DYNAMIC CUES FOR NETWORK MUSIC INTERACTIONS

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ABSTRACT

This paper provides an overview of a cueing system, the Master Cue Generator (MCG) used to trigger performers (humans or computers) over an IP-based network. The performers are scattered in several locations and receive cues to help them interact musically over the network. The paper proposes a classification of cues that dynamically evolve and reshape as the performance takes place. This begets the exploration of various issues such as how to represent and port a hierarchy of control over a networked music performance (NMP) and also takes into account parameters inherent to a network such as latency and distance. This approach is based on several years of practice-led research in the field of NMP, a discipline that is gaining grounds within the music technology community both as a practice and through the development of tools and strategies for interacting over disparate locations.

1. INTRODUCTION

Performing in real time over high-speed networks is a now well-accepted paradigm and has become an integral part of Telematic Art, considered by authors such as Roy Ascott, *"as an artistic medium in itself"* [1]. There have been several attempts to achieve interactive telematic performances. However the first telematic concert, using high-speed research networks with no audio compression and thus allowing CD like audio quality took place between two spaces at Stanford University in 2000, with an ensemble split and performing about one kilometer apart [3]. This initial test was led by the Sound Waves over the Internet from Real-time Echoes (SoundWIRE) project founded in 1998 at Stanford University [3]. SoundWIRE, through various experiments and studies such as the "clapping experiment" [4], which measured a threshold in milliseconds for ensemble accuracy, set the grounds for further development in the field of networked music performance (NMP). The discipline of NMP branched out in many directions, and due to its nature, which involves being distributed, led to the involvement of several new participants. The work of SoundWIRE, however, demonstrated that it was possible to interact musically over a long distance despite the inherent latency of the network. The excitement of being able to play apart led to the challenge of choosing whether music performed over a network could be simply improvised or formally structured through the help of network-centric cueing mechanisms.

2. IMPROVISATION

The network provides a platform for sharing synchronization information and cues as it allows several performers to share a common infrastructure for exchanging common musical structures. Performing over the network introduces the principle of dislocation of performers as they are not in the same space but are playing in real time together whilst being located in several spaces. Free improvisation has been a practice often employed in NMP due to its emphasis on musician-to-musician interaction and flexibility of materials; thus providing a good basis for developing musical strategies for interacting over a network regardless of its latency. Free improvisation as outlined by Derek Bailey, *"pre-dates any other music – mankind's first musical performance could not have been anything other than a free improvisation*" [2]. It is therefore not surprising that new media environments, such as NMPs, resort to basic sorts of musical forms, which do not involve a formal structure. NMP is such a recent practice that most performances will start from an empty shell, where the infrastructure will first be put into place followed by numerous tests to make sure that the communication works and finalised by a short rehearsal. The fact that the IP – based network is the medium that interconnects them will play a crucial role in the development of those social interactions through space and time. In this context, and based on several years of research in the field through large scale NMPs such as the Disparate Bodies series [7] as well as the experimentations of the Net. Vs. Net Collective [8], the development of coherent network centric cueing strategies was needed.

It is due to the fact that, very quickly the improvized performance requires some sort of formalization so that performers can be cued over the network, leading to the inclusion of a basic structure within the improvisation. In this context and as a result of the practice in the field, a formal classification of networked cues and how they can be used to interact musically over the network made sense.

3. CUES

3.1 Rationale

In order to provide an easy way to represent various cue information over the network, an integrated cueing system called the Master Cue Generator (MCG) was developed. The MCG aims to provide a rough standard to distribute cues over the network. The MCG has been used and tested in several NMPs such as the Disparate Bodies series [7] and with the Net. Vs. Net Collective [8]. The system is continuously being developed further with the goal to achieve a common cueing structured language for networked music improvisation.

The MCG was built with Max/Msp [6] and is able to send cues to a multitude of locations as standard OpenSoundControl (OSC) [9] messages, meaning that any OSC compliant application is able to receive the cues and converse back to the MCG should a direct feedback be necessary. The MCG was initially designed to function based on a client/server architecture. However, it was later discovered that modifications of the network configuration should be possible based on the changing attribution of roles, defined as who plays the role of the MCG in the network. This complex and challenging aspect is currently being developed.

Currently, the MCG broadcasts important musical information by providing a basic structure to the nodes playing over the network, such as which section of the piece the nodes are in, as well as warning messages that the piece is about to switch to another section. The types of cues and their specific nature can be customized depending on the artistic approach given to the piece.

Figure 1. The MCG engine

3.2 Types of Cues

There are three types of cues that have been so far identified as part of the classification: temporal behavioural and notational. All the cues below have been developed based on the practice in the field and the classification is constantly being updated as the practice progresses.

3.2.1 Temporal Cues

Temporal cues are sent out as information from the server to the nodes and are related to timing. Examples include the length of a cue, a warning that the cue is about to finish, or how much time a given node is in control of the improvisation until the given node delegates its control to another node and thus conceptually modifying the topology of the network. They are the most important types of cues, in order to keep the ensemble together and, thereby, can be synchronized with various audio triggering cues, which are indicators that the structured improvisation is about to change from one section to another.

