

Network Gyre by Ethan Cayko

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Original PDF with new page layout.

Comment by Richard Dudas

I found this paper particularly interesting when I heard it presented at the 2015 ICMC – perhaps because I am interested in canons and counterpoint. I thought it was a great example of a composer taking a drawback of a particular technology, which we all use to varying degrees, and figuring out how to use it creatively in a really cool and clever way. It is kind of an ideal ICMC paper – a composer writing about his piece which uses software he made that does something both technical and musical.

ABSTRACT

This study centers on an exploration of latency inherent in long-distance networked music performance as well as its application in the performance of “Network Gyre”, a work written for bi-located percussion. The research examines time delays in two ways: 1) by creating a series of exercises used to familiarize performers with the nature of network latency and 2) by providing an example of highly rhythmic music written for the network. Notational methods used by composers such as Steve Reich and John Cage are used to address communication and rhythmic challenges in network music. Finally, a description of the extra-musical applications and formal structure of “Network Gyre” is provided.

The research was made possible through numerous meetings between researchers at the University of Calgary and Dr. Kenneth Fields and percussionist Feng Piaoyang at the Central Conservatory of Music in Beijing in the fall of 2014. We utilized the research network Cybera to establish a high-speed connection and the program Artsmesh as an interface for connecting audio between sites. The outcome was a performance of “Network Gyre” and a series of exercises that display the characteristics of networked performance.

1. INTRODUCTION

Telematic Music or Networked Music Performance (NMP) is a new and budding branch within the vast reaches of music as an art form. Recent developments in high-speed net-

Post scriptum by Ethan Cayko

Following Network Gyre – Exercising the Network’s Rhythmic Potential, I expanded this research in my master’s thesis Rhythmic Topologies and the Manifold Nature of Network Music Performance (Cayko, 2016), which further developed the compositional technique I came to describe as toporhythm—a method of structuring rhythm through intentionally calibrated network latencies, yielding site-specific patterns that, while performed simultaneously, unfold differently at each performance node. Through collaborations with the Central Conservatory of Music in Beijing, UC Santa Barbara, and others through the DigiScore Project, I continued to refine both the technique and software tools used to perform and visualize toporhythmic network music. These subsequent works would not have been possible without the strengths gained while first exercising the network’s rhythmic potential.

work connections, especially research networks that connect universities and institutions, have brought NMPs into the realm of possibility. Chris Chafe, an expert and leading researcher in the field claims that the medium is an emerging realization of Sir Francis Bacon’s *New Atlantis*, illustrating his point that, “...from our present vantage point of rapidly expanding digital networks and media streaming, a compelling new reading emerges promising something much more.”¹

Early works in the field of network music such as performances by the Hub sophisticatedly explore the possibilities of a network and the interaction between nodes therein. However the technology at the time did not allow for much more than MIDI messages to be sent over any great distance and even this was a taxing endeavor.² Over time composers explored long distance network performance in other ways such as Atau Tanaka and his foundational installation “Global String” wherein a steel cable acts as a single instrument spanning the globe.³ However, in this work no live audio signals are being sent, rather there are sensors that convert the excitation of a cable on one end to trigger a synthesized physical model of an impossibly proportioned

¹ Chris Chafe. “Tapping into the Internet as an Acoustical/Musical Medium.” *Contemporary Music Review* 28, no. 4 (August 2009): 413–20.

² Scot Gresham-Lancaster. “The Aesthetics and History of the Hub: The Effects of Changing Technology on Network Computer Music.” *Leonardo Music Journal* 8, no. 1 (1998): 39–44.

³ Atau Tanaka and Bert Bongers “Global String – A Musical Instrument for Hybrid Space.” (Paper presented at Cast01: Living in Mixed Realities, St. Augustin. Germany, 2001).

string sound and mechanical movements of the cable on the other end. This way Tanaka was able to retain immediacy without dealing with the latency imposed by live audio transmission.

