Álvaro Barbosa (researcher), Music Technology Group, Universitat Pompeu Fabra, Passeig de Circumval·lació 8, 08003 Barcelona, España. E-mail: <abarbosa@iua.upf.es>

Displaced SoundScapes: A Survey of Network Systems for Music and Sonic Art Creation

Abstract

The ubiquitous nature of communication in computer networks, firmly manifested in the Internet era, provided a context for the introduction of different collaborative tools widely accepted by the on-line community, such as textual chats, white boards, shared editors, video conference systems, shared spaces for the exchange of multimedia documents or even simple e-mail based collaborative systems.

On the other hand, for the last decades artists have used cutting edge computer technology to maximize the aesthetics and conceptual value of their work, either by enhancing the way they traditionally create, or by using technology as a medium itself for art expression. The idea of using computer networks as an element in collective artistic creation is no exception, since it provides particularly engaging possibilities to achieve stylistic and conceptual originality.

Network Systems for Music and Sonic Art Creation emerged in the last few years, allowing geographically *displaced* creators to collaboratively generate shared *SoundScapes*. In this article the author presents a discussion about different system designs, ideas and concepts approaching this new interaction paradigm.

1. Introduction

Traditionally collaboration has always been a key element in music, therefore, the advent of collaborative systems based on computer networks to achieve musical results is a natural development which dates back to the late 1970's in California with early experimental performances by the League of Automatic Music Composers [1].

Up until the early 90's systems that approached music collaboration using computers were based on local networks. However, in the last decade, massive worldwide growth of the Internet network brought more appealing possibilities for music composers, performers and audiences.

On the other hand, it is well known that networks latency is a major drawback for real-time music collaboration over global networks.

It can be demonstrated that at a globe level there are physical limitations in current network technology, which will always introduce higher latency than the minimum acceptable values for real-time acoustic collaboration.

For the Human ear to perceive two simultaneous sounds, they should not be displaced in time over 20ms [2], which means that for mutual awareness to be supported in a bilateral performance this threshold would be around 40ms (the time period that it would take one performer to perceive the other performers reaction to his action).

It should be noticed that the perception of two different sounds performed simultaneously is strongly dependent from sound characteristics (timbre, pitch or loudness), music style and other feedback types, such as visual or physical stimuli. Nevertheless, a 20 ms threshold is reasonably high enough to characterize a worst-case scenario.

If we consider the smallest possible peer-to-peer connection length between two opposite points on the planet, we have an approximate distance of 20.004,5 Km (half the distance of earth's perimeter – 40.009 Km). Even with data transfer at the speed of light (approximately 300.000 Km/s) and unlimited bandwidth, bi-directional latency would be approximately 133,4 ms, which is much higher then the minimum tolerable threshold.

In such a scenario, it is not surprising that recent research has been conducted based on the idea of accepting net delay, as a natural element when creating music over the internet.

The thought that net delay is the particular acoustics of Internet and that composers should create music embracing this fact is clearly expressed in Golo Föllmer's essay "*Soft Music*" [3] by the experimental artist Atau Tanaka pointing out his personal view on this topic (excerpt from a video interview) "*I find Internet time delay rather interesting and I think of it as a kind of unique acoustic of this media (…) rather than to play existing music on this new time basis, what is interesting to me is trying to find a musical language that works on this time axis (…)*".

This idea has also motivated the SoundWIRE group, at the Center for Research in Music and Acoustics (CCRMA) at Stanford University, to conduct very significant research work over the last few years, addressing the influence of network conditions in acoustic communication [4] [5].

Latency has a highly variable and unpredictable nature creating time base errors, de-sequencing and even partial loss of the content, resulting in a severe condition for performance control. Therefore, a major effort is being done by the scientific community in order to diminish this condition, by increasing bandwidth, compressing data, and also by using content based transmission techniques.

Nevertheless, if instead of a globe wide network of communication is considered Large Area Networks or even Wide Area Networks in geographically constrained territories (a country or even a continent), it can be expected that in the near future network latency is likely to be reduced to values that will not represent an impediment for real-time acoustic communication over the internet.

Network Latency tends to be the central issue when discussing the topic of network based music creation, yet, other important issues can be addressed, such who will be performing in these systems or if the notion of a time limited musical event/performance is always applicable.

2. Redefining the Acoustic Community

Designing and implementing Network Music System aims to address the hypothesis that new meaningful sonic results can be achieved by collaboration over computer networks. When first addressing this question one should start by observing the target audience of such a system.

