Dislocated Sound: A Survey of Improvisation in Networked Audio Platforms

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ABSTRACT
The evolution of networked audio technologies has created unprecedented opportunities for musicians to improvise with instrumentalists from a diverse range of cultures and disciplines. As network speeds increase and latency is consigned to history, tele-musical collaboration, and in particular improvisation will be shaped by new methodologies that respond to this potential. While networked technologies eliminate distance in physical space, for the remote improviser, this creates a liminality of experience through which their performance is mediated. As a first step in understanding the conditions arising from collaboration in networked audio platforms, this paper will examine selected case studies of improvisation in a variety of networked interfaces. The author will examine how platform characteristics and network conditions influence the process of collective improvisation and the methodologies musicians are employing to negotiate their networked experiences.

Keywords
Networked Collaboration, Improvisation, Internet Audio. Sound Art.

1. INTRODUCTION
The dual development of Internet streaming software and high speed broadband has led to the production of sophisticated multi-user audio visual interfaces, able to facilitate a diverse range of remote musical expression. Synchronous online collaboration by "geographically dispersed" [1] individuals is now common in many organizational settings, and musicians are now able to improvise with other players as far as the network extends. Along with these new opportunities is the imperative for a greater understanding of the nuances of "dispersed" musical interaction, which as a field of research has recently gained significant interest. However, while much has been written about the history and aesthetics of networked music, it often coalesces around developments in technology and the manipulation of electronic sound, where improvisation plays only a perfunctory role. The author argues that this is the result of a dominant interest in network architectures, in which the "role of the composer", is "as a designer of a musical environment rather than a creator of a self contained musical work" [2]. Collaborative centered experience, and in particular that of improvisation, has become subsumed within a general study of networked musical interaction. The purpose of this paper is to address this under-representation, and in the following sections the author presents a non-exhaustive survey of a diverse range of improvisation in networked audio platforms. In the context of New Interfaces for Musical Expression, both the interface, its technology and capabilities, as well as novel musical collisions, co-operations, collaborations and discussions, form important ingredients in the dialogue opened up by recent technological advancements in networked audio platforms. The author will examine individual artistic projects, the influence of platform characteristics on collective improvisation and the rationale for new methodologies to mediate the new topographies of networked improvisation.

2. Origins of Networked Computer Music
One of the first groups to pioneer networked computer music in the late 1970s was The League of Automatic Composers at Mills College, Oakland, California. In tandem with the first commercially available personal computers such as the KIM 1, composers Jim Horton, Rich Gold and John Bischoff started experimenting with programming the machines 6502 language, and in 1977 they "linked their KIM's together in a performance at Mills College" [3]. However, perhaps due to their primary interest in circuitry assemblage and computer programming, the content of their performances was generative rather than improvisational. "League members generally adapted solo compositions for use within the band. These solos were developed independently by each composer and were typically based on algorithmic schemes of one kind or another" [3]. As Chris Brown remembers of the 1977 performance at Mills College, "Gold interacted with his artificial language program while Horton ran an early algorithmic piece based on the theories of 18th century mathematician, Leonhard Euler" [3]. Whilst the opportunities for collective improvisation were not a priority for the group, the first local computer networked performance had been achieved. This would be followed some ten years later with an expanded ensemble known as the Hub, performing the first networked distance concerts over two nights in New York. Performed from two separate venues via a modem over a telephone line, these were also the group's most improvised performances. Recognizing the need for a different methodology for performing from distinct locations, Chris Brown notes, "Three of the pieces [...] were designed as network pieces, that would use the modem network to create the

