflecting and analysing the outcomes of the final work allows me to consider the implications of enacting a neural network topology within a musical performance, evaluating if the topological and technological implementation imposed limitations, or allowances, on the three laptop performers. It also urges me to consider my own role as moderator, in control of the piece in a directorial role - managing the levels of 'intra-active' processes between the three other performers, governing levels and direction of 'relayed creativity', and governing the level and degree of these characteristics communicated to the audience.

6.3.4. Reflection and Analysis

This section will discuss specific decisions and outcomes of the rehearsal process, the performance, and the accompanying audio-visual digital artefact contained within the portfolio (~/Documentation_Material/5.Fields_Of_Feedback/Digital_Artefacts/...). I will consider the decisions taken by the performance group and the outcomes that emerged from the enactment of the neural network topology, attempting to highlight examples of their impact by pointing to specific moments in either the creative process, musical performance, or the audio-visual digital artefact.

6.3.4.1. Directed Outcomes

In *Fields of Feedback*, I took on the role of designer and moderator. As designer, I researched the neural network topologies, and programmed an interface to implement them within a performance context. I also designed the moderator's role, programming the control functionality into the performance patch (~/Documentation_Material/5.Fields_Of_Feedback/Performance_Code/...). As moderator, I was involved throughout the rehearsal and performance process - included in any decision made by the group. In section 6.3.3 I briefly discussed the deterministic nature of the moderation role - governing the nature of the 'intra-actions' of the three laptop performers and subjecting them to directorial decisions throughout the performance with respect to the feedback they received into their workstation. Decisions were also made by the group during the rehearsal process, included devising the musical form, the spatialisation strategy, the type and form of visual representation used, and the type of neural network topology enacted as the template for the feedback system (see section 6.3.2.2). These decisions impacted the outcome of the project.

It is possible to see and hear the impact of certain decisions by reflecting on the digital artefacts found within the thesis' portfolio (~/Documentation_Material/ 5.Fields_Of_Feedback/Digital_Artefacts/...). The most obvious example of a directed outcome is found in the visual representation. During the rehearsal stages, I tested a number of versions, all based on the initial visualisation method seen in the performance trailer at 2m 01s (~/Documentation_Material/ 5.Fields_Of_Feedback/Trailer/...). The representation is based on a digital oscilloscope, implemented through a *Max/MSP* patch. The patch monitored the audio outputs of the system and then visualised the waveforms through a magnified process [58] . In the first iterations of this method, I used colours to distinguish between three distinct stereo outputs [59] . This method was rejected through discussion with the group. It was felt that this type of visualisation did not represent the 'intra-action' of the three performers consistently. Though the visualisation was a combined representation of the groups' audio output, it did not aptly reflect the way in which their outputs would at times remain distinct, and at others become intertwined as feedback coursed through the system. This decision led to the visual representation found in the trailer at 4m 55s, and throughout the audio-visual digital artefact (~/Documentation_Material/5.Fields_Of_Feedback/ Digital_Artefacts/...). This representation visualises each of the three performers' audio outputs distinctly - with each laptop performer represented by their own horizontally scrolling digital oscilloscope display [60] . The audio feedback in the system is communicated to the audience through this representation, as the individual oscilloscopes begin to display similar patterns and oscillations as feedback is spread around the system. This is seen in the documentation trailer, at 4m 57s, and throughout the audio-visual digital artefact at various stages. As the amount of total feedback in the system increases, the scrolling representations increase in width [61], eventually leading to a situation in which the three lines appear as one unified mesh, as seen in the trailer, circa 6m 30s.

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58 There were six main outputs for the system, defined by the Hopfield Network topology. These represented a stereo output for each laptop performer. These stereo outputs were sent to a main mixing desk, from which they were spatialised on the speaker system in the performance space.

59 In the trailer, a version is displayed that represented the three performers in black, white, and green. The colour choice was arbitrary.

60 The following schematic was used. Performer A is represented by the top-most line, Performer B is represented by the middle line, and Performer C is represented by the bottom-most line.

61 The amplitude of the audio output of each performer is represented by the width of their visual representation, as is the case for the majority of oscilloscopes. For Fields of Feedback, the moderator had the ability to control the width of the representations manually. This was an artistic effect, to enforce a representation of merging and intermingling audio outputs on the visual display. In this manner, the moderator was also managing the aesthetic of the visual representation during the performance as well as the musical animations.

The group also decided on the overall musical form for the performance. Though the performance was improvised - with no control over the incoming audio from the microphone streams, and no strictly defined or determined processes instructed to the three laptop performers - it was felt that some musical structure should be imposed so that a sense of linear musical form would be communicated to the audience. The structure was decided during the rehearsal process, through an iterative rehearse, listen, evaluate, discuss, implement, and rehearse process. The decision was taken to impose a musical form over a pre-agreed time frame [62] - and that individual musical forms for each performer would be synchronised, and then augmented by the actions of the moderator. The musical form is shown in the diagram below (see Fig. 28).

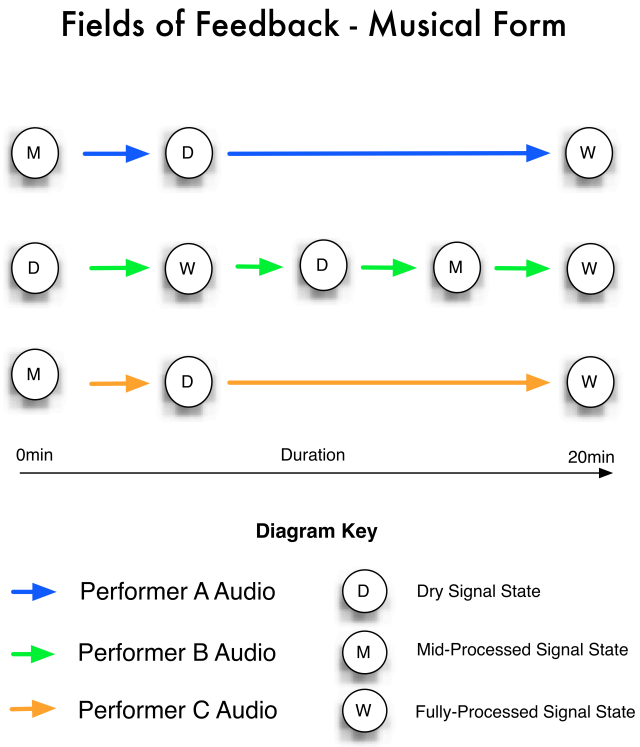

Fig. 28: *Fields of Feedback* - Musical Form

Certain physical cues had to be included in the performance so the group could synchronise performance actions. The first cue was made by Performer B when he arrived at his first W marker. This was a cue to the other two laptop performers and the moderator that the completion of the first stage had been reached. The second cue also arrived from Performer B, at the point at which he arrived at midpoint D. At this point all performers would move towards the musical climax - with every

62 It was agreed that the total performance time should be 20m, with all individual forms completed during that time.

laptop performer beginning their journey to the final W markers. The physical cues were done through a simple communication strategy - tapping the performance table so that all performers were aware of the marker being reached.