In 1984 Barry Truax introduces the concept of *Acoustic Community* at the book "Acoustic Communication" (pages 57 and 58) [6]:

"*(…) The 'Acoustic Community' may be defined as any soundscape in which acoustic information plays a pervasive role in the lives of the inhabitants (…). Therefore the boundary of the community is arbitrary and may be as small as a room of people, a home or a building, or as large as an urban community, a broadcast area or any other system of electroacoustic communication.*"

Truax's concept of acoustic community can be seen in the context of an on-line community. The notion of a soundscape familiar to all these users is inevitably tied to sonic events transmitted and produced with computers, suggesting that computer generated electronic music could be an engaging format to be addressed, instead of more traditional musical format.

However, past traditional musical culture is somehow strict in what is recognizable as a music event and one of the major questions regarding collective music creation by indiscriminate Internet users is if this community is prepared to express meaningful musical results.

On the other hand, the fact that internet technology provides permanent public access to musical creation and listening paradigms, raises even more questions regarding traditional aspects of a musical piece such as its duration. The idea of an ongoing music piece, which is not constrained by a time limited event seams to be a natural form for some of the emerging systems discussed further down in this article.

3. The time dimensions of a permanent event

In the book *Microsounds* [7] published in 2001 by the MIT Press, Curtis Roads introduces a taxonomy of timescales from a music theory perspective. In this proposal, music timescales are decreasingly the *Infinite* timescale, the *Supra* timescale, the *Macro* timescale, the *Meso* timescale, the *Sound Object* timescale, the *Micro* timescale, the *Sample* timescale, the *Subsample* timescale and the *Infinitesimal* timescale.

Most musical creations driven by an event are in the *Macro* timescale defined by Roads as "*The time scale of overall music architecture or form, measured in minutes or hours, or in extreme cases, days"*. However, one could wonder where an ongoing musical piece, permanently available for hybrid communities of creators and listeners belong.

Realistically it should fit in the *Supra* timescale, defined as "*A timescale beyond that of an individual composition and extending into months, years, decades, and centuries"*, since the *Infinite* timescale is an abstraction and it is beyond the time life of the present cultural and technological state of development.

Some recent Artistic proposals approached unlimited musical events. In 2000 Antoine Schmitt created the Infinite CD for Unlimited Music [8]. Once inserted in a computer, this CD generates music infinitely, always different and always similar, without any images or any form of interaction.

Another approach to this idea is to explore Internet technology and user interaction. In 2003 Chris Brown's presented the Eternal Network Music project [9], where a flexible music piece created on-line supporting up to four players at a time, changing the harmony and motion of 8 modulated sine-wave oscillators and producing a richly vibrating drone that goes on permanently.

4. Network Systems for Music and Sonic Arts

Given the subset of the music universe constrained to music based in computer networks, it is useful to consider the definition of music by Guy E. Garnett in the Article "*The Aesthetics of Interactive Computer Music*" [10]:

"*The nature of music, particularly in the century of John Cage, multiculturalism, and other varieties of aesthetic choice, become more problematic. Nonetheless, I think it is possible to reduce the problem somewhat. Just as I have considered aesthetics in only its broadest manifestations, similarly, music can be roughly considered to be sounds made with aesthetical intent, or even sound listened to with aesthetic interest. The former gives*

more weight to the role of the creator, while the latter formulation tends to privilege the listener."

In this sense we can consider the sonic outcome of a collective internet creation as a musical event, since users commit themselves to collaboratively create a sound piece with aesthetic intent and simultaneously are an audience interpreting the results with aesthetical interest.

In order to better define the subset of the music universe in which this approach for sonic creation is situated, the term *Sonic Art* as emerged in the Artistic community since the 60's. Historically, *Sonic Art* derives from the academic tradition of electroacoustic music, since until quite recently, advanced electronics and computer technology for audio has only been available to members of institutions such as universities and radio stations.

This tradition dates back to the 1950's and 60's, when the electroacoustic music discipline emerged in colleges and university music departments, based on the work of composers like Pierre Schaeffer and Karlheinz Stockhausen. Even though there is no comprehensive definition of *Sonic Art*, with the advent of computer technologies to the ordinary music creator in the 80`s, and with computer communication over the internet in the 90's, this field became the playground for diversified artistic proposals and experiments for music creation with electronic and digital technology.

