Facilitating Collective Musical Creativity

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ABSTRACT
We present two projects that facilitate collective music creativity over networks. One system is a participative social music system on mobile devices. The other is a collaborative music mixing environment that adheres to the Creative Commons license [1]. We discuss how network and community infrastructures affect the creative musical process, and the implications for artists creating new content for these formats. The projects described are real-world examples of collaborative systems as musical works.

Categories and Subject Descriptors
H.5.3 [Information Interfaces and Presentation]: Group and Organization Interfaces---Collaborative computing; H.5.5 [Information Interfaces and Presentation]: Sound and Music Computing---Systems

General Terms: Design, Experimentation.

Keywords
Interactive music, online communities, peer-to-peer, sensor interfaces, social computing.

1. INTRODUCTION
Networks and mobile devices have become new infrastructures on which to deploy music. However, typical commercial offerings are limited in their vision and do not exploit these media to their full musical potential. Downloadable music services commoditize music, treating it as a dead medium. Rather than using peer networks simply for file sharing, we propose a vision that respects both music and networks as dynamic, living forms. This vision is founded on a history of artistic practice that lends insight to musical creativity on these media. This leads to the vector of artistic creation pointing out potential new end-user content formats.

The work presented is situated at the intersection of electronic music, interaction, and social computing. The projects facilitate building creative communities as a fundamental part of the musical process. The act of musical creation thus incorporates notions of reciprocity, engagement, roles, belonging and awareness, to create live Social Music Software.

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The end result is a democratization of the creative process and an inclusion of the listener in the compositional loop. This leads to evolving views of the role of the artist and spectator, and of the forms in which cultural artifacts are created.

1.1 Network Music
There is substantial precedence of composers working with networks [2], [3], [4], [5]. Early works used radio and telephone networks to allow audience participation to become a musical material itself [3]. Digital networks have been used for remote performance, as well as for local communication among musicians onstage [2]. The Internet has been used to allow audience participation [6], [7], [8]. The history of network music has been published in the literature [9]. Here we describe the evolution of network music projects of one of the present co-authors [10].

Performance practice on networks has traditionally been concerned with perturbations of musical communication. Remote performance configurations were created to conduct investigations of the musical effects of the network data transmission. This meant setting up video conferencing systems whereby audio and video could be sent from a camera in one city to another and to have a concert connecting them, allowing musicians at the two sites to perform together. Such concerts were organized over a period of ten years, 1995-2005 connecting Paris and New York, Barcelona and Rotterdam, Budapest and Montreal.

The first challenge was to find a way to maintain eye-to-eye contact over a videoconferencing system when the act of sharing a single stage is extended by a pair of video cameras and video projectors. Part of the challenge was to maintain a compelling performance dynamic for the local audience while keeping contact with the remote performer. As there were audiences on both sides, the remote performer had the same responsibility at his site. Once communication was established, the musician's concern shifted to the quality of musical communication, manifested in system performance such as the trade off between picture pixelization, fluidity of motion, and time latency.

If networks have significant latency for real time applications, this means that they exhibit specific temporal characteristics. Seen in this light, it is the same musical concern as when composers consider the acoustical characteristic of the concert space in which their work will be performed. Composers of sacred music in the medieval age took advantage of the long reverberation times of cathedral architectures to write long, slowly moving lines, at times "hiding" secular melodies within the *cantus firmus*. Be-bop musicians exploited the intimacy and short reverberation time of jazz clubs to play blazingly fast solos. It is taken as a given by trained musicians that playing a be-bop solo in a cathedral would make little acoustical and thus little musical sense. Network transmission latency viewed in this way becomes the *acoustic of the* *network*, to be recognized and exploited as one does when composing for specific resonant physical spaces [11].

1.2 Interactive Music Systems

Interaction in music has been a concern since early digital systems of the 1970's [12]. It is also claimed that interactivity is a fundamental quality inherent in music, independent of technology, digital or not [13]. A summary of the field of gestural music is found in [14]. Interaction also is an element in algorithmic generative systems [15], [16]. Here we describe projects by the three authors in the area of music interaction. We propose applying the notion of *idiomatic writing*, taken from traditional musical instrument composition, to identify salient musical characteristics of interactive technology [13]. Rather than viewing technical limitations as such, this view considers them as qualities giving these media their distinct musical *voice* to be exploited creatively.