acoustically divorced, but [sic] informationally joined sextet. Then three other pieces would be independently performed, that could take full advantage of the improvisational predilections and local interactivity of each ensemble" [3]. This semi-improvisational approach was one that they would pursue in future performances using the then new MIDI (Musical Instrument Device Interface) protocol. Acoustic musicians were also included to provide live data feeds to be manipulated in real-time, which in 1997 culminated in "Points of Presence", a tri-location Internet performance, linking musicians at Mills College, Oakland, The Californian Institute for Arts, Valencia and Arizona State University. With two members of the Hub at each of the three locations, data was sent via the Internet to manipulate software and the algorithmic programs of the Hub laptop-to-laptop network at each end. However, differences between the various computers operating systems, CPU's and network speeds had a deleterious affect on the performance. "As a result, the full network functioned for only about ten minutes, and most of the performance, particularly in Arizona, was spent describing to the audience what they should have been experiencing" [4]. A breaking point between ambition and technology had finally been arrived at, and despite its impact on the demise of the Hub, what they had achieved would be a benchmark for future networked collaborations and performances.

3. Early Networked Performances

The modem and telephone line continued to facilitate new combinations of networked musical collaboration, and augmenting this with an emphasis on improvisatory performance, was composer and performer Pauline Oliveros. In November 1991, working with colleague Joe Catalano, a six-city video telephone transmission was organized, connecting the cities of Oakland, CA to Kingston, NY, and New York to Houston, TX, Texas to San Diego, CA, and finally Los Angeles, CA to Oakland CA. Inviting musicians in each city to perform a twenty-minute broadcast in celebration of Oliveros' forty years of composing, the event culminated in a six-city wide improvisation. The experience of performing via video telephone required certain skills of the performers, as Oliveros remembers, "Since the telephone line would grab the loudest signal the improvisation was based on sensitivity to give and take" [5]. An illustration of how early, networked improvisation was shaped by the technological conditions it was performed through, and like network latency became a "structural element of the improvisation" [5]. Oliveros continues to explore networked performance, and with her Deep Listening Band has performed with numerous musicians over evolving network infrastructures. Her recent collaborations with sound artist Jonas Braasch, Chris Chafe, director of CCRMA (Computer Research in Music and Acoustics) and researchers at Stanford University, has begun "a long term improvisatory collaboration using JackTrip" [6], an open source network software for multi-machine performance over the Internet, developed by Juan-Pablo Cáceres and Chris Chafe. In 2007 this involved a concert connecting "44 musicians participating in a three-site improvisation" [5] from University California, San Diego, CCRMA at Stanford University and IEAR studios at Rensselaer Polytechnic Institute, New York.

4. Online Musical Interactivity

If the innovations of the League of Automatic Composers, the Hub and Oliveros laid the foundations for the next decade of collaborative-networked music, "Brain Opera" (1996) by Tod Machover [4] and "Cathedral" (1997) by William Duckworth and Nora Farrell [5], took these principles into a new realm of interactive web-based multi-user environments. Reflecting a growing desire to "give listeners an active role in the creative process" [8], both projects called for audience participation in the manipulation of musical and sonic fragments, in virtual and physical performance spaces. However, what Machover, Duckworth and Farrell had created in these two works were composed web architectures, where the "active role" played by listeners was more collaborative interaction than improvisation. This is not to say that instrumental improvisation was excluded from the either projects ethos. The Cathedral band would often include audience manipulation of the sites "virtual instruments" (Pitch Web) and pre-composed "rhythm beds" as material to improvise with in their live online or venue performances. Fearing that the "Web" music of Cathedral could be perceived as exclusive, Duckworth was keen to be as inclusive as possible when it came to the musical ability or culture of the participants. To this effect, online participants could play Pitch Web as a real-time synthesizer, or by "typing" in words or phrases in any language and having the instrument […} convert them into musical sounds" [4]. By its nature this often produced eclectic musical results reflecting the abilities of the participant and/or the improvised response of the Cathedral band. This democratization of interaction has it's roots in the philosophy of earlier improvisatory groups AMM and the Scratch Orchestra, and highlights the creative advantages of integrating contributions by "musical innocents" [9] to dynamic improvisation.