Even though the term Sonic Arts applies to very broad spectrum of scenarios in whish acoustic phenomena are manipulated in different ways, the scope of this study is constrained to computer network systems, following up with a systematic overview on the topic, covering many representative projects.

4.1. Early Experiments with Music and Computer Networks

In the late 1970's the commercialization of personal computers in the United States, allowing fine tune network topologies, enabled the first groups of experimental musicians to create musical networks with computer technology at a local area scale.

The first events using computer networks for collaborative music creation were performed by the Oakland California group "*The League of Automatic Music Composers*" [1]. The "*League*" came together through the mutual interest of Jim Horton, John Bishoff and Rich Gold, naming their new genre of musical performance "*Network Computer Music*".

In 1985 *The Network Muse*, a Network music festival was held in San Francisco, featuring a collective of electronic musicians including John Bischoff, Tim Perkis, Chris Brown, Mark Trayle, Scot Gresham-Lancaster, Larry Polansky, Phil Stone and Phil Burk. From the context created around the activity of these composers, "*The League*" evolved into a subsequent group in 1987, "*The Hub*"[11], which employed more accurate communication schemes by using the MIDI protocol.

4.2. Local Musical Networks

In 2002 Gil Weinberg introduced the concept of Interconnected Musical Networks (IMNs), expressing it with an example from a performance at the MIT Media-lab in the spring of 1998 [12]:

"*(…) two musicians were playing a newly developed multiplayer squeezable instrument. While controlling the pitch curve of his own part, one of the players was also continuously manipulating the other player's timbre. This manipulation led the second player to modify her play gestures in response to the new timbre she received from her peer (…) an*

immersive and interdependent network of subtle mutual influences emerged, leading the two performers to a unique playing experience, where unpredictability, dynamism, self-evolving musical behaviours, and interdependent collaboration are at the core (...)"

The concept of a Musical Instrument designed to be played by more than one person simultaneously is not new, but there are very few examples in the history of western music, such as the piano, whish can be played by four hands.

With local high-speed computer networks and sensor technology, a new universe of possibilities has been unveiled in this field, providing a context for new experiments like the *Jam-O-World* Multi-player Musical Controller [13] and other *Multi-user Instrument* described in [3].

However, It is not always obvious if an instrument is in fact designed to be played by several performers simultaneously, or if it is able to evoke several instances of itself allowing different users to play together. Furthermore, the idea of a Multi-user Instrument is not necessarily bound together with the performance interdependency described by Weinberg.

Especially in IMNs, in order to achieve interdependency between performances with virtuosic results, real-time is a critical requirement and therefore this approach is mostly constrained to local networks.

4.3. Composition Support Systems

Composing music by two or more authors is a process that can be performed in different ways. Traditionally a composer conceives the music individually and registers his ideas with a symbolic musical notation score. In order to cooperate with other composers in a co-authored piece, it is necessary to exchange the ideas amongst contributors by a bilateral analysis of everyone's score.

The first systems based on the idea of using internet communication to enhance traditional joint music composition, goes back to the early 1990's with the Craig R. Latta's *NetJam* [14]. This system allowed a community of users to collaborate producing music in an asynchronous way by exchanging MIDI files through e-mail.

In recent years with the advent of recording and non-liner editing technologies a new form of composing music emerged. The idea of using a Recording Studio as a composition tool became increasingly successful especially in Popular Music. In a recording studio it is possible for one or more musicians to record their instrumental performances (synchronous or asynchronously), resulting in raw material registered acoustically that can be manipulated to a very large extent in order to create a complete musical piece.

Due to its simplicity of use, this method is highly suitable for less trained musicians and composers since it reduces the temporal gap between having an idea and achieving a result, and therefore provides the possibility to react, transform and improvise more efficiently and faster.

For the majority of internet users interested in creating music this process is inevitably more engaging and therefore a new class of internet applications for music creation emerged aiming to materialize the idea of an *on-line Recording Studio*.

This concept has been approached in the form of distributed systems coupled with centralized server instances, which manage multiple session and groups of users.

In these systems the interface layer resembles typical non-linear editing multi-track software, and allows the users to lay down tracks of MIDI and digital audio, either in an asynchronous or synchronous non-real-time mode, collaborating with other users from the same session.

Well-known applications in this area are the *ResRocket Surfer* [15] and the *Tonos* system [16], which also received reasonable support from music industry manufacturers.