One approach to interactive music in is the form of *composed instruments* [17]. An example of such an instrument was developed for the *Takemitsu: My Way of Life* opera [18], by Kent Nagano (musical director and conductor, USA), Peter Mussbach (director, Germany). The co-author's goal in this project was to compose a playable gesture instrument that could be used to accompany the existing orchestral, chamber and electronic music of the opera. Important musical aims were: 1) the ability to blend in with the existing music, 2) use the extremely limited rehearsal time as effectively as possible, 3) the ability to learn, vary, improvise, and 4) to create an enveloping and immersive sonic experience. Important design concerns in this undertaking were the integration of gestural controllers (including the JazzMutant Lemur [19] and a standard pen-based tablet [20]), real-time generative software, and mapping schemes for gestural control of audio signal processing [21], [22].

Generative software represents a second category of interaction. Sonasphere [23] is a kinetically driven graphical music environment. In Sonasphere, functional units, such as sound samples, effects and mixers, are represented as spherical "Objects" floating within 3D Space. Connections are made between these objects, using simple mouse interaction, to establish signal flow networks. A Sample Object playing a sound sample file is connected to an Effect Object, which is then connected to a Mixer Object. Parameters of these objects can be assigned to 3D coordinates of other objects within the 3D Environment. For example, the cutoff frequency of a lowpass filter can be controlled through the "Altitude" of a corresponding effect object. In addition, objects subject forces upon one another; creating simulated "Electric Charge" and "Springiness." This conceptual use of Newtonian physics leads to complex behavior, which drives object movement and dynamic changes in the structure of the signal network. The end result of this complex and sometimes chaotic environment is interesting and unique sonic effects. Sonasphere brings physicality and a generative approach to software-based sound performance, enabling users to intuitively control sample playback, effect parameters and mixing, to produce a highly original musical result.

1.3 Social Music Systems

While the work presented above is primarily aimed at trained musicians, the current work seeks to put those technologies to the service of democratizing musical creativity. The artistic mission, then, takes on a social aspect.

Networks have been facilitators of human communication, with email being the "killer app" of the Internet. Social interaction has evolved further with the advent of decentralized systems such as peer-to-peer (P2P) and Short Message Service (SMS). Social computing is the field emerging from the Human Interface community that looks at contexts of collective action catalyzed by technology. Social computing introduced the notion in of *facilitating serendipity* to catalyze human activity [24]. Here we describe the trends that define this broad area, and identify elements within them that have potential for application to musical creativity.

The phenomenon of scale-free graphs applied to human networks has brought about the popular notion of *six degrees* of separation being sufficient to traverse a large breadth of the population [25]. Various commercial services now exist exploiting this phenomenon for personal contacts on the Internet [26], [27], and mobile telephones [24].

The convergence of common activities among network users has created the notion of *online communities*. Communities are defined to be groups who share similar interests, characteristics, or activities. Fostering online communities technically includes assuring usability of a system and allowing sociability in the design of the system [28].

The Creative Commons (CC) is a legal model for cultural contents rights management that condones copying for purposes of re-use. It is intended to be complementary to current copyright law and responds to the claim that existing copyright laws are inappropriate for the models of transmission and dissemination made possible on digital networks. In this license model, copyright holders can grant permission for secondary use of their material including copying, modification and re-distribution under the certain condition without abandoning their original authorship rights.

Music is one area where the Creative Commons has sought to become established. The cultures of sampling and re-mixing indeed emanate from musical culture, and are a source of inspiration for distribution models like CC. While the Creative Commons recognizes repurposing as a creative act and creates a legal structure for artists to distribute their works, it does not directly provide tools or techniques for artists to create works in this new way.

If we observe new social phenomena emerging from network communications and mobility, and if there are now licensing schemes to support content distribution on these infrastructures, can we imagine ways in which musical creativity itself will evolve? Here we call upon our experience in artists projects in network and interactive music to create systems that allow the end-user to become more closely engaged in the musical creative process.

2. THE PROJECTS

The projects described here facilitate building creative communities as a fundamental part of the musical process. The process of musical creation incorporates notions of reciprocity, engagement, roles, belonging and awareness, to create live Social Music Software.