The third directed outcome concerned audio spatialisation. This was perhaps the most interesting decision, as it combined directorial impact, as each performers' audio output would be diffused within the performance space in a certain way, as well as affecting how the neural network topology elicited emergent outcomes in the musical performance. As a group we decided that there should be distinct spatialisation for each of the laptop performers. This was achieved by diffusing the stereo outputs of each of the performers in defined areas of the loudspeaker system. The loudspeaker array was located at the Sonic Arts Research Centre (SARC), at Queen's University Belfast (see Fig. 29).

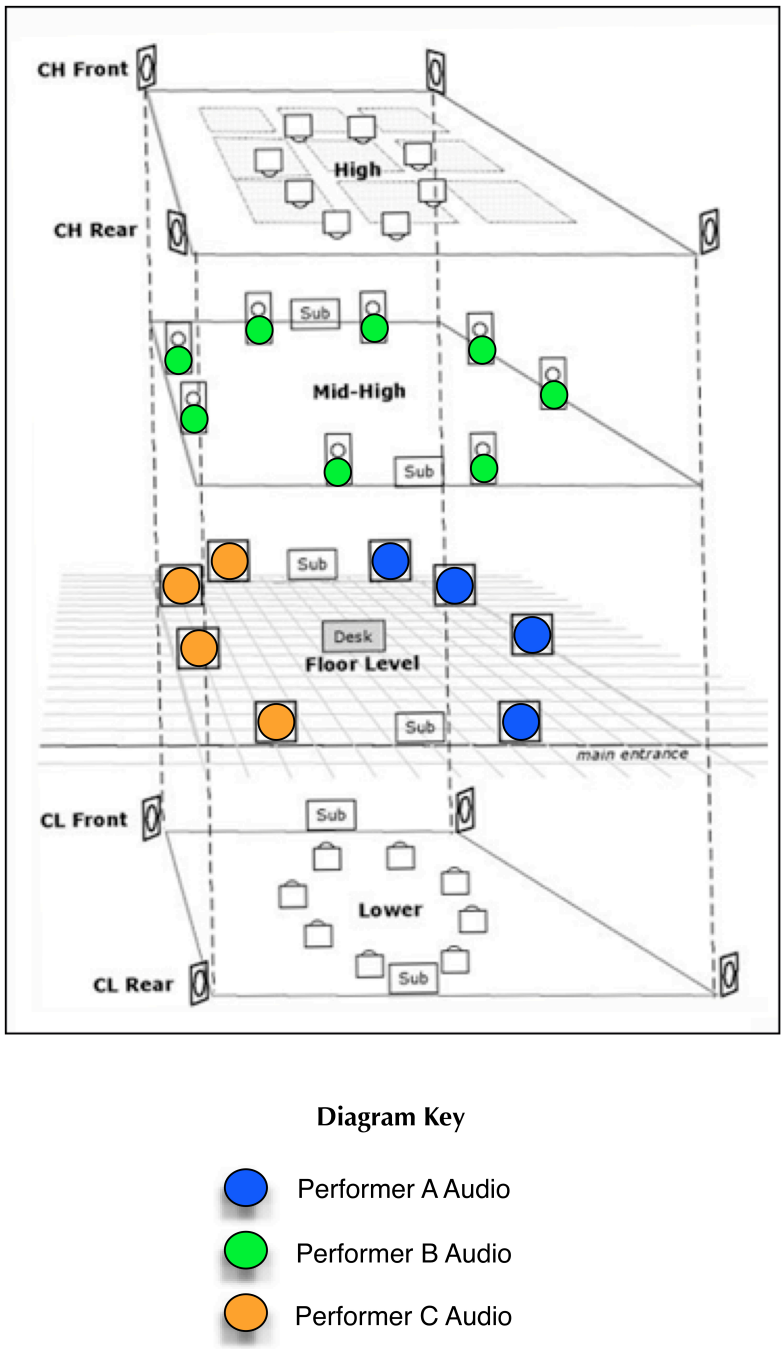

Fig. 29: *Fields of Feedback* - Sonic Lab Spatialisation

It was decided to spatialise each laptop performers' output as follows: Performer A would be sent to the four speakers located on the right side of the Floor Level. Performer C would be sent to the four speakers located left side of the Floor Level. Performer B's audio was diffused to the ring of eight speakers located on the Mid-High level (see Fig. 29).

The spatialisation method impacted on the performance in two ways. The first was that Performer B's audio filled the majority of the performance space, due to the number of speakers used. It also meant that Performer A and C were diffused onto distinct locations in the performance space. The technique can be heard clearly in the audio-visual digital artefact (~/Documentation_Material/5.Fields_Of_Feedback/Digital_Artefacts/binaural/mp4/...) from 0m, 02s until 3m 02s. The start of the performance consisted of Performer B's audio being slowly introduced (heard primarily on both headphones), followed by Performer A (heard primarily through the right headphone), and then subsequently Performer C (heard primarily through the left headphone).

A secondary outcome of this spatialisation method was that audio feedback concurrently became a dynamic spatialisation process, as audio was sent through the network by the moderator. For instance, during the first stage of the performance, the mostly dry signal of Performer B was sent to the inputs of both Performer A and Performer C through the feedback system. This meant that the dry audio signal was also being spatialised in the performance space, moving down from the Mid-High level, onto the Floor-Level and through the speakers on either side of the performance space. The moderator was not only in control of the amount of feedback in the system, but also the direction. The moderator decided which performer received feedback, and from where - and as a by-product which speaker received feedback, and from where.

6.3.4.2. Emergent Outcomes

Discussing the choices taken by the performance group details the pre-determined decisions that impacted the musical outcome, but it does not detail the impact the neural network topology had on the performance, and the involved agents. I will discuss three emergent characteristics which can be attributed to the enactment of the neural network topology, based on Goldstein's (1999) description of emergence outlined in section 5.3.6. Certain characteristics emerged due to the inherent properties of the performance system, and they impacted the outcome in ways that were not completely predictable or deducible within the design stages of the project. Goldstein acknowledges that "radical novelty" (Goldstein, 1999, p. 50) is a property of emergent phenomena, detailing that "features of emergents are neither predictable nor deducible from lower or micro-level components" (Goldstein, 1999, p. 50).

The critical reflection process, carried out post-performance, combined with observation and analysis carried out during the creation of the project allows me to understand the emergent characteristics of the work: the feedback tones and swells generated by the use of the feedback system - controlled by the moderator as a performative act; the audible signal delay - heard as a spatialised delay line due to the diffusion techniques and the hardware latencies in the system; and the reduction in individuality that the participants felt as they engaged in the rehearsal and performance process. During the design process, I imagined that all three characteristics would emerge - but I was not entirely certain of the level of impact they would have on the performance, and/or the agents involved. I also did not completely know how the enacted topology would afford exploration of the emergent characteristics, though I did understand that the performance system would afford some level of experimentation and exploration.