A different approach is using Internet to reach a broad spectrum of users and publishing specific software tools, which either are dependent on special purpose hardware, or are proprietary experimental systems from companies or research groups.

In 1995 with the support from Sun Microsystems the Institut de Recherche et Coordination Acoustique (IRCAM) started a project of an on-line studio [17], based on client/server Web technology. The main purpose of this project was to provide access to some of IRCAM's sound databases and sophisticated sound-processing tools like the phase vocoder SVP. This project has more recently developed to the On-Line Sound Palette under the CUIDADO project framework [18].

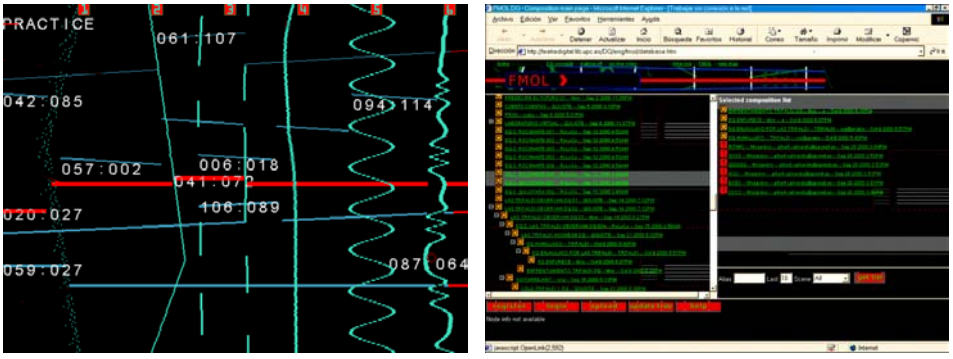
A similar project was started in 1997 by Ramon Loureiro [19] at the Audiovisual Institute from the Pompeu Fabra University in Barcelona, Spain. With this system it was possible to have a web front end to Xavier Serra's Spectral Modelling Synthesis (SMS) [20] technique.

4.4. Collective Creation Systems

Music composition can be approached trough a community perspective, since over the Internet it is possible to create systems available to large communities of anonymous users.

In 1997 the Catalan theatre company *'La Fura dels Baus*' commissioned the development of an On-line collective music creation system to the experimental artist Sergi Jordà. The system would allow the participation of Internet users in the creation of music pieces that would later be included in the play *F@ust 3.0* freely inspired in Goethe's work.

The original system followed a client server model, allowing composers, using the FMOL [21] software, to log into a central web based server, in order to download and upload pieces stored in a song tree-structure database.



Screen Shots of the FMOL software and the web based tree-structured data based with multiple generation pieces composed by different users

During the periods in which this project has been on-line, January/March 1998 and September/October 2000, several hundred of composers participated on the creation of musical scores' excerpts for two plays by la *'La Fura*', and a collective CD.

Yet, In 1996 a similar approach, but with different surrounding context was already presented in Tod Machover's *Brain Opera* [22], which among other things, was an attempt to combine *Staged Installation* and *On-Line Interaction*.

For this project a series of *Hyper-Instruments* were created both for a physical installation site and also for interactive sound applications available in the internet. The results from the *Hyper-Instruments'* performances at the installation site together with the results from the on-line users trough web applications converged in a final performance on stage.

Another project based on the idea of collective music creation, but with a different approach for a live event, was William Duckworth's 1997 *Internet based Cathedral* [23].This project was one of the first interactive music works created specifically for the *World Wide Web*. Live events conveying pieces created by users in this environment were presented on-line through *web-cast*.

4.5. Tele-Presence Systems

The idea of having the presence of one or more remote performers from anywhere in the world in events taking place in physical spaces, facing live audiences, during fixed periods of time is an exciting one. Logistic considerations must be made for events occurring simultaneously in different globe time zones, but the main concern in such a setting is usually network latency.

One approach to address this problem is to use cutting edge communication technology, like high speed and broadband networks combined with streaming techniques.

A unique public event following this idea took place on September 26, 1999 in New York, where a musical performance, at McGill University in Montreal, Canada, was transmitted to an audience at New York University, over the Internet during the 107th Audio Engineering Society (AES) Convention [24].

What made this event distinctive was the audience's experience of an uninterrupted transmission of multi-channel audio (AC-3) over a custom system employing both TCP and UDP protocols, providing its own buffering and retransmission algorithms.

