Interactive Sound Synthesis Mediated through Computer Networks

Kameron R. Christopher[*†], Jingyin He[§†], Ajay Kapur[*§†], Dale A. Carnegie[*]

[*]School of Engineering and Computer Science, Victoria University of Wellington, New Zealand

[§]New Zealand School of Music, Victoria University of Wellington, New Zealand

[†]Music Technology: Interaction, Intelligence, and Design, California Institute of the Arts, USA

kameron.christopher@ecs.vuw.ac.nz, jon.he@vuw.ac.nz

Abstract

Network music is the paradigm in which music is created through technology-mediated communication. In a world where we have become significantly dependent upon computer communication to relay and interact with affective information, methods of networking to generate music are becoming increasingly relevant to the way in which we communicate. The body of works in network music extends decades back to the music of *The League of Automatic Music Composers*. Still today, much of the work in network music has focused on the manipulation of parameters among group members, whether it is mediated through score, improvised, or arbitrary. The field of network music has yet to thoroughly explore the idea of using network as a tool for synthesis. Motivated in part by research into the microsonic components of sound creation, this paper presents the methodology of using network communication protocols for sound synthesis in live performances. A discussion of the authors' prior works highlights the considerations in software and hardware, and explains techniques that use the less-explored and intangible characteristics of network systems to generate sonic materials in a live performance setting.

Keywords: Network Music, Sound Synthesis, Sonic Arts

1. Introduction

The digital age is continuously redefining the bounds of interaction. This has never been more apparent in the realm of sonic arts, where the idea of network interactivity is becoming increasingly ubiquitous. After all, art is essentially born of the phenomenon around us.

Interactivity is a fundamental element of music performance, whether it is amongst performers, the performers and the audience, or the performers and the work itself. Since the era of the League of Automatic Music Composers and the Hub (Gresham-Lancaster 1998), composers, musicians, and music technologists have explored the paradigm of computer networks as the medium of interactivity in music systems (Barbosa 2003; Traub 2005; Mills 2010).

Motivated in part by research into the microsonic components of sound creation, the authors introduce a novel method of interactive network music. The approach is not only mediated through the network communication medium, but also relies on the medium of communication itself to generate sound generation from the microsonic level. Section 2 provides an outline of related studies in network music. An overview of the interactive synthesis system is explained in Section 3. Section 4 discusses the synthesis applied in several performance situations. Finally, Section 5 provides a summary of the authors' findings in the development and application of this method.

2. Related Works

In 2005, Weinberg provided a theoretical framework that categorizes the approaches to network music creation (Weinberg 2005). Much of the research in the field of network music has focused in the development of platforms for interactive and collaborative music making. Frameworks developed for musical jamming and improvisation include *Auracle* (Ramakrishnan, Freeman, and Varnik 2004), *Jamspace* (Gurevich 2006) *The Frequencyliator,* The DIAMOUSES Framework (Alexandraki and Akoumianakis 2010), and *Signals*, an interactive framework for music robotics (Vallis et al. 2012).

Some researchers have focused on the development of methods for real-time sharing of audio and visual information across interactive performance networks. Barbosa et al. experimented with methods of dynamically adapting computer latency in network music (Barbosa, Cardoso, and Geiger 2005). Kapur et al. developed a low latency framework for bi-directional network media performance over a high-bandwidth connection (Kapur et al. 2005).

Another common domain in interactive network music is social participatory work. Tanaka et al. explored the idea of social computing and participation (Tanaka, Tokui, and Momeni 2005). Stockholm's system was designed for a composition utilizing several users in a public space (Stockholm 2008). Recently, Wolf and Fiebrink have created a software tool for artists to access the low-level packet data that flows across networks (Wolf and Fiebrink 2013).

Researchers have considered many ways of developing network interactive music through the collaborative manipulation of musical parameters and, or the sharing of musical content. However, they do not utilize networks as components to generate sonic materials. Our approach is a novel introduction of the creation of sound through the medium of computer networks and interactivity.