In *Fields of Feedback*, the moderator decides amplitude and direction of feedback - and is afforded use of feedback tones and swells as musical material. The tones and swells derive from the sound loop created between one performer (or node) and another - or multiple nodes to/from one another. They are similar to how a normal acoustic feedback circuit sounds. It should be noted that as the feedback loop is never a 'perfect sound loop' - due to the individual digital processes at each node, the moderator is not in complete control of the levels of audible feedback in the system. The levels of audible feedback depends on the actions of each laptop performer, and the governed 'intra-actions' between laptop performers.

During the performance, I acted as moderator, always in negotiation with the system, trying to ensure that the levels of audible feedback never reached a level that completely dominated the system's sonic output. As moderator, I felt that I was in constant dynamic negotiation with the system as a whole. Moderating and governing the overall level of feedback was a exacting task - demanding concentration, and subtle, intricate interactions with the moderating patch. The tones and swells can be heard through the direct recording of the audio-visual digital artefact (~/Documentation_Material/5.Fields_Of_Feedback/Digital_Artefacts/direct/mp4/...), most notably at 5m 50s (subtle feedback tones), 6m 35s (feedback swells and tones), and 8m 29s (feedback swells). These animations became a central part of the musical outcome - sonically communicating the impact of the enacted neural network topology to the audience.

Subtle delay lines also emerged in the performance. This was due to the latency impingements of the system - a combination of the input/output latency at every

workstation. No effort was made to reduce this latency - and all digital audio interfaces were left at default settings. This meant that input and output latencies were introduced into the performance, and these in turn created spatialised delays - as feedback was sent from node to node in the system. This can be heard in the binaural recording of the audio-visual digital artefact (~/Documentation_Material/ 5.Fields_Of_Feedback/Digital_Artefacts/binaural/mp4/...) at 7m 53s, as gentle, processed 'flutters' alternate from the right and left headphones - and again at 9m 01s - 10m 50s, as rhythmic processing shifts from right to left as feedback is sent around the system. This was a property of the system that I understood would elicit an emergent outcome, as recurrent processes and computational cycles would create an overall system latency - but I did not know how it would sound. On reflection it became a musical animation that led credence to the work, communicating the topological structure, as well as the technological dependencies of the work to the audience. I also did not completely envisage how the enactment of the neural network would create a system property that could be explored in a creative manner by the moderator. The enactment of the topology, coupled with the creation of the moderation layer, affords a type of musical behaviour, dependent on the actions of the laptop performers, the topological organisation, and the levels and direction of 'intra-actions', as decided by the moderator.

The third emergent outcome was perhaps, on reflection, the most interesting. During the design phase, I envisioned that the three laptop performers would begin to lose sense of what did, and did not, remain under their control. I observed this during the rehearsal process, and indeed, felt it myself. At times, when the total level of feedback in the system was high, it became difficult to distinguish where musical animations and processes originated - whether from individual performer, from moderating processes, or from the system itself. The performers communicated to me, and to each other, that processes originating on their own workstation would sound different when processed through someone else's - confusing their perception and interpretation of how sound was being sent around the feedback system - leading them to temper and augment their own performance strategies. There were some actions taken by the group to mitigate against this - including a session where each performer would process his stream individually, while the rest of the group listened - attempting to grasp each workstation's musical character so that they may be better able to distinguish the origin of musical animations.

It was also decided that a panning technique would be implemented on the feedback channels. As each performer received a stereo feedback channel (which

was a sum of all feedback sent to that performer), a decision was taken to pan each performer to a side. For instance, Performer A would receive feedback from Performer B, panned left, and C, panned right - aiding his own monitoring capabilities (each performer monitored their feedback input audio through headphones), and aiding his understanding of how feedback was being sent from performer to performer. This strategy emerged as the group became familiar with the system, and its characteristics, during the rehearsal process. Performance strategies were altered and augmented due to the impingements of the feedback network - which supports the eco-systemic discussion outlined in section 6.3.3. The musical outcome of *Fields of Feedback* became the sum of interactions between elements involved in the process. A performance strategy, and thus musical outcome, emerged that encompassed all four elements:

1) performers (sound sources and musical and performance processes)
2) instruments and workstations (hardware and software latencies)
3) topology (recurrent feedback paths of the enacted neural network)
4) environment (speaker layout within the performance space)

In section 5.3.3 of this thesis, while discussing *Web Variations,* I detailed Deleuze's notion of the 'dividual', which was described by Varnelis as individual identity dispersed through community (Varnelis, 2008). I also noted how *Web Variations* explores the concept through an internet based performance environment, using web technologies to leverage the theme into musical realms through collective creation of musical material. In *Fields of Feedback* a similar thematic concern emerges - but now agents directly observe its musical outcome, while comparably observing how performers deal with the reduction of individuality in a musical context. I directly observed a certain degree of negotiation and strategy formation between performers during the rehearsal process, and crucially, I observed how the network topology ensured the theme surfaced in a performance context. As designer of the project, I hoped this concern would emerge, as it is a direct artistic interest for myself. However, I did not envision how the participants would enjoy the reduction of their individuality - ultimately embracing it by augmenting, tempering, and changing their own musical performance and processing strategies in order for the group performance to be successful. I also did not envision how the participants would enjoy rehearsing and performing with the system when the total level of feedback was high - so that origin, direction, and distinction of sounds became difficult. The performance became a dynamic negotiation between individual creativity, and collective, collaborative, and 'intra-active' creativity - afforded by

the enactment of the network topology, and the tools and technologies which created the moderation layer.

6.4. Summary

This chapter has discussed the final work of the attached portfolio, *Fields of Feedback*. It has acknowledged that the work acts as a summation of the research, and explores a theme that emerged during the process - that technology supports the creation and implementation of complex network topologies, and that these topologies in turn afford musical exploration of concerns such as 'relayed creativity', 'intra-action', and the reduction of individuality. The chapter has also outlined supporting theoretical context, and detailed examples of similar music research and practice, so the project may be viewed alongside a wider body of work. I compared *Fields of Feedback* to other work contained within the thesis to outline the development of my own ideas and concepts of network music - as well as highlight my evolving ability to develop network music projects, as designer, programmer, author, and performer.

In the latter sections, I detailed how *Fields of Feedback* consisted of a number of aspects that impacted the rehearsal and performance process, and musical outcome. These aspects were directed, in the form of pre-performance decisions, and emergent, in response to the enacted neural network topology. I also detail how the enactment of the topology, along with the creation of the moderation layer, affords specific musical behaviours that may be explored by the moderator, which are in turn dependent on the laptop performers, and their topological arrangement. This line of thought supported an eco-systemic view of *Fields of Feedback*, where the performance is viewed holistically, incorporating aspects and properties of performer, moderator, instrument, system, and environment.