Despite these and other works many of the affordances of the network are still to be explored and in the coming years as high-speed research networks expand more possibilities will arise. As the list of repertoire for networked performance is still quite small, building to this library is of vital importance. In order to do this composers and performers alike need not be intimidated by the possible perils of the network. If the medium is considered to be cumbersome, it will be. However, if there is a system of principles that make composing for the network a palatable new avenue for composers, more music will be written and more advancement will be made. This system starts with an understanding of the idiosyncrasies of NMP.

2. EXERCISING THE NETWORK

Each co-located site, otherwise known as a node, has a unique relationship to the other(s) due to the geographical distance and symmetry of the signal’s path. New works for the network can all have unique combinations of nodes and those nodes can be in an ever-expanding variety of places, each with their own idiosyncrasies in terms of delay time, jitter, and symmetry. This implies that music written for network performance can be idiomatic, in that each work is specific to a particular configuration of nodes. When a different combination of nodes is used, the music must be able to adapt to that new environment.

In the new work *Network Gyre* two of the primary considerations were synchronization between performers without a conductor or visual cues and notational methods for distributed rhythms.⁴ Chris Chafe’s study on performer accuracy and synchronization concluded that any latency greater than or equal to 20ms results in progressive deceleration among the given performers.⁵ However, because *Network Gyre* is intended for long-distance performance, namely that of Calgary to Beijing, we are dealing with a significantly larger delay time. This creates an entirely different dynamic. Instead of focusing on unison synchronization, offset synchronization becomes the issue; therefore dealing with the notion of distributed rhythmic patterns posed by Juan-Pablo Cáceres⁶ and first put in to practice by Stanford University and Peking University’s network performance of Terry Riley’s *In C* in 2008.⁷

“The Pacific Rim of Wire” was a multi-ensemble network music performance between Stanford, California and Beijing, China. The issue of synchronization faced in this performance parallels that of *Network Gyre*, but as *Network Gyre* was written specifically for bi-located performance, the methods used vary in fundamental ways.

⁴ Juan-Pablo Cáceres and Alain B Renaud. “Playing The Network : The Use Of Time Delays As Musical Devices.” (Paper presented at the International Computer Music Conference, Belfast, Northern Ireland, 2008).

⁵ Chris Chafe, Michael Gurevich, Grace Leslie, and Sean Tyan. “Effect of Time Delay on Ensemble Accuracy.” (Paper presented at the International Symposium on Musical Acoustics, March 31– April 4, 2004).

⁶ Cáceres et al. “Playing the Network.”

⁷ Juan-Pablo Cáceres, Robert Hamilton, Deepak Iyer, Chris Chafe, and Ge Wang. “To the Edge with China : Explorations in Network Performance.” (Paper presented at ARTECH 4th International Conference on Digital Arts, Porto, Portugal, November 7–8, 2008).

Using the command `ping6` the round trip time (RTT) between Calgary and Beijing was found to be ~186 milliseconds. The tempo at a certain rhythmic unit can be derived from that time via a simple calculation.

$$\text{Tempo} = \frac{60 \text{ (seconds in a minute)}}{0.186 \text{ (seconds)}} = 322.58 \text{ bpm} = \text{♩}$$

(1)

With this standard in place every rhythm can be written to creatively consider the delay. The aforementioned network performance of *In C* allowed for a metronomic pulse to be transmitted to each node, synchronizing performers through the method of feedback locking. Cáceres describes in detail the way feedback locking works and how it was implemented in the network performance of *In C* in his paper on the topic.⁸ *Network Gyre* and the rhythmic exercises created for this research employ the same method of feedback locking but instead of applying them to a loose system of instructions like that of Riley’s *In C* the music is through-composed and designed to specifically integrate the latency in both the compositional process and the music’s performance. One aspect of rhythmic displacement that is not dealt with in the network performance of *In C* is that of performers starting and stopping simultaneously. Here the idea of a “conductor node” serves to provide a solution.