3.2.2 Behavioral Cues

Behavioral cues are cues that are sent with a certain scenario attached to them. This can, for example, include the triggering of a waveform, or the suggestion that a given node needs to play certain nodes only above the note C4. Behavioural cues can also trigger physical elements in a remote space such as the ringing of a distant bell or the triggering of an analogue synthesizer. Behavioural cues are more complex types of cues. They allow the broadcast of messages that will have an influence on the actual audio content of the piece being performed over the network. Behavioural cues are often part of the process of a structured network improvisation. An example is the triggering of pre-recorded waveforms that reside on remote computers.

The waveforms are being played back remotely but triggered by the MCG. Behavioural cues also have the potential to influence the actual frequency content of each remote node by broadcasting messages that will interpolate or cut-off. The MCG, in this case, provides the intelligence behind the system by ensuring that each node has a different frequency bandwidth. The frequency dependent interconnections that are being created in this case, also allow for a morphing of frequency range distributions across the nodes. For example, a node can decide to borrow a frequency range from another node, in which case the frequency distribution is swapped between nodes. Amplitude control is also an important type of behavioral cue. As part of the pre-defined structured improvisation, a distribution of amplitudes across the nodes can be implemented in advance.

It allows the distribution of intensities across the network and is a very democratically aware way of ensuring that each node can be properly identified during a performance. For example, in the case of a performance between three nodes, the MCG will make sure that in Section 1 of a piece, Node 1 is the loudest, while Node 2 is the quietest and Node 3 is at mid-level. As a result, reasonably complex interdependencies can be achieved by swapping loudness information between nodes as well as interpolating them. They are, of course, many other interaction cues that can be created and their types and resulting actions wholly depend on desired objectives in the design of the performance.

3.2.3 Notational Cues

Notational cues are able to display content that can be identified by the performers as being helpful in the good running of the performance. This can include the visualisation of the waveforms from each site, the display of the cue number, a countdown or dynamic shapes that can be activated by various factors in the performance. Transmitting concrete or abstract notation based information is a real challenge over a network due to the latency and of the different distances between the MCG and the nodes. Even though the MCG is capable of re-triggering events so that a cue information arrives simultaneously at all nodes, which is a punctual or periodical type of information, the triggering mechanism does not work well for continuous information and, thereby, a drift is likely to occur over a period of time. Therefore, notational cues have traditionally been sent over the network in a punctual fashion, where the graphical representation is analogous to a slide show. If some events are of continuous nature, they tend to be transferred to remote nodes before the performance and triggered remotely. In order to efficiently represent the cues and the synchronicity information, a set of visualisation tools has been developed to simply, but efficiently, display score information on various sites.

3.2.4 Active/Passive Cues

The three types of cues identified above can have two distinct modes of operations:

Passive: the cues are only sent as a suggestion to the nodes. Each node can decide whether or not to follow the guidelines suggested by the MCG. One particular example includes a suggestion that one node should decrease its general amplitude while another node should stay steady or a flashing warning indicating that the improvisation is about to switch to another section. Passive cues are generally rendered graphically as part of the score of the structured improvisation so that performers can take the suggestions (or obligations) into account while performing in remote sites.

Active: the cues are actively triggering/processing a concrete element on a distant node. This includes, amongst others, the opening of a filter or the interpolation of its center frequency, the reduction or augmentation of the amplitude of a distant node or the activation of a remote oscillator. Another aspect of active cueing that is currently being explored is not only the triggering of events from the MCG, but also the triggering of events from node to node. This possibility adds to the complexity of distributed cues and permits the building of complex patterns and interdependencies that use the network to create them.

A cue can be both passive and active simultaneously. One example would be the triggering of a sample along with the visual indication that a sample is about to be triggered. This introduces both an automated musical event (the sample) and an indication to a human performer that an event is about to occur, hence, suggesting a reaction of some sort.

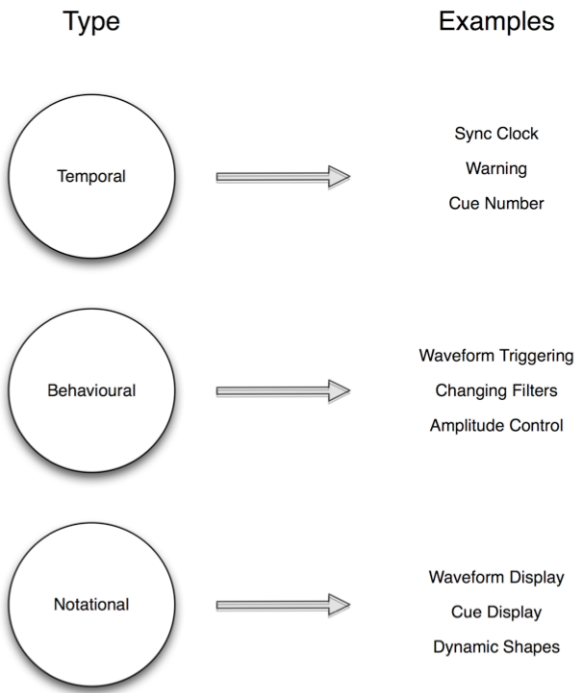

Figure 2. Cue types and corresponding examples

4. CHANGING TOPOLOGIES

The MCG should not be location centric by always being located in the same physical space, but should be able to take over a specific node at a given time. This leads to a far greater flexibility of the network topology as the MCG can virtually travel between nodes and position itself at any point on the network.