Chapter Seven

7. Conclusion

The first section of this conclusion summarises the thesis, briefly outlining the central discussions found within each chapter. The second component will discuss the thesis' contributions to the field; aligning the prospectives outlined in Chapter 1 (see section 1.7) with what has been discussed. The third section contains a reflective summary, comparing this thesis' research contributions with those found within the existing literature discussed in Chapter 2. I will then move onto future developments; reflecting on the thesis as a whole, and speculating on possible directions the research may take. This chapter will conclude with some final remarks, commenting on the development of my practice through the doctoral process, both as artist and as researcher.

7.1. Chapter Summary

The introduction to this thesis outlined my personal background and motivations for pursuing the doctoral process. I detailed definitions of the network from various fields, before offering a perspective drawn from within the field of network music, which led to an outline of a working definition of the practice. Chapter one contained an overview of the thesis' structure, and detailed the research methodology. I also described the rationale for the choice of historical works, and detailed the structure of the attached portfolio. The prospective contributions to the field were also outlined.

The second chapter functioned as a literature review. Its role was to outline various forms, types, strategies, and methods for network music practice. I described various examples of network music, making comparisons to the works found within the attached portfolio, and the supplemental works found within the appendix.

Chapter three introduced the first of my portfolio works, *Skype Supply*, alongside the historical work on which it was based, Max Neuhaus' *Public Supply I*. I outlined the similarities and differences between the two works, detailing the way in which contemporary technologies altered certain thematic and artistic concerns - with respect to participants' relation within the virtual space, modes of participant interaction, and the method through which contributions to the piece were moderated.

The fourth chapter turned attention to the second of my portfolio works, *Synchrocities*. The work was compared to Maryanne Amacher's *City-Links* series, with differences and similarities detailed. I also described how the contemporary technologies used within my artistic response altered certain aspects: the addition of visual representation; leveraged concepts of telepresence and synchronicity; and technologically augmented perception, moderation, and intervention.

Web Variations was the focus of the fifth chapter - as I compared it to John Cage's *Variations VII*. This chapter described how I interpreted certain aspects of Cage's performance instructions whilst redesigning the performance space as an internet based environment. Like the preceding chapters, I compared the historical work with my own response - detailing how the reconfigured performance environment altered thematic concerns such as indeterminacy, instrument design, performance topology, and modes of interaction. The chapter also outlined certain artistic and thematic concerns as they emerged from the work - supported through the use of contemporary technologies - 'navigable music', 'relayed creativity', and 'intra-active' performance processes.

Chapter six introduced my final portfolio artwork - *Fields of Feedback*. This work is, unlike the three other portfolio works, not based on existing repertoire. It was inspired by concepts and themes that emerged from the practice-based research process: how technologies allow more complex network topologies to be explored through musical performance; how these topologies afford exploration of themes such as 'relayed creativity' and 'intra-action', while altering, restricting, or supporting both directed, and emergent, network music practice.

The final chapter, being read currently, offers a brief summary, details primary and secondary contributions to the field, reflects on the research and its position alongside recent literature, and speculates on future directions and developments for this particular strand of practice-based research. It concludes with some final remarks, offering my own perspective of the research process.

7.2. Summary of Contribution

A set of proposed research contributions were outlined in Chapter 1 (see section 1.7). It consisted of primary contributions, which guided the overarching research process, and a number of secondary contributions, which were acknowledged as emerging from the project specific, practice-based process. This section will give a brief overview of how the thesis' proposed contributions were met, and detail the method through which the secondary contributions emerged during the creative process.

7.2.1. Primary Contributions

The primary contributions to the field of network music were outlined in the introductory chapter (see section 1.7). In chapters three to five, I reflected on the process of creating artistic responses to three iconic, historical network artworks. I re-interpreted these projects through my own artistic vision, supported by my knowledge of contemporary technologies. This enabled a bi-focal reflection and analysis process to be undertaken; communicating the original creative and artistic themes of the historical works, and comparing them with any development or change that appeared within the artistic responses. It is noted that contemporary technologies altered the artistic themes, and the perception of them - for performers, participants, and audience members.

7.2.1.1. Skype Supply

In *Skype Supply*, I described how indeterminacy and virtual space remained as core artistic themes, given the replacement of telephone and radio with *Skype* and *YouTube*. I acknowledged that *Skype* altered participant interaction, due to the levels of embodied knowledge of the medium - with a consistent use of the *Skype Supply* platform as a collectively created public facing diary, as apposed to a dynamic sound instrument. I detailed how I attributed my artistic agency to the piece through the use of automated software processes, built using *Max/MSP* and *Applescript*, with the moderating role in Neuhaus' *Public Supply I* transferred to an automated, software based process in *Skype Supply.* I also discussed how the project leveraged a relatively modern audio-visual communication medium to create an immersive and engaging collectively composed performance.

7.2.1.2. Synchrocities

In my second portfolio project I detailed how a software program, built in *Max/ MSP*, allowed me to shift attention from Amacher's concept of 'telelinked' sound towards a concept I entitled sonic synchronicity. Digital signal processes allowed a communication of subtle sonic simultaneity to an audience, leveraged though the use of contemporary technologies - urging the listener to reflect on the hidden relationships that exist between remote locations. I also urged the audience to reflect on the perception of a network - supported by internet technologies - connecting otherwise disparate locations by enabling a software program to create sonic animations borne from convolution and time stretching signal processes - communicating an interaction of acoustic information.

7.2.1.3. Web Variations

In *Web Variations*, I explored the concept of topologies in network music directly. By creating an internet based collaborative performance environment, I turned attention to a hidden sound world - as Cage did within *Variations VII* - but also to the ways and methods in which topological formations of networks may be instantiated between performing agents. This raised investigative themes such as 'relayed creativity' and 'intra-action', as the system allowed topologies to be created that explored these concerns directly through the creation of dynamic organisational structure. The design of the performance environment opened up a discussion on 'navigable music', as audience members could explore the performance as, and how, they wished - creating unique interpretations based on the interactions, and 'intra-actions', of performers. The technologies used in the project urged performers and audience members to turn attention towards network technologies, network concepts, and crucially, the ways in which network formations and the navigation of network organisations alter the perception of organised network systems in the context of musical output. The appearance of the themes of 'relayed creativity' and 'intra-action' led to the development of the final portfolio project, *Fields of Feedback*, which also drew inspiration from a number of the thesis' supplementary works found within the appendix - the simple topology structures of the *Amalgam* projects (see Appendix E and Appendix F), the bi-directional interaction of *Ellipses* (see Appendix G), and the 'intra-active' line structure imposed within *Sourced Cities* (see Appendix H).