2.1 CC-Remix

CC-Remix is a network-based collaborative music creation system that subscribes to the Creative Commons license [1]. It is a facilitator of social creativity. The system allows multiple (up to four) users to participate in a process of mixing and creating new music. Participants can take excerpts from existing songs, and mix them together. In this way the project taps into the underground movements of *bootleg* and *mash-up* culture [29]. CC-Remix extends this by

1. Adding a collaborative element to mash-ups
2. Tracking authorship and content re-use

The source materials come from a CD published by Wired Magazine to promote the Creative Commons [30]. The Wired CD collected songs by well-known musicians, such as Beastie Boys and David Byrne, who each released and published a title under CC.

Alongside the release of the Wired CD, the Creative Commons created a web site for the distribution of music under the CC license. Their site [31] is dedicated to uploads and distribution of Creative Commons contents. All uploaded remixes are automatically propagated under the CC-license. A salient feature is the notion of a "sample tree", whereby re-use of musical samples is tracked from song to song.

While the Wired CD provides an example of music published under the CC license, and while the CC has a website allowing dissemination of works under the license, they do not broach directly the impact of the model on the act of music creation itself. There remains the assumption that the user is versed in music production techniques and there is no provision for the tools necessary to create music. Our project, CC-Remix, on the other hand, is targeted at normal users, non-musicians who do not possess specialized tools for music making. The idea was to create a complete end-to-end system from collaboration to creation to dissemination in one package. We are interested in how people listen to music and how network technologies can foster creativity in the process of music appreciation.

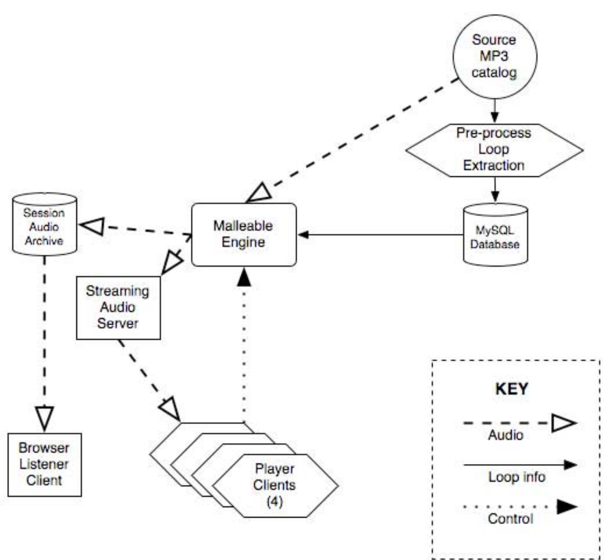

Figure 1. CC-Remix architecture

2.1.1 *Usage Scenario*

CC-Remix system is intended to be played by a group of clients. These clients listen to a single audio stream from the server that is the combined result of the activities of the four connected users. Each client can select a single song to play from the list of available songs. Once a user selects a song, loops in these songs (extracted automatically by preprocessing) will be shown graphically on the client software. Each client will see other clients connected to the server and their activities including song title, loop position currently being played, and playback volume. In this way, a collaborative mix session is established among the users.

The server performs beat matching and synchronization, technical tasks typically performed by a DJ. The users have only to choose loops that are musically interesting when superimposed over those loops selected by the other participants. The net sum result is a mix of all parts, and are streamed back to the connected clients. Participants listen to a single musical collage they are creating together. At the same time, the result is recorded on the server as an audio file. Recorded sessions are published on the CC Remix web site automatically under the Creative Commons license. The published works adhere to the Creative Commons license in the recognition of original authorship of sampled materials used, and the traceability of content re-usage.

2.2 Malleable Mobile Music

Malleable Music places similar concepts of participative music mixing in a mobile environment [32]. It uses wireless ad-hoc networks to create participative, shared musical experiences amongst listeners.

Mobile devices endowed with sensors are in communication with each other and with a music engine. Communities of friends enter a virtual space, where each person is identified by a distinct part in the music. Subconscious gestures made in the act of listening – be it gripping the device, or tapping along to the beat – are picked up by sensors. The server side music engine aggregates this user-level context with system-level context based on localization, transforming the ensemble into a musical context. This musical context modifies a piece of music on the fly, resulting in a “social re-mix”, a single audio stream of music that contains the social information, and that is listened to by all participants as a shared musical experience.

