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Musical Networks in Experimental Electronic Performance

Abstract

The paper outlines three practical uses for Internet and LAN networks in the performance of electronic and electroacoustic music currently utilized in teaching and learning at WAAPA Composition and Music Technology, Edith Cowan University: From live streaming audio broadcasts connecting virtual performers around the world, to synchronised electronic graphic scores and on to distributed computing networks utilizing Max/MSP over UDP to produce multichannel spatial music works. The use of musical networks enables the electronic composer to integrate virtual ensembles and/or large amounts of data distributed over LAN and the Internet. These networks and their technological setups also both open up and form the limits of the possibilities for electronic composition and are particularly useful for indeterminate approaches to highly structured improvisation in electronic composition and performance.

Introduction

Typical of the history of electronic music, the use of digital networks in electronic and electroacoustic music composition and performance has a history that closely tracks the development of the digital network technologies it utilizes. Electronic ensembles such as The League of Automatic Music Composers for example began exploring the performative improvisation possibilities of network technologies in 1977 utilizing two or more KIM-1 microcomputers connected via their 8-bit parallel data ports (Bischoff, Gold and Horton, 1978 and Bischoff and Brown, 2002). With the gradual development of mainstream access to Ethernet Local Area Networks through the 1980's and then TCP/IP and the Open Sound Control (OSC) communications protocols followed by the mainstream Internet in the 1990's came more efficient and sophisticated audio compression and data communication technologies - from low bandwidth MP3 audio and MIDI data streaming over IP networks to interactive real-time synthesis and data control via Max/MSP to web based composition and performance as well as the use of interactive graphical and notated scoring.

Electronic musicians pioneered the compositional strategies appropriate to the emerging electronic technologies utilizing both audio streams and data controllers across a multiplying number of software platforms including web based interactive music (Young, 2001). Collectives such as Faust Music On Line (Jorda, 1999), Timesup in Austria (Timesup, 2001), the Brain Opera (Paradiso, 1999) and Cathedral websites (De Ritis, 1999) to name just a few, further expanded the possibilities available to networked music composition and performance from the late 90's into the 21st Century.

While still arguably in its nascent stages network music has undergone a steady development alongside the evolution of the digital communication technologies that support it. The network technology itself both constrains and opens up the compositional and performative strategies available and problematizes the spatiotemporal relations between the audience, the performers, their performance space(s) and collaborative composition processes.

The last decade has seen a steady proliferation of networked musical possibilities including the use of Java Music Specification Language for live, interactive scoring (Hajdu and Didkovsky, 2009); the Princeton Laptop Orchestra (PLOrk) connecting large laptop computer ensembles over a wireless network (Trueman, 2007); mLan over Firewire networks (Garth, 2004); the web-based collaborative virtual environment of the Public Sound Objects project (Barbosa, 2005); the Transnational Ecologies (Rogalsky and Cameron, 2007) Internet streaming performances; and the Auracle voice controlled Internet synthesizer (Freeman, Varnik, Ramakrishnan, Neuhaus, Burk, and Birchfield, 2005). This is by no means an exhaustive list yet it illustrates the expanding musical potential opened up by maturing hardware and software network technologies. This maturing potential can only increase as computer processing power increases and as we transition towards the mainstream adoption of Internet2 and the musical possibilities it opens up (Helmuth, 2005) coupled with the ongoing construction of the fibre optic National Broadband Network here in Australia.

While this expanding multiplicity of musically networked possibilities might seem daunting they can be broadly categorised into three main uses: audio, control data and scoring. Thus the three WAAPA Composition and Music Technology strategies outlined in this paper involve an Internet audio streaming ensemble; a Laptop ensemble using graphical scoring over LAN; and a LAN enabled distributed computing project for performance using data controllers over UDP.

Internet music performance

Peer to peer audio networking utilizing live audio broadcasting and streaming servers of various and quite often incompatible formats (such as Real Networks, Quicktime Streaming Server MP3 and MPEG 4, and Windows based Shoutcast MP3) is perhaps the most common form of Internet music performance. WAAPA Music Technology currently runs a student network ensemble with annual performances in association with Griffith University in Brisbane (2009) and RMIT in Melbourne (2010). Future performance collaborations are under discussion with several Australian and international universities as well as with the Australian university high bandwidth Internet backbone AARNET.

The basic technological framework for the streaming performances involves setting up a continuous streaming audio loop between the various IP nodes. For each physical performance group this involves receiving audio from one IP stream, using this as an audio input into the mixing environment alongside the group's other audio channels, and then broadcasting the remix on to the next IP node in the loop. Each physical performance group thus has two virtual groups it directly interacts with plus as many others as there are nodes in the loop (see Figure 1).