7.2.1.4. Fields of Feedback

The final work of the portfolio explored the key research imperatives of the thesis directly. I used contemporary technologies to enact a performance topology based on a neural network - more specifically a Hopfield Network. I explored 'relayed creativity' and 'intra-action', investigating how the neural network topology altered audience perception of the network, and elicited behavioural changes in participants. I directly observed how contemporary technologies, combined with a complex topological formation, altered performative behaviour and the audience's conceptual understanding of the network. I also observed how the Hopfield Network contained emergent characteristics when implemented as a network music organisational structure, modifying musical outcome and directly communicating the effects of the implemented topology to the audience. I also detailed how the network topology altered how participants viewed their role in the performance, their perception of musical individuality, and their performance strategy.

7.2.2. Secondary Contributions

The secondary contributions to the field are found by analysing the artefacts that appear as a result of the creative process. Though a large amount of the contributions are represented by embodied knowledge, acquired over the research process, there are also a number of software tools and programs that enable new forms, strategies, and methods for creating, developing, and designing network art, sound installations, and topologies for network music. The complete list of secondary contributions is found within the introductory chapter (see section 1.7), with the artefacts found within the attached documentation portfolio and appendix on a project specific basis.

7.3. Reflective Summary

Within this thesis' Literature Review chapter (see Chapter 2), I described a number of existing perspectives of network music - detailing how different strategies have developed as the practice evolved. This section will summarise the content of Chapter 2 and then detail the relation of this thesis to existing literature, describing how my own research supports, augments, and contributes to the practice's continual development, detailing how this thesis' outcomes have significance beyond that of my own practice.

Barbosa (2003) researched practice-based strategies within network music, creating a survey of practice, which I leaned heavily on while describing forms of the practice within Chapter 2. Weinberg (2003), detailed the notion of interconnected music networks, illustrating decision making processes within the design and compositional stages of network music. Follmer (2005b), in a similar vein to Barbosa (2003), developed a typological ordering of network music practice - highlighting the diversity of examples accepted as network music. Carot (2009) and Renaud (2009) viewed network music from more technologically centred positions, detailing a number of strategies for exploring the technological restraints and affordances of specific networking technologies - with concentration paid to latency, and its impact on topological structure.

This thesis sits alongside the existing literature as it details a number of existing strategic practices (see section 2.1) drawn from the writings of Barbosa (2003) and Follmer (2005b). In Chapter 2, I also detail a number of practices that have recently emerged, such as the field of Live Coding which has adopted networking technologies as an important determinant of its ongoing evolution and development. I also pointed to Hickmann (2013), as he described a number of works that explored the notion of 'play' and game-based strategies within the field of network music - offering a personal and explorative investigation into the practice from the perspective of his own research interests and artistic experiments. I also discussed some extended and emerging strategic forms, detailing projects that do not easily fit into any standard typological ordering, such as *Play The World*, *Serendipity*, and *Ping* (see section 2.1.8). I also detailed a number of examples of each category - attempting to describe contemporary types of practice, as well as discussing a number of commercial products, reflecting how research areas have been adopted into mainstream commercial applications such as *Ableton*, *OhmStudio*, *Audiotool*, and *Soundtrap* (see section 2.1.2).

The significance of this thesis resides in the methodology through which it explores the research imperatives. The research methodology consists of investigating three historical network music artworks, creating artistic responses by adopting contemporary technologies and adapting thematic concerns, followed by questioning whether the technologies alter outcomes and leverage specific affordances. Within Chapters 3 - 5, I completed this process, discovering that artistic concerns were transferable to contemporary artistic responses, while new themes emerged due to the use of the contemporary technologies, which in turn became sources of inspiration (see Chapter 5), ultimately inspiring an original network artwork - *Fields of Feedback* (see Chapter 6). I also discussed how

contemporary technologies allow exploration of complex topologies within network music - attributing technological affordances to the topologies explored within *Synchrocities* (see Chapter 4), *Web Variations* (see Chapter 5), and *Fields of Feedback* (see Chapter 6). I noted how certain topologies elicit emergent characteristics, urge behavioural and/or perceptual changes in performers and audience members, as well as directly allowing the thematic concerns of 'relayed creativity' and 'intra-action' to be explored.

The research undertaken within this thesis supports and augments the research outlined within Chapter 2, augmenting the survey of Barbosa (2003) by including contemporary examples of practice and extending the typological ordering to include Live Coding, and extended notions of network music. The final project within the portfolio provides an example of an extended form of network music, as it borrows a topological form drawn from the field of computer science, urging artistic concerns such as 'relayed creativity' and 'intra-action' to surface within the musical outcome. It also demonstrates how certain topologies allow emergent characteristics to surface - reflected within the musical outcome of the practice - representing network music as an investigation, not only into themes such as organisation and collaboration, but also the perception, communication, and impact of network effect.

7.4. Future Developments

The methodology outlined in Chapter 1 (see section 1.4) could be explored further; interpreting and researching historical works for their prevalent themes and investigating how original concerns may be transferred or augmented through the implementation of contemporary technologies - updating works with modern means of communication, organisation, or instrumentation. This methodology is transferable, and has the ability to garner interest in historical projects that may otherwise be forgotten, whilst also turning attention onto the affordances of contemporary technologies, or the behavioural or perceptual changes that they elicit in involved agents.

The latter two projects in the portfolio emerge as possible research development directions in their own right - with the potential to move network music closer to some of the idealogical speculations I encountered during the research process. For example, Novak's idea of 'navigable music' (see section 5.2), inspired *Web Variations*, alongside Chris Brown's vision for an *Eternal Music Network* (Brown,

1998), which Bosma (2001) and Follmer (2001) describe as having the potential to completely alter traditional musical performance roles.

> " [The *Eternal Music Network* is] a website, where one or several flexible musicians are permanently going on. Whoever passes by can join in to play on the accessible controls of the music system, interacting with the machine as well as the other players." (Follmer, 2001, p. 3)

Web Variations has the potential to be developed both technologically and ideologically - moving the project closer to one that exists eternally, in constant dynamic flux as listeners and performers enter, and exit, altering the topological structure of the performance and continually creating new, unique listening experiences composed of the dynamic 'intra-actions' and 'relayed musicality' of performers. The project, residing on the internet, could potentially be explored as a type of 'virtual music', which Duckworth has described as having "the potential to become a live musical organism, living in cyberspace, growing, and changing course because of the collective actions of its users" (Duckworth, 2003, cited in Tanzi, 2005, p. 548).