The option to change topologies means that, an NMP can start as a basic star network topology with one node being at the center of the network. In this case, the chosen node is not only at the center of the network but also takes the role of a leader in the performance. At any time the controlling node can transfer its powers to another node on the network. The move can happen when switching from a cue to another in the piece or it can be randomly attributed based on the distribution of roles and voting by other participants or the audience. Many permutations are possible, which lead ultimately to a change in the network topology. For example, in the case of a network with four nodes, called A, B, C and D respectively, if node C takes the lead, all the commands from the MCG will be issued by node C until the next change in topology. This series of permutations, as a network improvisation takes place, is analogous to the modus operandi of a musical improvisation that would happen on a real stage in terms of delegating control to a performer over others. This approach adds various levels of interplays between dislocated performers and leads to the creation of music that uses the network architecture as the core and to a certain extent as the score.

The concept of changing topologies outlined above allows the creation of complex interdependencies over the network (local or wide-area) and can easily implement some of the earlier network topology principles for musical collaboration such as the ones illustrated by Weinberg [11]. The MCG to node relationships allows the implementation of a, *"Process Centered Musical Network"* [12]. The flexibility brought by the MCG in terms of network topology for the improvisation of musical content brings an additional layer of structure that is not necessarily musical, per se, but allows an allocation of performative roles despite the distance and the absence of physical contacts between the performers. This concept also ties up well with Weinberg's principles especially when the notion of Goal Oriented Interaction is mentioned [12].

The latter introduces two separate principles of interactions: Collaboration and Competition. The MCG along with structured improvisation allows the ensemble to morph between the notion of collaboration and the notion of competition, in musical terms, which creates diametrically opposed musical forms that are created by the changes in network topology.

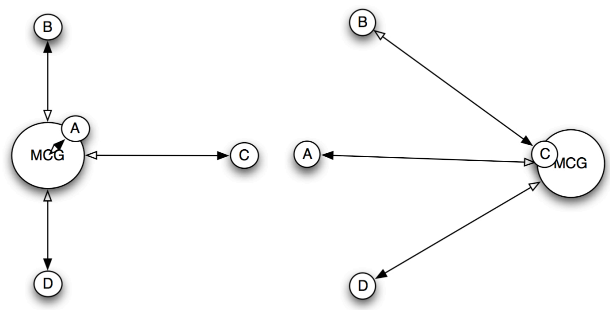

Figure 3. Changing relationship between nodes and MCG

5. THE ISSUE OF LATENCY

Latency is a pretty common term in the field of computer music and is defined as, *"the delay between the stimulus and the response"* [13]. In a more musical fashion and when parallelised with the speed of sound in air, latency can be defined as, *"the speed of sound through computer algorithms"* [10]. In the context of NMP, latency is often considered as a musical feature in its own right and, *"can be used as a specific compositional tool"* [13]. It needs to be highlighted that regardless of the quality and bandwidth of the networks used for NMPs the distance between two nodes will introduce a certain amount of latency. Even data traveling over fiber optic networks will be subject to a certain latency, not only because it cannot travel faster than the speed of light but also because that data will go through several switches and hubs along the way, introducing conversions and thus slowing down its delivery to destination. The MCG includes two approaches to latency, which are defined as synchronous interactions and asynchronous interactions.

5.1 Synchronous interactions

In this case the relationship between the MCG and the nodes is calculated in terms of time lag. For example, if the relationship from the MCG to node A is 100 milliseconds and the relationship from the MCG to node B is 75 milliseconds, an additional 25 milliseconds will be added to the relationship between the MCG and node B so that cues arrive at exactly the same time at node A and C. Since the networks used in this case are very stable, the timing is very likely to stay firm through the piece.

5.2 Asynchronous interactions

In this case, the MCG ignores the latency values between the MCG and the nodes and deals with the network as it is, leading to the generation of rhythmical patterns created by the network itself.

6. CONCLUSION AND FUTURE WORK

As illustrated through this paper, the MCG is the outcome of several years of practice in the field of NMP to answer the growing needs for distributed cueing structures. This ever-evolving exercise is an attempt to formalize some sort of convention in the practice of NMP and will be developed further as the practice progresses over time.

In the short to medium term, the goals regarding the development of the MCG and associated cueing strategies are:

- To develop a proper cross-platform application so that the system can be embraced by a wider community
- To offer a web platform on which a set of standard messages fitting in the cues classification outlined in this paper can be implemented and formalized by the NMP community
- To advertise in a more formal manner, mostly through online channels, applica-

tions and event in which the MCG is being used and can be further developed.

- To make the MCG freely available online to the NMP community.

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