The boundaries of what could be achieved through the Internet as a network were also to prove crucial to the success of these works. As William Duckworth notes of this period in the mid 1990s, "the two fundamental factors hindering real-time, online collaboration on the Internet were limited bandwidth and lack of speed. All sound files, with the exception of MIDI files [...] could take a considerable time to upload and download" [4]. Fortunately Internet technologies were developing at such a pace that this was not to impact significantly on works like "Brain Opera" or "Cathedral", however it would still be some years before musicians could stream live audio of their playing in real time.

5. Collaborative Client / Server and Data Base Models

In 2003, new media art collective Furtherfield.org (UK) launched the multi-user file-mixing platform VisitorsStudio. Programmed by Neil Jenkins, VisitorsStudio is a Flash based audiovisual environment enabling musicians and artists to "upload sound files and still/moving images (jpg, png, mp3, flv, swf) to a shared database, mixing and responding to each other's compositions in real-time" [10]. With similarities to the data base models of Craig Latta's "NetJam" (1990) [11] and Kenny Sabir's "DASE", (1999) [12] musicians and sound artists improvise together by layering loops of musical phrases or sound events from any networked computer, without having to wire in interfaces, microphones or electronic instruments. Network delay imposes some limitations for synchronicity, however artists have learnt to use this "as an aesthetic parameter" [13]. Examples include using network delay to phase shift between two rhythmically identical phrases, or layering non-rhythmic beds of sound, which intersect, rather than glitch when re-triggered.

In 2005 the author produced a radio program for Resonance FM (London), using VisitorsStudio as the platform for a live cross-continental collaborative file mixing improvisation. "Furthernoise" featured musicians John Kannenberg (US),

Mark Francombe (NW) and Midori Hirano (JP) uploading and mixing sound files live on air from their respective home cities of Chicago, Oslo and Osaka. Whilst the performance was not streamed instrumental improvisation in real-time, its synchronized layering of musical sound was very much improvisatory in aesthetic. Reflecting on the similarities of this performance to live improvisation, performer John Kannenberg states, "There are similar issues involved, like attentive listening. There is also the situation of being in touch with your instrument, having a relationship with it and being able to predict how it will respond (or not respond!) to your input" [14]. These sentiments are intrinsic to improvisation in any setting, however it is Kannenberg's notion of "attentive listening" that becomes so important in networked collaborations, without the visual signifiers present in a face-face improvisation.

Figure 1. Furtherfield's VisitorsStudio Interface

6. Collaborative Web Streaming

radio.electro-music.com [15] is the Internet radio portal of an international community of networked musicians. In January 2006, they started meeting online and improvising together using peer2peer Internet broadcasting software, such as PeerCast, SHOUTcast, Icecast and Nicecast. During a performance, musicians collaborate by collectively streaming their improvisations to the electro-music.com server. Each new stream is manually mixed with the other player's streams, and broadcast to an online audience through the websites radio page. As a client server model, peer2peer broadcasting is designed to stream a single output for applications such as Internet radio, making this an interesting and unique use of a technology designed for different purpose. However, it does require musicians to work with network conditions as they are, and there are no structures to regulate network latency. Musicians have to navigate significant latency, whilst simultaneously interacting with others performances. Once a musician begins playing a phrase, either to start an improvisation, or as part of one, it may be several seconds before this is heard with the other player's streams. The effect of this is that the musical dialogue becomes punctuated by past musical events, necessitating a form of extended listening and response. The temporal nature of this experience can create interesting musical collisions, where a musician is able to improvise contrapuntal melodic developments over a previously played phrase. Having to assimilate delays of ten seconds or more, composer, improviser and tele-music performer Warren Burt notes of his numerous experiences with latency in performances of this nature, "I learned to […] respond to things I heard, knowing that all my responses would be "in canon" with any desires for interaction I might have had" [16]. It is this mediation of asynchronous interaction, and creative musical response, that engages musicians to develop extra-musical mechanisms to attenuate their performance to latency of this nature.