The final portfolio project is perhaps the most apt for future development, especially when related to some of the ideological views of network music that have been discussed by authors such as Ascott, Tanzi, and Duckworth as they describe decentralised music systems and their link to concepts of consciousness and mind. *Fields of Feedback* is a musical performance system modelled on a neural network - itself a loose model of the neurological structure within animal brains. A possible line of explorative research could mirror and augment Phillip Stearns' *AANN* (see section 6.3.2.2), as he created a physical artefact that behaved as a light and sound based artificial intelligence. Exploring this further may open up avenues linking network music to distributed mind. Ascott has previously discussed how "a technoetic infrastructure is forming through which art will lead us to a state of distributed mind" (Ascott, 1999, p. 219). William Duckworth has elucidated similar views, whilst discussing internet based interactive, distributed projects.

> "...this model is more directly related to the functioning of a neural network than the music-as-sonic artifact concept of the past. Furthermore, the non-linear, time-curving nature inherent in these new Web technologies, when distributed in large-scale throughout the network, offers, at least in principle, a new metaphor for consciousness." (Duckworth, 2003, p. 260)

Continuing a line of enquiry by adopting neural networks, their topologies, affordances, designs, and technologies as both compositional and performative forms and models may lead us to a direction where network music becomes an avenue for exploring the relationship between musicality and consciousness - especially if they incorporate contemporary networking and internet technologies. I was not aware of this connection as I began the research process, but it has become more feasible, more ideologically achievable, and ultimately believable as themes and technologies emerged from the research process aligned themselves with ideological literature that I had digested during the research process. Relayed and 'intra-active' processes within music may become an investigative avenue for research into relayed or 'intra-active' thought, or communication. It may be a fanciful notion, but as a future direction for network music research, it has the potential to be as enticing to others as networked models for performance practice were to me.

7.5. Final Remarks

The research process was testing, but ultimately rewarding. I learned a tremendous amount as I investigated and explored iconic network music artworks. As I created artistic responses, I learned about the demands of creating network art: aspects of design; technology; co-ordination; co-operation; management; strategy; and of course problem solving. I learned first-hand about the issues that arise whilst developing multi-site, multi-participant works, and this in turn led me to develop not only as researcher, but as artist and as person. I am confident that the skills, knowledge, aptitudes, and inspirations I absorbed and persevered with will continue to contribute to me, personally, as I move onwards from this phase.

Appendices

The following sections include a guide to what is included in the documentation folder. The folder contains all materials necessary to re-create the works, full documentation material, and any other associated components: patches, code, set-up diagrams, set-up instructions, topology diagrams, and any material associated with public facing communication.

The included USB memory drive containing the information is organised on a project name basis. The memory drive also contains a digital copy of the thesis' text.

The thesis' portfolio may be viewed through an internet browser, as a full website. The instructions for doing so may be found within the READ_ME.rtf file located within Home folder.

The following file structure will be employed.

Home Folder:
~/Documentation_Material
~/READ_ME.rtf

Sub Directories:
~/Documentation_Material/1.Thesis/...
~/Documentation_Material/2.Skype_Supply/...
~/Documentation_Material/3.Synchrocities/...
~/Documentation_Material/4.Web_Variations/...
~/Documentation_Material/5.Fields_Of_Feedback/...
~/Documentation_Material/6.Appendix_Projects/...
~/Documentation_Material/index.html
~/Documentation_Material/style.css

Appendix A: Skype Supply

Credits:

- Design and Architecture: Robin Renwick
- Programming: Robin Renwick

Performance Details:

Friday 19th April, 2013 @ PS2 Gallery, Belfast

Documentation:

- Live YouTube Broadcast Video (.../2.Skype_Supply/Broadcast/...)
- Communication_Information (.../2.Skype_Supply/Communication_Info/...)
- Participation_Installation (.../2.Skype_Supply/Participation_Installation/...)
- Participation_Videos (.../2.Skype_Supply/Participation_Videos/...)
- Documentation Trailer (.../2.Skype_Supply/Trailer/...)

Installation Materials:

- Installation Folder (.../2.Skype_Supply/Installation_Folder/Installation_Folder.zip)
- Installation Instructions (.../2.Skype_Supply/Installation_Folder/1.README)
- Installation Max/MSP patch (.../2.Skype_Supply/Installation_Folder/1.SS_Installation.maxpat)
- CallRecorder Software (.../2.Skype_Supply/Installation_Folder/CallRecorder.zip)
- Installation Topology (.../2.Skype_Supply/Installation_Folder/Skype_Supply_Topology)
- Video Renaming AppleScript (.../2.Skype_Supply/Installation_Folder/Video_Renaming_App)

Programme Note:

Skype Supply is a response to Max Neuhaus' *Public Supply I* (1966), one of a suite of works Neuhaus entitled *Broadcast Works*. *Skype Supply* implements the often used modern day communication mediums *Skype* and *YouTube* to create a virtual stage that affords dialogue between members of the public; both at the gallery space and further afield. Users interact with the work by calling a designated *Skype* address: skypesupply2013, delivering their voice, image, words, actions and creativity into the installation. The system then supplants their offering into a bespoke software management application; creating a dynamic collage of participant offerings - attempting to forge semantic dialogue and meaning through

its efforts. The output of the installation is simultaneously broadcast onto the Internet through the medium of a 'one-to-many' broadcast station: *YouTube*. Members of the public not situated at the gallery space may watch this broadcast and communicate with the installation, through *Skype*, from their own Internet enabled device. The two-way dependency between the installation and the participant creates a dynamic space in which the artwork pertains the ability, if leveraged, to feed back into itself.

Appendix B: Synchrocities

Credits:

- Design and Architecture: Robin Renwick
- Programming: Robin Renwick

Performance Details:

Saturday 27th & Sunday 28th September, 2014 @ Network Music Festival, Birmingham

Documentation:

- Documentation Video (.../3.Synchrocities/Documentation_Video/...)
- Documentation Trailer (.../3.Synchrocities/Trailer/...)

Installation Materials:

- Installation Folder (.../3.Synchrocities/Installation_Folder/Installation_Folder.zip)
- Installation Instructions (.../3.Synchrocities/Installation_Folder/1.README)
- Installation Max/MSP patch (.../3.Synchrocities/Installation_Folder/1.Synchrocities.maxpat)
- Installation Sub Patch (.../3.Synchrocities/Installation_Folder/convolve_test_1.maxpat)
- Installation Sub Patch (.../3.Synchrocities/Installation_Folder/cross3.maxpat)
- Installation Map Jpeg (.../3.Synchrocities/Installation_Folder/Europe_2400_1839.jpeg)
- Installation Max/MSP Externals (.../3.Synchrocities/Installation_Folder/Externals)
- Installation Sub Patch (.../3.Synchrocities/Installation_Folder/ogg_streamer_3.maxpat)
- Installation Topology (.../3.Synchrocities/Installation_Folder/Synchrocities_Topology)

Programme Note:

Synchrocities is a multi-channel audio/visual installation in which a series of live microphone streams are analysed, in pairs, through FFT based spectral analysis. When the governing system, based in *Max/MSP*, determines a synchronous event it performs a specific process. A synchronous event is determined as a period of time in which simultaneous audio activity exists in two concurrent streams above a certain amplitude threshold and within a pre-defined frequency range (FFT bin). Four streams are analysed, in a bi-focal system. When a simultaneous event occurs,

specific processes intervene. In the first instance, the governing system replays the specific FFT bin in which the synchronous event transpired. This may be called a 'frozen' moment. In the second instance, the system replays the sonorous activity through a convolution technique. The synchronous events from each stream are convolved with one another, and then replayed through the space - accentuating an interrelation between the two places.