2.2.1 *Usage Scenario*

The usage scenario consists of three parts:

- community building
- song and musical identity selection
- participative listening

Community building takes place in a way now familiar in Chat and Instant Messaging software. Users announce themselves to the project server, and find friends, or “buddies” who may also be online. Chains of social acquaintance are managed in a way similar to popular Social Software services. The notion of six-degrees of separation is used to track direct acquaintances, friends-of-friends, and distant contacts. We have previously demonstrated the establishment of Trust based on such mechanisms [33]. Here, the trust level could determine the level of play that one user can engage in with another, or with another group.

Once a group of users has established a common listening group, they select together a song to listen to. As there will be a single piece of music that constitutes the shared experience, they must have a mechanism by which to agree on what to listen to. This can be through voting or through common titles in their personal playlists.

Within the selected song, each participating user must select their own musical identity. This can be a specific instrument (for example horns or bass), or an identifiable family of sounds (for example percussion or synthesizer beds). The identity chosen by the user can be manual and specific to a song, or can be automatic and associated with identities that the user has in different songs. The goal of the latter is to have a characteristic type of sound that characterizes and identifies a user to his friends across different songs that they might listen to together.

2.2.2 Listener Gesture

Enriching the users' musical experience with information about their bodily gestures is a central concern in this project. We attempt to derive the long term evolution of the music as well as the more immediate features and modifications of the musical material from analysis of the users' bodily movements and physical interactions with the interface. We attempt to take into account sub-conscious user participation, as well as volitional actions of the listeners. For example, the intensity with which a listener holds the mobile device can be translated into the timbral brightness of the music; the rhythm the user makes as he swings along with the music, is captured and used to drive the tempo through time-stretching techniques. The relative geographic location of users in the group provides a higher level information about the community and drives the mixing of the different musical modules. As a listening partner gets closer, their part is heard more prominently in the mix.

2.2.3 Musical Modification

Musical pieces are conceived as open forms with elemental modules. Modules that make up a musical piece include rhythm generators, time stretching modules, sequencers, and samplers. These elements are processed by time and frequency domain signal processing and combined to make a single musical flow. Treatments could include time stretching to reconcile differing tempos of the modules, filtering, or time domain re-ordering. The modules are submixed and assigned to different "tracks" that represent the contribution of individual connected users. The master mix represents the sum total of the different tracks.

The time re-ordering of elements in the music is applied at the rhythmic level and also at the structural level of a song. The low level re-sequencing allows user actions to intuitively create new rhythms and melodies based on existing elements in the music. The high level re-ordering allows the top level structure of the music to be malleable, making total song length flexible to match the corresponding social activity that drives the progress of the music.

These techniques are applied to standard popular songs and assume a constant meter and tempo. The temporal reconstitution uses techniques from sampler looping, allowing synchronization and assuring musical rhythm. At the same time, a second order temporal organization takes the music out of the repetitiveness of simple looping systems and permits an evolving high level structure for the song.

This approach is applied as a technique for creating new musical content for the system, but can also be used to repurpose existing songs, or legacy musical content.

3. TECHNICAL DESCRIPTION

3.1 Malleable Music Server

The music generation engine is built using the Max/MSP real-time music environment and is a common engine to both projects described here. Instead of the classic configuration of taking user input from the mouse/keyboard or piano keyboard (MIDI) controller to synthesize music to be output to a soundcard and speaker system, the input/output of the engine are the network. Gestural input from the group of connected users arrives via XML or Open Sound Control (OSC) messages [34]. The engine reconciles the multiple control inputs to generate several parallel music channels that are streamed up to an Icecast type streaming audio server [35].

The music is sent in multitrack and mixed formats to the streaming audio server. They are accessible by the clients independently at different mountpoints of the streaming server.