3. System Overview

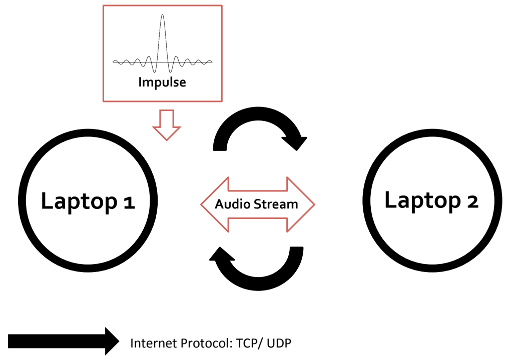


Figure 1: System Flowchart

We designed a unique interactive system in which computer networks facilitate the synthesis of sonic material. Figure 1 shows an overview of the system in which the feedback of an impulse between laptop performers over Internet Protocols (IP) generates the sonic material. This section describes the impulse, the framework for the synthesis, and the sonic material that results from the synthesis technique.

3.1 Impulse

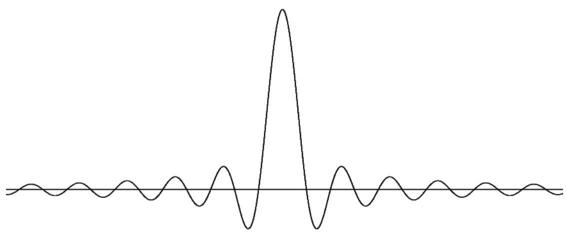


Figure 2: Generated Impulse

The basis of this method is the impulse, an almost instantaneous burst of substance that can be generated with different pulse widths. Methods of sound synthesis and filter design have long employed impulse generation in their construction (Roads 2004). As the initial input of our system, a single impulse – such as the one shown in Figure 2 – is evolved into complex tonal material through the chaotic feedback created between performers across a network.

3.2 *Framework*

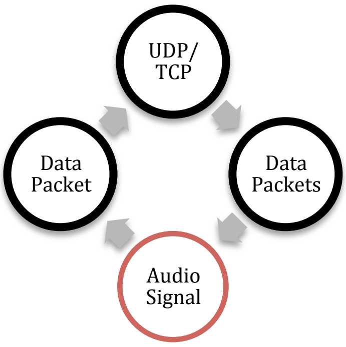


Figure 3: The flow of audio and data in a performer

The communication framework is constructed of the User Datagram Protocol (UDP) or the Transport Control Protocol (TCP). These IPs are used to pass sonic material from performer to performer. A typical workflow is shown in Figure 3. Audio is converted to data and passed to the network. Each performer converts data received from the network to audio.

3.2 *Synthesis*

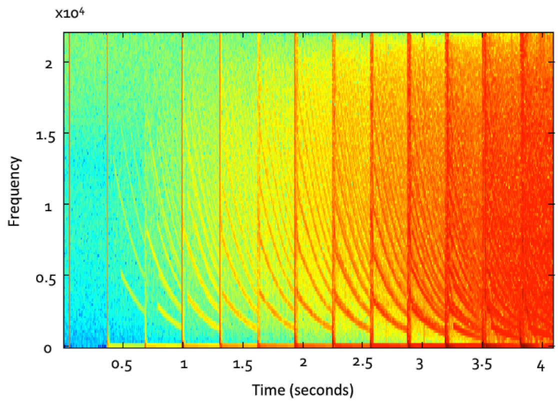


Figure 4: Spectrogram of 4 seconds

The sound synthesis is a result of a convolution between the feedback of impulses between performers, and the inherent features of the network. This results in rich and chaotic sound. In methods such as Trainlet Synthesis, series of impulses are used to generate tones and clouds (Roads 2004). Our method starts from a similar basis but departs in its approach, construction, and results. In Figure 4 the spectrogram shows an instance of this process in which the initial impulse evolves over the duration of 4 seconds from a single impulse to complex sound. In Figure 5 there is a similar process occurring over 1.2 seconds with completely different resulting sounds. The resulting material can be used in further digital signal processing chains to generate the desired aesthetic output.