The installation also contains a visual element in which a map is displayed on the front wall. The map remains hidden until a time in which a synchronous moment emerges. The synchronous event then reveals the specific locational origins of the streams. The interplay between the visual representation and the sonic events allow the listener to forge an understanding of the spectral relationship of the paired sites. *Synchrocities* is displayed within a quadrophonic array. The sonic pairings are made from microphone streams sourced through the *Locus Sonus* open microphone platform (www.locusonus.org/soundmap).

Appendix C: Web Variations

Credits:

- Design and Architecture: Robin Renwick
- Programming: Stuart Brown and Robin Renwick

Testing Procedures:

- Documentation and testing procedures carried out during August 2015 @ the Sonic Arts Research Centre (SARC), Belfast
- Website currently resides at http://www.webvariations.herokuapp.com.

Documentation:

- Documentation Videos (.../4.Web_Variations/Documentation_Videos/...)
- Documentation Trailer (.../4.Web_Variations/Trailer/...)

Installation Materials:

- Website Code (.../4.Web_Variations/Website_Code/webvariations-master.zip)

Programme Note:

Web Variations is an artistic response to John Cage's *Variations VII*, which was performed in 1966. *Web Variations* is an Internet based performance environment that allows performers, and listeners, to explore and navigate interrelation through musicality; creativity never in isolation, but always in relation.

Upon entering the system, a base node appears. This node represents the fundamental sound source; a live microphone stream, sourced from the *Locus Sonus* live microphone platform. A user may create their node by performing with this sound source. If more than one user is performing in the system, they will also appear as nodes. A user may listen to, or perform with, any available node within the environment.

The performance stage resides on the Internet, as a website. All interactions are interfaced by this website. As of now, the system only runs on the *Google Chrome* Internet desktop browser: due to complications with cross browser web-audio standard implementations. It is hoped that as the web standards develop and evolve, the website will be accessible through a multitude of browsers, and a multitude of devices.

Appendix D: Fields of Feedback

Credits:

- Design and Architecture: Robin Renwick
- Programming: Robin Renwick
- Performers: Hadi Bastani, Aidan Deery, and Sandor Mehes
- Moderator: Robin Renwick

Rehearsal and Performance:

- Design, testing, and rehearsal procedures carried out from May - July, 2016 @ the Sonic Arts Research Centre (SARC), Belfast
- Performance on 27th July, 201@ Sonic Arts Research Centre

Documentation:

- Digital Artefacts (.../5.Fields_Of_Feedback/Digital_Artefacts/...)
- Documentation Trailer (.../5.Fields_Of_Feedback/Trailer/...)

Performance Materials:

- Performance Code (.../5.Fields_Of_Feedback/Performance_Code/FoF-Performance_Code.zip)
- Performance Instructions (.../5.Fields_Of_Feedback/Performance_Code/1.README)
- Max/MSP Dependencies (.../5.Fields_Of_Feedback/Performance_Code/Externals/...)
- Signal Flow Diagram for Hopfield Network Topology (.../5.Fields_Of_Feedback/Performance_Code/Signal_Flow_Diagram-Hopfield.png)
- Hopfield Topology Diagram (.../5.Fields_Of_Feedback/Performance_Code/Topology_Diagrams/FoF-Hopfield)

Programme Note:

Fields of Feedback is a live, improvised group performance involving three laptop performers and one moderator. The performance topology is a direct representation of a specific type of machine learning algorithm, called a Hopfield Network. Within the performance each laptop is designated a unique input stream - a remotely located live microphone sourced from the *Locus Sonus* soundmap (www.locusonus.org/soundmap). Each performer's output is sent to a local feedback moderation platform which connects the output of each performer's workstation to the input of every other performer - creating a complex and

manipulable feedback network. The feedback platform is controlled by a fourth performer, who acts as moderator.

The performance is a delicate balancing act between individual and collective creativity, between artistic individuality and systemic governance. Directed relational paths enforce the emergence of aural communicational channels, as performers are urged to understand their individual actions, inspirations and modulations within a collaborative networked context; performer action is interdependent, as outputs directly intercede and intra-act on others' inputs.

Appendix E: Amalgam 2012

Credits:

- Design and Architecture: Aidan Deery, Michael Dzjaparidze, and Robin Renwick
- Programming: Michael Dzjaparidze
- Performers: Aidan Deery, Michael Dzjaparidze, and Robin Renwick

Testing Procedures:

- Design, development, recording, rehearsal procedures carried out during an artistic residence in 2012 @ The Metropolitan Arts Centre, Belfast
- Performance on 21st and 22nd June, 2012 at The Metropolitan Arts Centre, Belfast

Documentation:

- Documentation Trailer (.../6.Appendix_Projects/1.Amalgam_2012/Trailer/...)
- Academic Paper (.../6.Appendix_Projects/1.Amalgam_2012/Academic Paper/...)
- Topology Diagrams (.../6.Appendix_Projects/1.Amalgam_2012/Topology_Diagram/...)
- Audio (.../6.Appendix_Projects/1.Amalgam_2012/Audio/...)

Performance Materials:

- Performance Code (.../6.Appendix_Projects/1.Amalgam_2012/Performance_Code/Amalgam-2012.zip)
- Performance Instructions (.../6.Appendix_Projects/1.Amalgam_2012/Performance_Code/Amalgam-2012.zip/readme.md)

Programme Note:

Amalgam is a collaborative project between three artists who work within the domain of sound art. The project endeavoured to develop a compositional framework for a live performance based on the combined approaches of three distinct compositional methodologies: algorithmic composition, soundscape composition, and network performance - representing the area of expertise of each of the performers.

he project was realised during an artist's residency in the Metropolitan Arts Centre (MAC), Belfast, throughout which aspects of each artist's individual work combined to compliment the objectives of the project. A fourth component of the collaboration was to involve the host building itself: both in terms of subject matter

providing sonic ‘material’ and, conceptually at least, as an additional ‘performer’. It was decided in the preliminary stages that information provided by the buildings wireless network would be used as a trigger system around which the composition would develop, thus allowing for dynamic control over the samples of field recordings, also gathered from different parts of the arts centre. As such the aesthetic and practical contribution of each of the performers could be satisfied, and the development of the project prompted engagement with particular discourses, for example the conflict between delineated and open-ended form within a live performance, and the public reception towards sonic art.