Depending on bandwidth constraints, the geographical locations of the nodes and the number of Internet server hops between each peer, the latency or lag times between sending audio and then hearing its remix return can be upwards of several seconds around Australia (Perth to Brisbane being 7200km as the crow flies) to several minutes for around the world loops. While there are various other possibilities for linking IP nodes in performance, such as receiving several streams at once to form a more traditional physical/virtual ensemble of individual voices, the use of a loop maximizes the available bandwidth (receive and send one high quality audio stream as opposed to several lower quality streams depending on bandwidth constraints) and yet also allows all the participating nodes a voice in the networked performance.

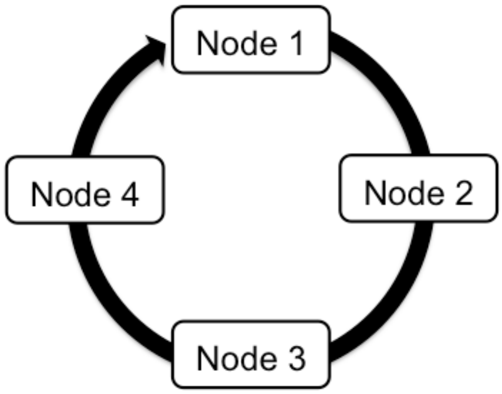

Figure 1: Looped streaming audio signal path through multiple IP nodes.

Keeping the IP path as simple as possible also helps in a teaching and learning environment when introducing students to the complexities of network music composition and performance. Even so, those complexities can still be daunting and involve understanding the difference between LAN IP's, shared Internet IP's, firewalls and actual external IP's, blocked and open ports, port forwarding, encoding/decoding formats and their client applications and streaming servers and so on.

Internet composition constraints

Beyond the above technical complexities there is also the consideration as to how the network affects electronic composition and performance. The musical form of real-time Internet streaming audio improvisation is constrained by the inherent fragility of long distance multi-node Internet streams and the necessity of also using text based communications to set up and maintain the loop. One performer is needed to keep in text based chat contact with the other IP nodes in order to ensure that if/when a node drops out the loop can be repatched on the fly with all the requisite IP addresses and ports assigned to keep the music flowing. This fragility has a definite impact on how the electronic composition is structured as well as how the performance proceeds.

Indeterminacy has historically been a prerequisite composition concern where multiple broadcast and receive formats are in use across varying Internet lag times. Synchronized performance and the development of a predetermined theme are difficult under these conditions where latencies above 30ms are generally perceptible. However, various networks such as eJamming (http://www.ejamming.com) have been developed to introduce network latencies based on tempo calculations to mitigate this problem for rhythmically based compositions while Wide Area Networks (WAN) can also provide low latency for synchronised performance (Kurtisi, Gu and Wolf, 2006).

With a loop based performance however, varying latencies and the constant remixing of audio inputs and outputs are a positive aspect of the electronic composition. Under these conditions the theme develops organically so to speak and performative attention must be open to the constant change and repetition as elements of one's own audio output come back around in the ongoing remix. This forward looking attention is an element of all improvisation (Bailey, 1993) but emphasized here by the technology itself. In this context the network environment requires a concentrated focus on the sounds themselves as they occur and constantly fade away, an attentional listening process that Feldman (2005) termed the "departing landscape". Here also the technological setup demands an experimental approach in the sense Cage intended where an experimental composition defines a performative action the "outcome of which is not foreseen" (Cage, 1961).

Synchronised laptop ensembles

The use of either wireless or Gigabit Ethernet to synchronize laptop computer ensembles over a LAN offers much higher bandwidth possibilities, very stable connections and minimal network lag as compared to the Internet. The basic network setup makes use of private range IP addresses and subnets, as well as private user/password file sharing and even private website connectivity when using the inbuilt Mac OSX Apache web server on Apple laptops. These basic network services allow for a high degree of connectivity and collaboration between performers and composers working in the digital realm.

The WAAPA student laptop ensemble under consideration here was tasked to re-interpret Stockhausen's 1953 studio tape music work Studie II for performance. The original graphic score uses 193 sine wave frequency sets of 5 tones per set with a frequency scale of 81 steps starting from 100hz at an interval ratio of $\sqrt[25]{5}$. The Studie II tutorial patch included in Max/MSP (stockhausen-studie-II.pat by Georg Hajdu) was reverse engineered to provide the frequency set data for a manually triggered digital sine wave generator, and the original 26 page graphic score was scanned and cropped to produce a continuous scrolling score (see Figure 2).