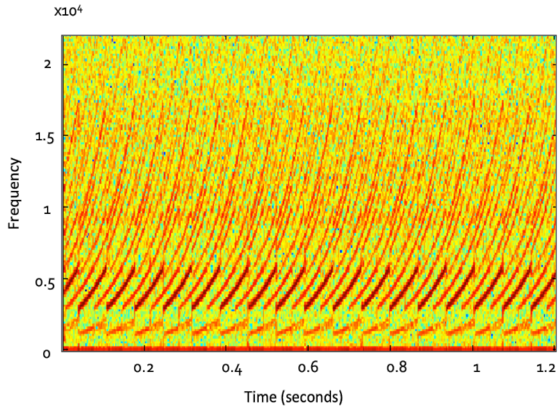


Figure 5: Spectrogram of 1.2 seconds

4. Performance

The implementation of the abovementioned system in performance practice resulted in a series of audio-visual compositions by the first and second author.

Media File 1: SS-0010.110011111011, Mixed Signals (http://vimeo.com/34928714).

At the outset of this collaboration, the authors explore the use of inherent characteristics of the system to induce emergent behaviours towards generating sonic materials. The first composition of the series focuses on intuitively generating a rich palette of sonic materials (Media File 1).

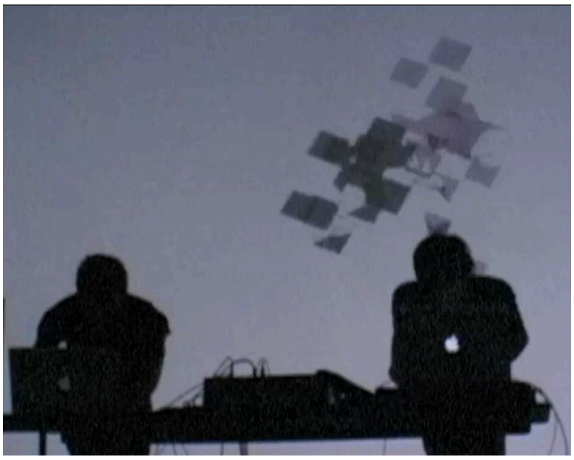
In *SS-0010.110011111011*, the secure wireless connection provided by California Institute of the Arts is used. The entire campus, including the dormitories, uses this connection. The composition is performed on a Gallery Night at 9pm. Network traffic is lowest during this time, because most students are attending the gallery openings on campus. The following observations are made:

- Wireless connection causes interesting rhythmic structures, and timbre. However, it is unstable and prone to having overflows.
- Restricted shared wireless connections (i.e. academic institutions, arts venues, etc.) vary the pitch and timbre.
- Setting up different bit-depths causes high aliasing and bit-crushing effects.

Media File 2: Planar Chaos @ Transmigration I, Beyond Baroque (http://vimeo.com/38194767)

Building upon these techniques, *Planar Chaos* (Media File 2) focused on the control of timbres, as well as compositional form and structure by steering the chaos. Due to the technical circumstance of the venue, this performance used a wired connection between the performers. The characteristics of wired connection with regards to the sonic materials and resulting composition are as follows:

- Connection via ethernet cables provides responsive and stable connections. However, rhythmic structures tend to be rigid and timbre tends to be homogeneous.
- Given cables of the same quality, length is directly proportional to latency.
- Increasing computational processes and memory usage can cause intermittent increase in latency. This can be used to simulate the varying latency in a wireless connection.