This idea of performer as conductor is not without precedent. Music of West African cultures, Balinese Gamelan, and even American marching bands all use audible signals for cuing musical events. Famous American composer Steve Reich has also employed this method in work such as *Music for 18 Musicians*.⁹ The rhythmic exercises in this research use a count-off technique similar to that of a marching band. One node (N1) starts the exercise with one measure of eighth notes in an accented pattern that outlines the main quarter note beats.¹⁰

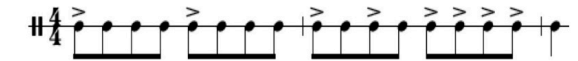


Figure 1. Count-off

The remote node (N2) hears the count-off and starts the exercise in unison with N1. The result is that N1 hears N2 an eighth note late as illustrated in fig. 2¹¹, while N2 hears the exercise being played in unison.



Figure 2. N1’s heard result of the eighth note offset caused by latency

All of the exercises function in the same way and they each display a different way of subdividing the latency as well as illustrating the concepts of feedback locking and distributed rhythmic patterns.¹²

⁸ Cáceres et al. “To the Edge with China.”

⁹ Steve Reich and Joana Batista. *Music for 18 Musicians*. (Boosey and Hawkes, 2000). Accessed December 7, 2014. <http://search.alexanderstreet.com/view/work/376153>.

¹⁰ See Figure 1.

¹¹ See Figure 2.

¹² Cáceres et al. “Playing the Network.”

3. NETWORK GYRE

3.1 Notational and Compositional Influences

Applying the above count-off method with a piece of music like *Network Gyre* is obviously not ideal, the cues should be given in a musical way so as not to disrupt the flow of the piece. Again drawing from Steve Reich, this problem is remedied through the use of a modular score similar to that of *Music for 18 Musicians*.¹³ The cues come from the conductor node as a rhythmic change in a repeated pattern of undetermined length. This way the performers are not bound by rigidly counting each repetition, and when the conductor node decides to move on to the next section, he or she simply plays the cue and both nodes know to continue on.

In tandem with this method for notation is a compositional strategy of building rhythmic density used by John Cage in his "Trio" from *Amores* outlined by percussionist and writer John P. Welsh.¹⁴ Welsh describes Cage's use of rhythmic units which he calls "modules" (it should be noted that the term "module" here is unrelated to Reich's use of the term). These modules are basically rhythmic motifs that Cage juxtaposes between the three performers and creates energy and rhythmic density through more or less "attacks per ♩", or more instances of the module in a given time frame.¹⁵ In *Network Gyre* a similar approach is taken to build density but influence is drawn from extra-musical sources.

3.2 Extra-Musical Influences

The idea of performing music in real-time from across the globe is a fantastic one. It conjures up thoughts of distance, travel, and the sheer enormity of the planet on which we live. *Network Gyre* is written with the delay of 186ms as the eighth note time value. As mentioned before, this is the RTT between Calgary and Beijing. More importantly though is that the signal travels between two nodes separated by the largest body of water on the planet, the Pacific Ocean.

In formulating and structuring *Network Gyre*, the time-scales proposed by Curtis Roads in his book *Microsound* are employed.¹⁶ Each element from the entire piece to the small rhythmic motifs reside in one of Roads' time-scales, furthermore each of these categories of time correspond to an extra-musical concept.

3.2.1 Macro

A gyre as defined by Merriam-Webster is, "a circular spiral motion or form; especially: a giant circular oceanic surface current"¹⁷ These gyres form when the sun's rays warm surface water and create a phenomenon known as the Coriolis effect which results in the large-scale swirling motion of the ocean's currents. There are many categories of gyres in the world's oceans but this piece of music is, in a way, an ode to the North Pacific Gyre. The gyre being the overarching structure of the entire piece resides in the *Macro* time-scale.

3.2.2 Sub-Macro

The piece is broken into four main sections and these could be considered as being on the *Sub-Macro* time-scale. These four main sections correspond to the four ocean currents that comprise the North Pacific Gyre. The first section being the least rhythmically active corresponds to the slowest current in the gyre, the California Current. The next section builds in activity and energy and corresponds to the North Equatorial Current. Then the piece evolves into a constant pulsing unison section, this corresponds to the fastest current in the gyre, the Kuroshio Current. The piece concludes with a section that slowly unravels the density preceding it, representing the North Pacific Current and a return to the California Current, completing the full cycle of the gyre.