Another project developed in 1997 in collaboration between the University of Geneva - Switzerland, the GRAME in Lyon - France and the GMD in Birlinghoven - Germany was based on the development of a system for Tele-presence with the goal of creating an environment for *distributed rehearsals* where the conductor of an orchestra would be present remotely [25].

In order to give the impression to the participants that the conductor was actually present in the room and that he would preserve the required awareness of the musician's gestures, eye contact and body expression, the project required special purpose high-end technology with high video quality and spatialized sound.

A different approach for performance in a live public event is to create systems based in *low-cost public domain technology*.

Different styles of music, instruments and technical setups have been tried like the *Telemusic* and the *Piano Master Classes* by John Young and Randall Packer [26] or the New York University's *Cassandra Project* [27].

4.6. Remote Collaborative Performance Systems

A more complex scenario than *unilateral participation* (Tele-presence) is *bilateral collaboration* between two simultaneous events.

In 1998 an interview for the Computer Music Journal with the *Sensorband* ensemble, [28] Zbigniew Karkowski refers to fundamental artistic issues raised in collaborative performances over the internet:

"*Another artistic aspect of ISDN concerts is the idea of control. Very often, composers use computers to achieve greater control. We have found, after playing several concerts like*

this, that we could never control the output 100 percent. Aspects like the delay become unknown variables, which is interesting (...)"

The *SensorBand* concerts were based on *synchronous collaboration* in a peer to peer model (using ISDN connections) between two performers.

Yet, other experimental systems focused on the idea of having synchronous performances, as close as possible to real-time, designed for multiple users. The 1998 *TransMIDI* [29] system, allows performers (and listeners) to perform together in multiple session groups. Players perform on MIDI controllers, and different topologies are possible, including the formation of hybrid groups with one or more leaders.

Another relevant reference following this approach is Phil Burk's *TransJam* [30], which also allows synchronous peer-to-peer interaction between several users but going beyond the MIDI format supporting low fidelity digital audio.

A different approach to this concept based on a mixed environment between a museum interactive installation and synchronous multi-user internet based collaboration is the *Worldbeat/GlobeMusic* project [31] currently hosted by the Ars Electronica Center in Linz. The creators of this project are developing ways for offline/online interaction with other musicians (WorldBeat: NetMusic).

An additional experiment that reflects the potential of multi-user remote performance over the internet, took place in October 2001, during the *Networkshop* festival in Dresden, Germany, when several collaborative on-line concerts based on Sergi Jordà's *FMOL* Virtual Music Instrument [32], were presented between Dresden and Barcelona.

Even though latency was in the range of 100 ms with a 56 kb modem connection, a very good feeling of playability was accomplished. The sound sequencing technique used in this system, based on sound generators' excitation by low frequency oscillators, creates rhythmical and melodic progressions, which support flexible reaction times and short lacks of synchronicity from the performing partners motivated by network latency.

4.7. On-Line Improvisation and Shared Sonic Environments

Even though setup requirements for performance and improvisation are physically the same, there are major conceptual differences between these two approaches.

In the context presented in this article, by performance is meant the process of playing a sequence of musical events providing some sort of synchronism with other musical or visual events. In a performance there is space left for individual expression and for improvisation, but in musical terms the event should be driven to a certain extent by a predetermined and rehearsed composition.

In pure improvisation musicians are not engaged in such a systematic approach, and much more space is available for spontaneity, free expression and continuous development of elaborated interactive relationships between the participants. This process is many times referred to as a *Jam* session.

Since no musical knowledge or instrumental performance requirements can be demanded from a regular Internet user, a spontaneous improvisation approach is quite suitable for an emergent new class of applications which can be defined as *Shared Sonic Environments*.