The project focused both on methods of collaboration between artistic methodologies that are often realised in isolation, and exploring structure and content for the live performance of sonic art, demonstrating this amalgamation of sound art practice in a public setting.

Appendix F: Amalgam 2013

Credits:

- Design and Architecture: Aidan Deery, Michael Dzjaparidze, and Robin Renwick
- Programming: Michael Dzjaparidze
- Performers: Aidan Deery, Michael Dzjaparidze, and Robin Renwick

Rehearsal and Performance:

- Design, development, recording, rehearsal procedures carried out during April, 2013 @ the Sonic Arts Research Centre (SARC), Belfast
- Performance on 26th April, 2013 at the Sonorities Festival of Contemporary Music, Beyond Soundscape - Sonic Arts Research Centre (SARC), Belfast

Documentation:

- Audio (.../6.Appendix_Projects/2.Amalgam_2013/Audio/...)
- Programme Note (.../6.Appendix_Projects/2.Amalgam_2013/Programme_Note/...)

Performance Materials:

- Performance Code (.../6.Appendix_Projects/2.Amalgam_2013/Performance_Code/Amalgam_2013_Software.zip)
- Performance Instructions (.../6.Appendix_Projects/2.Amalgam_2013/Performance_Code/Amalgam_2013_Software.zip/readme.md)
- Topology Diagram (.../6.Appendix_Projects/2.Amalgam_2013/Topology_Diagram/...)

Programme Note:

Amalgam describes a site-specific collaborative project that combines three distinct compositional approaches to explore the sound world of a particular building. Each performer arrives from disparate practices (physics based sound synthesis, network music performance and soundscape composition), whilst a fourth 'performer' is included in the project in the form of wireless Internet data, representing the host building. The content of the performance is site-specific, resulting in a cooperative live performance that explores the sonic identity of the location: ceding a level of affordance to the network data to create a collaborative schematic that evolves our understanding of the term soundscape.

Aidan Deery, Michaël Dzjaparidze, and Robin Renwick first performed together during a residency at the MAC in Belfast in June 2012. They are PhD students at

SARC each with a wide and varied background composition and performance, all of which has contributed to the conceptual and artistic evolution of the on going project that is Amalgam. The 2013 interation of the piece was realised specifically for Sonorities Festival of Contemporary Music, 2013, hosted by the Sonic Arts Research Centre, Queen's University Belfast. A component of the collaboration was to involve the host building: both in terms of subject matter providing sonic 'material' and, conceptually at least, as an additional 'performer'. It was decided in the preliminary stages that information provided by the buildings wireless network would be used as a trigger system around which the composition would develop, thus allowing for dynamic control over the samples of field recordings, also gathered from different parts of the university department. The project also implemented the customisable array of loudspeakers located in the Sonic Laboratory.

The project focused both on methods of collaboration between artistic methodologies that are often realised in isolation, and exploring structure and content for the live performance of sonic art, as well as implementing spatialisation strategies for adequately representing the mapping of network activity.

Appendix G: Ellipses

Credits:

- Design and Architecture: Ivani Santana and Robin Renwick
- Programming: Robin Renwick and Graham Booth
- Performers:
    - Belfast: Ivani Santana, Robin Renwick, and Graham Booth
    - New York: Paredes Lascan

Rehearsal and Performance:

- Design, development, recording, rehearsal procedures carried out during January - April, 2013 @ the Sonic Arts Research Centre (SARC), Belfast
- Performance on 24th April, 2013 at the Sonorities Festival of Contemporary Music, Beyond Soundscape - Sonic Arts Research Centre (SARC), Belfast

Documentation:

- Academic Paper (.../6.Appendix_Projects/3.Ellipses/Academic_Paper/...)
- Programme Note (.../6.Appendix_Projects/3.Ellipses/Programme_Note/...)
- Topology Diagrams (.../6.Appendix_Projects/3.Ellipses/Topology_Diagram/...)
- Documentation Trailer (.../6.Appendix_Projects/3.Ellipses/Trailer/...)

Performance Materials:

- Performance Software (.../6.Appendix_Projects/3.Ellipses/Performance_Software/Ellipses-Performance_Software.zip)
- Performance Instructions (.../6.Appendix_Projects/3.Ellipses/Performance_Software/1.README)

Programme Note:

Entanglement is the watchword of this network performance. Two dancers, located in dislocated environments, are bound together through network protocols, communication infrastructures, and programmed computational architectures; creating a performance system that is inter-relational, interdependent and interweaved. Nodes within the system act as communicational hubs, sharing information in a dualistic paradigm to create a web of performance intrigue. Dance movements are sonified; afforded a direct relationship with aurality through their alliance with computer musicians. The musicians attempt to invoke a direct sense of intertwinement, as interwoven aesthetics fuse a relational sense; a sense of

community, abstracted through the direct correspondence that all nodes have through the technology at their disposal.

Appendix H: Sourced Cities

Credits:

- Design and Architecture: Robin Renwick
- Programming: Robin Renwick
- Performers: Jan Cathala and Robin Renwick

Testing Procedures:

- Documentation and testing procedures carried out throughout April and May 2014 @ University of Bahia, Brazil.
- Performance on 30th of May, 2014 at the University of Bahia, Brazil.

Documentation:

- Documentation Trailer (.../6.Appendix_Projects/4.Sourced_Cities/Trailer/...)
- Audio (.../6.Appendix_Projects/4.Sourced_Cities/Audio/...)

Performance Materials:

- Performance Software (.../6.Appendix_Projects/4.Sourced_Cities/Performance_Software/Sourced_Cities-Performance_Software.zip)
- Performance Instructions (.../6.Appendix_Projects/4.Sourced_Cities/Performance_Software/README)
- Topology Diagram (.../6.Appendix_Projects/4.Sourced_Cities/Performance_Software/Sourced_Cities-Topology)

Programme Note:

Sourced Cities 2014 is musical offering that is governed by a specific typology of network performance. Real-time open microphone streams are sourced from an Icecast server, owned and operated by the sound art research organisation, Locus Sonus. Encoded, ogg-vorbis audio streams are accessed by the performer through a bespoke performance system, and then implemented as source material in a real-time musical interpretation. The re-articulation and re-animation of the streams enforces a sense of indeterminacy onto the piece. The performers remain in control of how the audio sources are interpreted and re-modulated, not how they appear offered to him. This indeterminacy ensures a sense of fragility runs throughout the performance, as the performers are not entirely certain of what events will occur within the sound worlds being sourced. The fragility is realised through fragments of reality being moulded and shaped into a compositional dream, ensuring processes and fixations obscure natural soundscapes. Moments in time, from distant

places and spaces, are distorted and fractured, moulded and revealed; allowing the listener only splinters and slivers of the sound worlds as they are. The listener is transported to worlds, imagined and interpreted by the composer; wormholes into a sonorous sphere rich for experimentation, exploration, and discovery.

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