Media File 3: Interpolations: Noise in Space I (http://vimeo.com/42026195)

Interpolations: Noise in Space consolidates the observations from past performances and presents the refined practice of this methodology. *I* (Media File 3) explores the more abrasive and visceral aspects of this synthesis technique. It exploits the complex timbre burst produced by events in the network data stream. *II* (Media File 4) explores the opposite aspect of the synthesis method, showing how the sounds can be used in highly controlled systems, and manipulated by other digital signal processing methods to produce aesthetic outcomes.

Media File 4: Interpolations: Noise in Space II (http://vimeo.com/42375054)

Interpolations: Noise in Space demonstrates that this method is suitable for producing complex sounds that can easily be modified towards compositional ends.

5. Conclusion

This approach to interactive sound synthesis mediated through computer networks provides an interesting approach to the field of network music. The methodology puts forth the idea that sonic artists and technologists can consider networks as not only a means of information transfer, but also as a means of generating sonic content.

Several live performance applications and considerations are presented. These performances evolved from early rudimentary implementations, to more complex musical compositions. It also shows diversity in its sonic content. Performance variations caused by software and hardware means that composers are able to tune these considerations towards stylistically individualized results.

References

Alexandraki, Chrisoula, and Demosthenes Akoumianakis. 2010. "Exploring New Perspectives in Network Music Performance: The Diamouses Framework." *Computer Music Journal* 34 (2): 66–83.

Barbosa, Álvaro. 2003. "Displaced Soundscapes: A Survey of Network Systems for Music and Sonic Art Creation." *Leonardo Music Journal* 13: 53–59.

Barbosa, Álvaro, Jorge Cardoso, and Gunter Geiger. 2005. "Network Latency Adaptive Tempo in the Public Sound Objects System." In *Proceedings of the 2005 Conference on New Interfaces for Musical Expression*, 184–187.

Gresham-Lancaster, Scot. 1998. "The Aesthetics and History of the Hub: The Effects of Changing Technology on Network Computer Music." *Leonardo Music Journal*: 39–44.

Gurevich, Michael. 2006. "JamSpace: Designing a Collaborative Networked Music Space for Novices." In *Proceedings of the 2006 Conference on New Interfaces for Musical Expression*, 118–123.

Kapur, Ajay, Ge Wang, Philip Davidson, and Perry R. Cook. 2005. "Interactive Network Performance: a Dream Worth Dreaming?" *Organised Sound* 10 (3): 209.

Mills, Roger. 2010. "Dislocated Sound: A Survey of Improvisation in Networked Audio Platforms." In *Anonymous Conference on New Interfaces for Musical Expression (NIME 2010)*.

Ramakrishnan, Chandrasekhar, Jason Freeman, and Kristjan Varnik. 2004. "The Architecture of Auracle: a Real-time, Distributed, Collaborative Instrument." In *Proceedings of the 2004 Conference on New Interfaces for Musical Expression*, 100–103.

Roads, Curtis. 2004. *Microsound*. The MIT Press.

Stockholm, Jack. 2008. "Eavesdropping: Network Mediated Performance in Social Space." *Leonardo Music Journal* 18: 55–58.

Tanaka, Atau, Nao Tokui, and Ali Momeni. 2005. "Facilitating Collective Musical Creativity." In *Proceedings of the 13th Annual ACM International Conference on Multimedia*, 191–198.

Traub, Peter. 2005. "Sounding the Net: Recent Sonic Works for the Internet and Computer Networks." *Contemporary Music Review* 24 (6): 459–481.

Vallis, Owen, Dimitri Diakopoulos, Jordan Hochenbaum, and Ajay Kapur. 2012. "Building on the Foundations of Network Music: Exploring Interaction Contexts and Shared Robotic Instruments." *Organised Sound* 17 (01): 62–72.

Weinberg, Gil. 2005. "Interconnected Musical Networks: Toward a Theoretical Framework." *Computer Music Journal* 29 (2): 23–39.

Wolf, KatieAnna E., and Rebecca Fiebrink. 2013. "SonNet: A Code Interface for Sonifying Computer Network Data."