7. The Real-Time Jam

While database and peer2peer client server technologies have advanced the potential for asynchronous networked improvisation, it is conceptually quite different from what Eddie Prévost states is an, "inter-active dialogical relationship between performers" [17]. In 2004, Brennan Underwood and Cockos Incorporated realized the concept of plugging a microphone or instrument into a networked computer and "Jamming" with up to eight musicians in real-time. Developing the client server model further, "NINJAM uses OGG Vorbis audio compression to compress audio, then streams it to a NINJAM server, which can then stream it to the other people in your jam" [18]. NINJAM provide a free software download DAW (Digital Audio Workstation) and NINJAM client for Windows and OSX. Running in tandem to the computers soundcard, the DAW software, known as "Reaper" facilitates the use of VST (Virtual Studio Technology) and MIDI hardware with the NINJAM client. It also allows musicians to import previous sessions for editing or re-mixing. The client appears on screen as a console with parameters such as channel transmission, mute, solo, master volume controls and metronome, which synchronize collaborators to a "measured latency". Musicians select and perform to a chosen BPM (Beats Per Minute), allowing the software to measure the latency or "ping", (the amount of time a packet of data takes to reach it's receiver) between players, locking them into synchronization with one another.

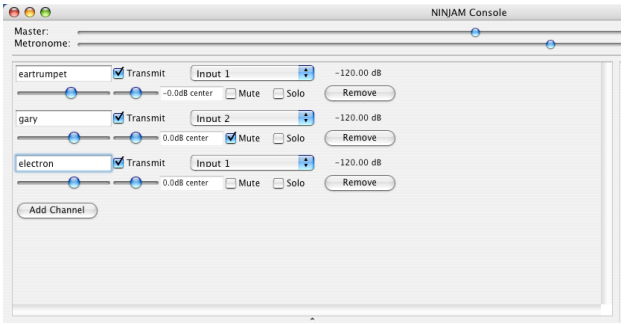

Figure 2. NINJAM Interface

8. Network Latency and Performance

The phenomenon of "ping" has for some time, been an ongoing issue for "real-time collaboration over global networks" [19]. As we have seen, musicians increasingly try to integrate latency into their work "using network time delay in a musical fashion rather than constantly trying to counter it" [20]. Another example of this is an innovative program developed by the Net vs. Net Collective (2007), "a collective of musicians exploring the potential of high-speed networks as a real-time performance medium" [21]. Incorporating latency into their performances, founders Juan-Pablo Cáceres and Alain Renaud have developed a Feedback Delay Network (FDN) as part of a comb filter, (Comb filters are extremely basic building blocks for digital audio effects). The FDN is used to "bounce" sounds from one location (ipsilateral) to a second one (contralateral)", which can be used as "a reverberator or as a delay type of effect" [20]. With an ethic of using network conditions "as they are", the Net vs. Net Collective perform with their self titled software

application Master Cue Generator (MCG), which broadcasts signals to various nodes from a central location. Implemented in Max/MSP (Cycling 74), the application "is able to analyze the latency between the master and the nodes and compensate the delay to ensure that each cue arrives simultaneously to each node" [20]. MCG is used in conjunction to the previously mentioned JackTrip software [6]. Although discreetly contained within the platform, NINJAM uses network latency in a similar way, only extending it in metronomic measures to create synchronization between players. "Just as the interval finishes recording, it begins playing on everyone else's client, […] So, when you play through an interval, you're playing along with the previous interval of everybody else, and they're playing along with your previous interval [18]. This mechanism of measured latency allows musicians to create a performance continuum, which is easy to adapt and integrate into their playing. Former Cranes guitarist and improviser Mark Francombe notes of his experience of NINJAM, "Latency is quite an interesting aspect of the NINJAM experience, as people take time to react to what you are playing. If you set a measure of eight bars to one hundred and eighty BPM and start playing, your collaborators will hear you eight bars later. Eight bars later than that, you will hear them, and they appear to be playing with what you are playing now. In reality they are hearing what you were playing sixteen bars ago" [22]. In this scenario all but one of the improvisers are performing in the past tense, and the latency is imposing a creative temporality on the musical dialogue. The consequence of this is that the improviser has margins of time in which to consider and formulate creative responses. NINJAM redefined the topography of remote musical collaboration, and as a networked audio platform continues to facilitate interesting improvisatory collaborations. Musicians often face problematic audio monitoring in live performance, and adjusting to the parameters of measured latency will be instinctual to most. However, the goal of low or no latency was still one that was being pursued.