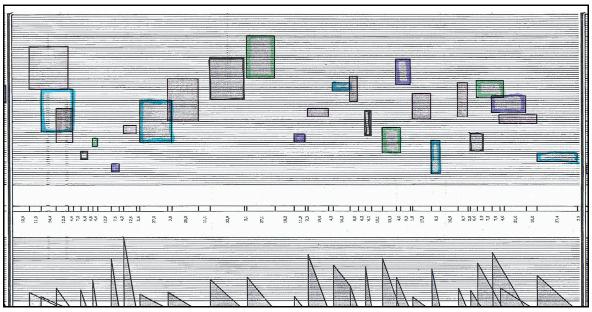

Figure 2: Scan of Stockhausen Studie II score page 13 of 26 (Stockhausen, 1956) used in Max/MSP synchronized ensemble score. Top is frequency data, middle is timeline defined by tape length at 76.2 cm/sec and bottom is amplitude data.

The sine wave generator and graphic score were combined into one Max patch with five performers assigned to trigger discreet frequency sets and manipulate the associated amplitude envelopes via MIDI keyboards. A master controller patch used a Max/MSP udpsend object to synchronize the slaved patches via a metronome object that controlled the variable speed scrolling scores. Stockhausen's original minutely scored 26 page tape composition runs for 3 min 30 sec whereas the performance Max patch using variable speed scrolling allowed for a graduated rehearsal schedule paced to human rather than machine responses.

Distributed computing networks

Distributing control data streams across multiple computers over a LAN can give an electronic composer access to high powered digital processing without the need for expensive high end computer hardware. As opposed to synchronised laptop ensembles however, the distributed computing network under consideration here is being used to coordinate an ensemble of computers with only one performer for a graduation recital. Using Max/MSP the electronic composition was created specifically for controlling unmanned laptops during performance with UDP data packets sent via a master computer to control processing parameters on the slaved laptops in real-time. The slaves are completely independent of each other in terms of processing and can send a single data stream back to the master computer without consuming excessive CPU and RAM resources.

Using multiple computers an electronic performer can produce sounds that would not be possible without extensive pre-processing and in turn can treat each of the laptops as individual instruments. The complexity of the electronic composition in this instance is primarily limited by bandwidth constraints when using a wireless LAN or the number of ports on an Ethernet switch as well as the availability of slave computers. For the recital performance four laptop computers were slaved to the master via a Gigabit Ethernet switch with each slave laptop outputting two channel audio to a stereo speaker pair placed within the space producing an eight channel spatial music work. A sound mass is gradually developed as the networked slaves coordinated from the master create as many playback buffers and their associated synthesis and DSP processes as their combined CPU and RAM resources allow - without the usual processing constraints involved in multichannel spatial works utilizing only one computer. Each slave also sends monitoring information back to the master Max patch allowing for dynamic load balancing as well as interactive parameter control across the slaved patches.

The use of networked control data across multiple computers in this instance has allowed for expanded complexity in the electronic composition and a more dynamic and responsive solo performance environment for producing a complex multichannel spatially arranged soundscape. The modular approach also offers a very flexible and open ended method for developing the electronic composition and performance possibilities in this work.

Musical networks and electronic music

Given the considerably higher bandwidth and lower latency available on LAN as opposed to the Internet there are considerable differences between the use of Internet and Ethernet or wireless networks for the composition and performance of electronic and electroacoustic music. Generally speaking the indeterminacy of Internet latency has an impact on real-time performance that favours more experimental approaches to performance. Likewise, bandwidth constraints can limit the amount and complexity of control data as well as the use of multichannel audio streams in composition. The development of mainstream access to low latency, high bandwidth networks such as the Internet2 and the ABN promises to expand the functionality of live virtual performance and close the gap with LAN based musical networks. Much work has already been done towards this over the last decade on university Internet2 enabled campuses such as the Princeton University GIGAPOPR project (Kapur, Wang, Davidson and Cook, 2005) as well as the development of musically focused teleconferencing systems for the 'Global Conservatory' program at the Manhattan School of Music in New York (MSM, n.d.). While these high bandwidth possibilities will open up the potential for increasingly sophisticated interactive real-time music networks over the Internet the inherently ad hoc nature of this global network will most probably always call for a flexible approach to music composition. As the Japanese experimental musician Atau Tanaka stated, "Latency is the acoustics of the Internet" (Tanaka, 2000).

Given the increasingly prolific and divergent history of this 30 year old musical paradigm the future potential for the further development of teaching and learning strategies in networked music composition and performance would seem to be limited only by the availability and constraints of the constantly evolving technology. Some possibilities under research at WAAPA Composition and Music Technology include the use of waveform data from sinusoidal analysis of acoustic instruments to control any parameter in multiple networked instances of Max/MSP; the virtual mixing of full bandwidth audio streams over Gigabit Ethernet for further processing including spectral analysis for spatialization; and web based control of Max/MSP in live performance. The possibilities in fact would seem to be an open road back to the future of the League of Automatic Music Composers.

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