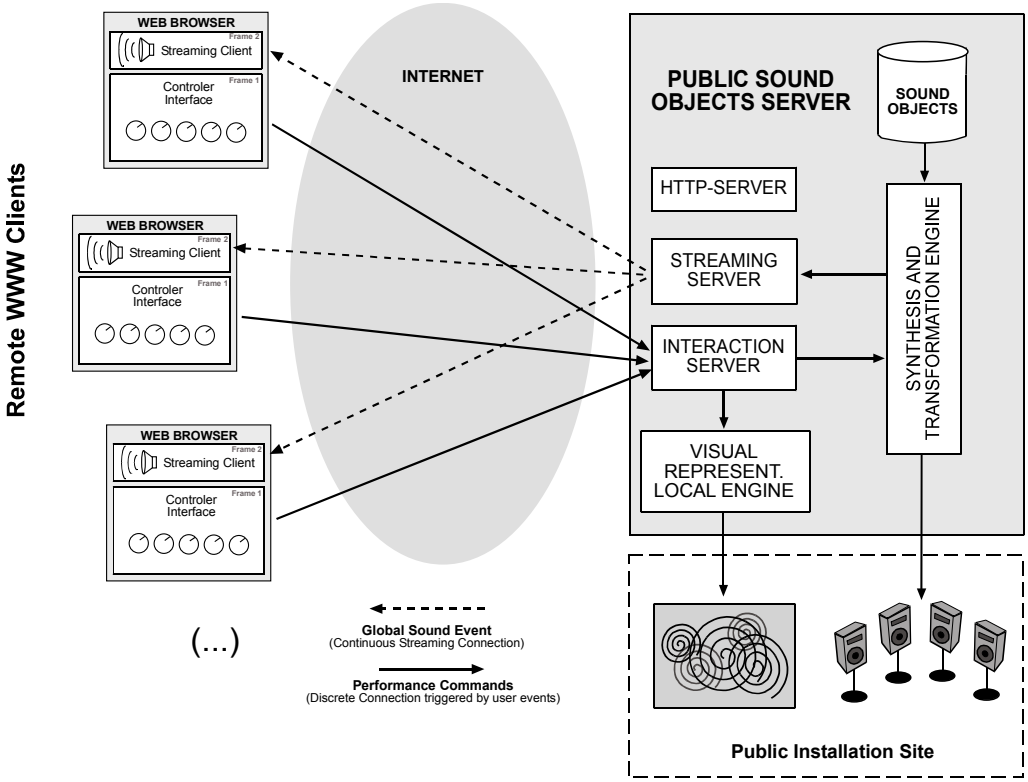
In these openly shared spaces members of the online community can be found participating on a public event by manipulating or transforming sounds and musical structures, or simply listening to music pieces created collectively.

One of the first examples of such system is the *WebDrum*, a drum box that can be shared by several people over the Internet, based on Phil Burk's Audio Software Synthesis API for Java *JSyn* and the *TransJam* Architecture [30].

Another recent artistic proposal following this approach is Atau Tanaka's *MP3Q* piece [33], classified by the author as a shared on-line sound space, which streams multiple channels of mp3 audio from different servers. Users can concurrently manipulate these mp3 sources by actuating over graphical representation of the systems current behaviour by a 3D Cube.

The *Public Sound Objects* (PSOs)is a system designed from scratch as a Shared Sonic Space, in the Music Technology Group of the Pompeu Fabra University [34]. In this project the concept of a shared space is explored in the sense of community-driven sonic creation, and simultaneously in an on site audiovisual installation, which brings together both a physical space and a virtual presence in the Internet.

PSOs is based on classic client-server architecture. The server handles the actual sound synthesis computation and the interaction interface is implemented on the client side. One of the main characteristics of this implementation is its modularity.



The *Public Sound Objects* system architecture

One important aspect to notice is that from the user to the synthesis server this system does not require real-time continuous connection in the communication stream. It is based on a communication model that enables the triggering of sounds in the server responding to discrete events in the client, which provides faster communication in this direction.

5. A Classification Space for Computer-Supported Collaborative Music

The systems presented previously, have different sonic communication requirements for music creation, and can be categorized in different classes:

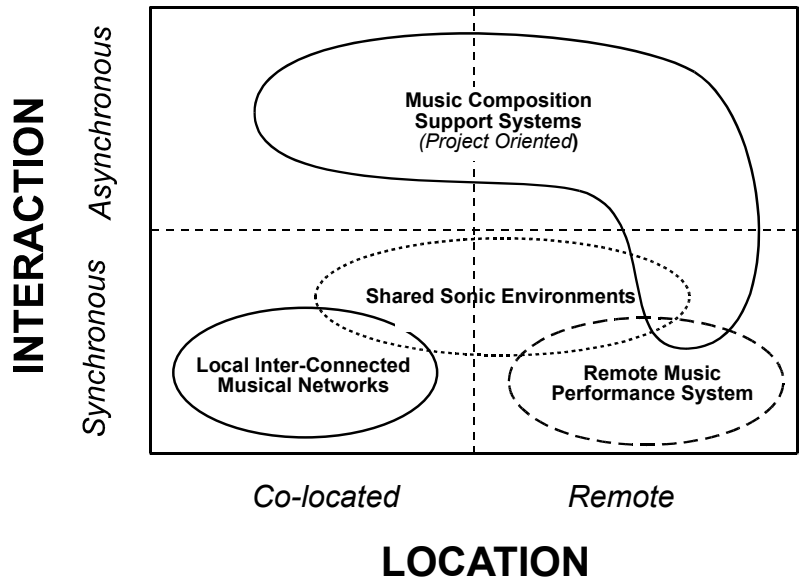
Local Inter-Connected Musical Networks – Used in organized events for groups of performers that interact in real-time on a set of music instruments (or Virtual Music Instruments) with sonic interdependency provided by a local computer network.