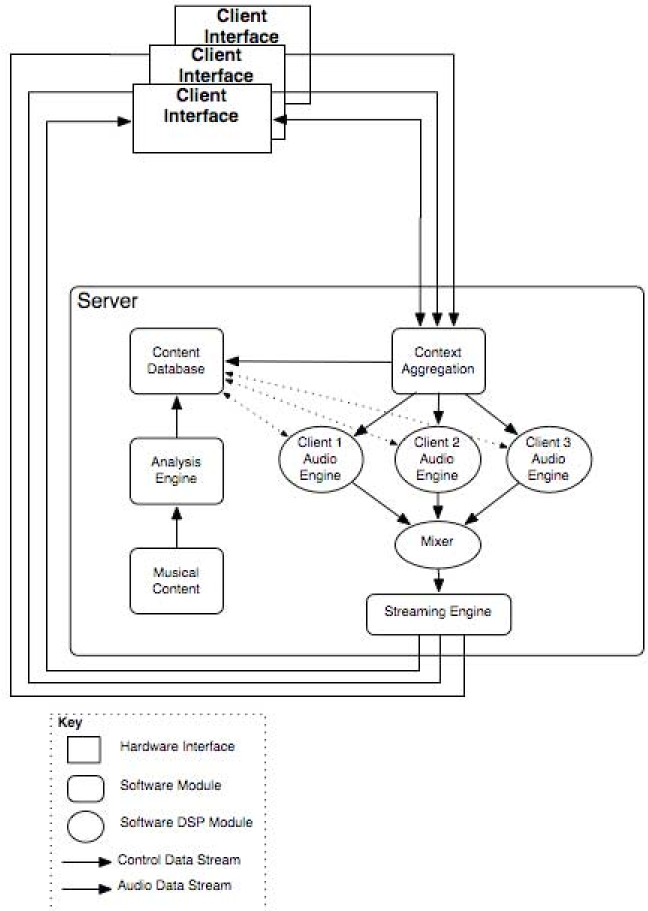

Figure 2. Malleable Music Server, with network control inputs and audio stream outputs

3.1.1 Source content analysis

Source content could be whole songs, individual tracks or loops. We assume these source contents have constant tempo throughout the music. We extract loops with the deduced tempo value and assign appropriate loop start points (i.e. start of measure). The system performs automatic extraction of musically interesting loops.

To conduct this task, we applied the following techniques:

- segmentation based on similarities of FFT vectors
- tempo detection by auto-correlation of FFT vectors
- attack detection based on envelope following

Independently, each of these three techniques is commonly found in digital signal processing applications. While each of these techniques is well established [36], the combination of these techniques gives an output useful for the real-time nature of our application.

Song segmentation is performed by processing statistical similarity maps of audio FFT vectors [37]. With simple image analysis techniques we can find points that correspond to significant changes in the music. The nearest strong beat from these points is used as a start point of loop.

We use the same similarity maps in order to perform tempo detection [38]. This time, we take auto-correlation of similarity to find highly correlated time interval to calculate the beats-per-minute (BPM) tempo value of the song.

Frequency domain processing used in the segmentation gives low time resolution, so we perform attack detection in the time domain. We take the filtered amplitude envelope to find candidates for start points of loops. Once we have found the start points, we can deduce the end point with estimated tempo information and the desired loop length.

3.1.2 Database storage

Extracted loop points and estimated BPM are stored in a MySQL database alongside additional meta-data (Artist, Title, Album etc) extracted from the ID3 tag of the MP3 files [39].

The client software can access the MySQL server over the network and retrieve a list of the available songs and additional song information. When a user selects a song to be played, the audio file will be loaded on the playback engine and the engine starts playing the song using tempo and segmentation information calculated in the analysis stage.

Playback on the server follows the main clock in the timing of every downbeat. Users' discrete operations, such as changing song, loop point, loop length, will be quantized and applied at a musical measure.

3.1.3 Audio rendering and streaming

Each of these audio synthesis modules uses a variety of synthesis techniques that allow tempo matching of the extracted loops and can be run simultaneously. Information about extracted loops and tempi is retrieved from the database. Control input is mapped to synthesis parameters, thus allowing real-time control of the synthesis modules. Three DSP synthesis modules are used: a frequency-domain phase vocoding stretcher, a time domain slicing sampler, and a speed-variable sample playback module. All modules allow tempo matching of the extracted loops. Modules with dotted borders represent inputs sources and output destinations of the audio engine. Low-dimensional control input is mapped to high-dimensional synthesis parameters using the "Gesture Mapping" module. Information about loop points and tempi are received from the analysis and database modules and sent to all DSP modules. Outputs from all DSP modules are mixed and sent to the streaming engine, which in turns sends the audio to all clients.