In 2006, as part of the Sound Wire research group at Stanford University, Juan-Pablo Cáceres and Chris Chafe, started researching networked computer and acoustic music performance whilst developing the afore-mentioned JackTrip software [6]. Using the user datagram protocol (UDP), JackTrip works by sending "uncompressed audio (avoiding the latency introduced by compression encode/decode algorithms) through high-speed links like Internet2" [23]. While facilitating improvisatory performances by students, and artists such as Pauline Oliveros, much of their research has been focused on networked ensemble performance, latency studies and Internet acoustics. One area of particular interest is Chafe and Gurevich's findings on "beneficial" delay, in which short delay amounts have the best tempo stability" and that "very low delay […] produced tempo acceleration" [24]. Although this study was carried out analyzing the accuracy of synchronized hand clapping, it is interesting to note that a certain amount of latency, can actually help, rather than hinder playing accuracy in networked performance. JackTrip is a sophisticated network technology, however it does require a level of system knowledge to install and use. In possible recognition of this, Cáceres and Chafe have recently produced Jam Link [25], a portable "plug in and play" unit, that operates as stand alone hardware, and plugs into any network connection.

9. User Experience and Community

As the author is currently engaged in studies of improvisation across a number of network platforms, it has become apparent that interface installation issues form a key part of a musicians user experience and resulting collaboration. Encountering problems in installing hardware, software or comprehension of control parameters, can often taint the initial experience and interaction between remote collaborators. Likewise, problems with monitoring audio levels in transmission or playback can also have a negative affect on the fluidity of improvisation. Other areas impacting user experience include communication (language or abilities to type or articulate ideas in chat windows), as well as issues integral to the medium itself, such as latency, temporal dislocation and divorced or culturally attuned listening. Platforms that facilitate social networks or "communities of users" circumvent many of these issues, as musicians are able to assist and learn from each other in a pedagogical environment of exchange. An example of this is eJamming, released in 2008 by Alan Gluckman, Bill Redman and Gail Kantor. A multi-user audio platform, eJamming has a database structure where musicians can search for collaborators according to preferences in instruments, abilities and musical styles, as well as building online associations with players they meet in open seat sessions. There are online forums, where musicians can share experiences; upload media and trouble shoot problems. Whilst eJamming isn't the first networked platform to facilitate a user community, its current social architecture surpasses other models.

Using peer2peer architecture and UDP packet sending, ejamming transmits 44.1 kHz, 16 kbt WAV files with unperceivable latency (11ms) for WAN (wide area network) connectivity.

Figure 3. eJamming Interface

All control parameters are housed within the client software, which has two modes, JAM and VRS. JAM mode facilitates up to four players with manually adjustable buffer for distance collaborations, and VRS (Virtual Recording Studio), online multi-track recording. When recording in VRS mode, musicians can monitor their performance in complete synchronization with previously recorded tracks, which are stored and accessible for further editing via the eJamming server. In their studies of auditory perception, Szymaszek et al, suggest for a subject to identify two successive auditory stimuli "that the typical temporal order threshold (TOT) is between 20 and 60 ms" [27]. That is, that under 20 ms the human ear can not perceive two sounds as being separate from each other. With a TOT of 11ms, eJamming is among the first platforms to facilitate high fidelity networked musical interaction in real-time. It's worth noting that this has also impacted on the way musicians use the platform. Local ensembles and bands are as likely to rehearse pre-composed music, as explore cross continental improvisation.