Music Composition Support Systems – Used to assist more traditional forms of music composition and production, both for composition oriented towards a written music support or music production based on experimental processes in recording studio setups. It enhances the traditional collaboration paradigms, by allowing geographical displacement and asynchronous collaboration.

Remote Music Performance Systems – Used in organized events for groups of multiple remote performers/users, displaced in space, improvising and interacting synchronously on a set of music instruments (or Virtual Music Instruments). In this case the sonic interdependency is affected by network latency. Tele-presence (remote unilateral participation) is a particular case of this set of applications.

Shared Sonic Environments – New class of emerging applications, which explores the internet's distributed and shared nature. It is not oriented towards a time limited event scenario and it is more suitable for synchronous improvisation. Since these systems are addressed to a broad audience, usually it is not required previous musical knowledge from the participants, and therefore results are often experimental sonic pieces.

Based on this categorization proposal a *Classification Space* can be defined in relation to Rodden's Computer-Supported Cooperative Work environmental facets [35] (*Synchronous* and *Asynchronous* for the Time Dimension; *Remote* and *Co-located* for the Space Dimension).



A Classification Space for Computer Supported Collaborative Music

It should be noticed that these are by no means closed categories, and many of the mentioned applications could belong to different classes.

For instance the FMOL system described previously represents an extreme example of an application with characteristics from different categories. It can be used locally in an Interconnected Musical Network, it is a multi-user instrument, it can be used in remote music performance over the internet and it also supports on-line asynchronous collective composition in a sort of centralized studio paradigm.

6. Conclusions

One should be aware that this study is not exhaustive, and due to the experimental nature of this field it is clear that information about many interesting and relevant projects has probably never been published or made public. Nevertheless, an attempt has been made to review and classify representative projects, which provide useful references and concepts for future work on network music systems.

It is also possible to infer from this study that most of the projects approaching geographical displacements over the Internet are oriented towards:

(a) The creation of networks where documents in digital audio or logical formats can be exchanged amongst geographically displaced contributors, in project oriented collaboration paradigm like in a typical Computer Supported Cooperative Work application;

(b) Providing a channel for tele-presence between performative spaces and therefore enhancing the efficiency of traditional collaborative paradigms for music performance/composition, music education or even for music sharing, by adding long distance collaboration possibilities.

In this context a different approach has emerged, going beyond the enhancements on existing acoustic communication paradigms, and focusing on a diverse breakthrough aspect of Internet collaboration, its shared nature:

(c) The possibility to create community oriented Shared Virtual Environments, where users can dynamically join and leave a group in a collaborative ongoing sonic performance based on the simple manipulation of sound objects from a *soundscape*, or even on the creation of musical structures.

Like similar paradigms oriented towards visual or textual communication (MUDs, MOOs, IRC, Active Worlds, etc) tend to lead to new mechanisms of interaction not usually seen in "real life" [36], a similar result can be expected in paradigms oriented to music or sonic arts, suggesting that the sonic outcome of such systems could express interesting new artistic results.

It is clear that this area of sonic creation is quite promising, not only by the fact that it allows the enhancement of known paradigms to make music, but also because it provides a context for stylistic novelty.

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Álvaro Barbosa is a PhD researcher at the Music Technology Group from the Pompeu Fabra University in Barcelona, Spain. He holds an Undergraduate Degree in Electronics and Telecommunications Engineering from the Aveiro University in Portugal, and a Post Graduate Degree in Digital Arts from the Portuguese Catholic University. His Experimental Sonic Artwork and recent Research was presented in several events in Portugal and abroad (Jubileu 2000, Olhares de Outono, MOSART Wokshop, Wedelmusic). His latest research is focused on the study and development of experimental systems for Network Music under the framework of a preliminary project entitled *Public Sound Objects*.

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