3.2.3 Meso and Sound Object

These four sections are comprised of rhythmic phrases that inhabit the *Meso* time-scale. These phrases are then made up of rhythmic cells, which are on the order of slightly more or less than one second, placing them in the *Sound Object* time-scale. These two categories of time correspond to the materials at play in a phenomenon known as the Kelvin-Helmholtz (KH) Instability. This process occurs in a fluid that is stratified by different densities, such as our oceans. When internal waves shear at different velocities instability occurs. "The result is a growing wave train reminiscent of surface waves approaching a beach."¹⁸ KH instability also occurs in air. The figure below illustrates a rare example of this phenomenon.¹⁹



Figure 3. Kelvin Helmholtz billows visible in clouds. (from <http://www-frd.fsl.noaa.gov/mab/scatcat>; photo by Brooks Martner)

The rhythmic phrases in the *Meso* time-scale are seen as the mixing and churning of each smaller rhythmic cell. These rhythmic cells build activity in a way similar to the aforementioned Cage piece but instead of more occurrences of the same rhythmic cell, here the rhythmic cells are further subdivided and offset between the two performers. This subdivision corresponds to more or less velocity in a fluid. Musically this manifests itself in the form of interlocking patterns, hocketing, polyrhythms, and polymeter.

4. CONCLUSION

The implications of network music are vast. Connecting the world's cultures through a musical medium instead of a musical genre allows composers unique opportunities for collaboration instead of appropriation. With the newness of this medium fading and more systems being put into place, extensions of current possibilities will be achievable. Some of these extensions could be in the form of notational methods.

¹⁸ W.D. Smyth, and J.N. Moun. "Ocean mixing by Kelvin-Helmholtz instability." *Oceanography* 25 no. 2 (2012): 140-149, <http://dx.doi.org/10.5670/oceanog.2012.49>.

¹⁹ See Figure 3.

Network Gyre is written in two scores, one for the conductor node (N1) and one for the remote node (N2). Each score displays that performer's part as well as the resulting rhythms of remote node's part. Very little explanation is necessary for a performer to approach the piece; they can simply read it like any other piece of traditionally notated music. However, in composing the piece a method more akin to the grid-like score in Iannis Xenakis's *Psappha*²⁰ was used to understand the relationship between the nodes in the context of a consistent rhythmic offset.

Another logical extension of network performance is the inclusion of more than two nodes. This quickly creates incredibly complex rhythmic possibilities. Depending on the location of the nodes, it is highly likely that artificially added delay would be needed in order to align all the nodes' latency with an equal rhythmic value. This is easily achieved through software and has already been demonstrated by Chris Chafe and others through their studies.²¹

Different instrumental configurations could be yet another extension of the current state of network performance. In addition to computer-generated sounds other acoustic instruments with various attack and decay factors lend themselves to the network medium. *Network Gyre* is written for six woodblocks but the instrumentation is not set in stone. In fact, any three objects that ascend in pitch and have a pure timbre with a very fast attack and decay could be used in place of woodblocks (such as three pieces of litter found floating in the Pacific Ocean).

As mentioned previously, network music can open doors to musical worlds never before seen. Soon musicians will no longer be daunted by the technical challenges of the network. Furthermore, latency is proving to no longer be considered a problem but instead is accepted as an affordance of the network and utilized as a creative musical device. A global platform for music collaboration is emerging and brings this author to wonder if, at least on this planet, *being apart* will soon be understood as *being a part*.

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²⁰ Iannis Xenakis. *Psappha: Pour Percussion Solo*. (Paris: Salabert, 1975.) 1-12.

²¹ Chafe et al. "Effect of Time Delay."

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¹⁴ John Welsh. "John Cage's 'Trio' from Amores (1943): A Study of Rhythmic Structure and Density." *Ex Tempore* 4, no. 2 (1988). Accessed December 1, 2014.

¹⁵ Welsh "John Cage's 'Trio' from Amores."

¹⁶ Curtis Roads. *Microsound*. (Cambridge, MA: MIT Press, 2001), 3-5.

¹⁷ "gyre." Merriam-Webster.com, accessed December, 2014. <http://www.merriam-webster.com>