10. Interfaced Performance and Dislocated Listening

Reflecting on the author's involvement as a beta tester of various networked audio platforms, he has "sat in" on many "jam sessions", and enjoyed a variety of improvisatory experiences. Whilst network latency has been reduced to imperceptible levels, there are still multiple user issues encountered by the remote improviser. These are many and varied, and can greatly influence the construction, timbre, style, quality and interactive dialogue of the improvisation.

An example is the control parameter of eJamming's session "leader", where one player creates a session and adds seats for other players to join. This introduces a hierarchy within which that player can control who is allowed to play in the session, as well as attenuating the input of each player at her discretion. This has implications for a shared authority of expression in that musical process becomes subject to individual mediation. Paradoxically, this can also introduce new combinations of improvisational cultures and techniques, as specific combinations of players can arrange to improvise together in private.

Perhaps one of the most significant influences on remote improvisation, through any interface, is the scenario of performing without visual referents. This can affect a number of aspects in the improvisational process, which can impinge in different ways on the results. In a face-to-face setting, musical characteristics such as the length of notes, or the timbre of the way a particular musical phrase might be played, are mediated by the sight of gestures or expression in fellow collaborators. In his essay "The Pedagogical Imperative of Musical Improvisation" [28], Scott Thompson highlights George E Lewis' statement in the liner notes of "Voyager" CD.

"Improvisation is about […] interaction and behavior as carriers for meaning. On this view, notes, timbres, melodies, durations, and the like are not ends in themselves. Embedded in them is a more complex, indirect, powerful signal that we must train ourselves to detect."

Without these signifiers of "interaction and behavior", the remote improviser is required to engage in heightened or what Pauline Oliveros describes as "deep listening" [29] in order to perceive multiple messages in the musical dialogue. Although listening is imperative for improvisation in any setting, being separated in cyberspace creates a dislocation that permeates the listening experience, and the messages derived from it. With unparalleled access to collaborators of multifarious improvisatory cultures and disciplines, the opportunities this presents are as exciting as they are treacherous. Negotiation of linguistic, social and cultural sensibilities as well as the "role of agency in others to condition one's own play" [2], are paramount if new improvisatory collaborations are to be successful.

11. Conclusions and Future Directions of Research

This is not a definitive study of networked improvised music or technologies. Rather, it is an overview of their evolution, recent development and the impact that they are having in the field of remote musical engagement. Future research will look further at user experience, the effects of interface design on tele-musical collaboration and physical and temporal dislocation on improvisatory practice. This will include the dissemination of cross-cultural dialogues, disciplines and the dialectics of collective improvisation, performance and listening. Improvisation and networked performance form a major part of the authors practice, and as such he has collaborated in many of the platform technologies referenced in this paper. There are still many concerns facing the remote improviser, and in turn her creative interaction with other musicians. Characteristics such as culturally attuned listening, expression, linguistic and aesthetic communication without visual referents and differences in time zones, climate and environment, all create varying impositions on the remote improvisatory collaboration.

Whilst we look to a future of latency free, tele-musical collaboration, improvisers will need to formulate new approaches and methodologies to deal with the issues presented by these new opportunities. As Dante Tanzi states, "Hybridization among musical objects and their re-contextualization can dictate the conditions for the emergence of musical meanings" [30]. In order to derive musical meaning from divergent improvisatory cultures in collaboration, we must develop new forms and structures in which hybridization can occur in a shared and open environment.

12. Acknowledgements

The author would like to thank Neil Jenkins, Furtherfield, Alan Gluckman, John Kannenberg, Mark Francombe, Warren Burt and Kirsty Beilharz for their assistance and contribution to this study.

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