The audio rendering and streaming system is comprised of a set of components running on a server and a set of complementary components running on each client (Figure 2).

3.2 CC-Remix Client

Client software has three distinct parts: browser, controller and display. The song browser shows a list of available songs. Once a user connects to the server, the title of songs with additional information (album title, artist name) will come up. Users can browser the list and select a song he or she wants to play by double-clicking the song title.

Sliders give users the ability to control the process of playback on the sever side.

- loop position - select one extracted loops
- loop length - select among 1,2,4,8,16 bars
- EQ - High, Middle, Low Frequency

Figure 3. CC-Remix client interface with local user (L) and remote users (R)

The right side of the client software is for monitoring other clients' activities. Display section consists of three small parts, each of them resembling the controller part for the local client, so that the activity of the three remote collaborators can be visualized.

Participants can start and stop recording of their session on the server. Recorded sound is auto-encoded in MP3 format and published on the web site with information on the session (names of participants, authorship trace of utilized songs and samples).

3.3 Malleable Mobile Client

The mobile terminal device functions as an input device for user actions, as a graphical display interface, and audio rendering destination. It is network enabled using a standard 802.11b (Wi-fi) network card, permitting input, interface, and musical output to be synchronized in real-time with the server and other clients.

User input to the mobile terminal takes places via the touchscreen as well as by a sensor sub-system. The touchscreen captures voluntary input to the graphical user interface (GUI). System functions such as user log-in, as well as musical functions like slider manipulation take place over this channel. The sensor sub-system is a data-acquisition board, and allows involuntary input to the system. Force sensing resistors (FSR) capture grip pressure, while accelerometers sense gesture, tilt, and motion in three-dimensional space. This channel allows expressive information more typically associated with musical instruments to be captured and sent up to the music generation engine.

The graphical user interface gives visual feedback to the user. The first screen displays the available group of "friends" within range of the wireless network. Once the user has joined a session, musical controls and network status are displayed.

A variety of sensors are used to allow participation from the users through their bodily gestures. The choices of sensors and mapping techniques is motivated by a desire to integrate subconscious as well as volitional participation. Pressure sensors reveal information about how the interface is being held. Accelerometers and gyroscopes describe the user's periodic body movements (a swinging arm in response to the music's rhythm, or simply the periodicity of her gait), as well as irregular and sudden gestures. A touch-screen interface allows the user to interact with a simple graphical interface that visualizes the state of all participating users.

A basic gesture mapping principal at work is a the use of perceptual maps (described in [21], [40], [41]) to allow intuitive control of the generative software.

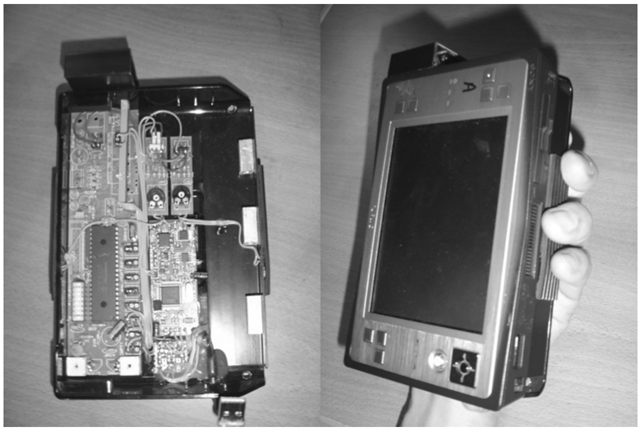

Figure 4. Malleable Mobile device with sensor subsystem (L) and touchscreen (R)

Gesture data from the sensors and touch-screen of the client interface are sent over the network and aggregated by the server. Gesture data is used select material from the content database and to control the audio synthesis engines. The sensor data aggregator module also communicates back with the clients in order to give visual feedback on the touchscreen interface.

The audio rendering engine is a network audio streaming client, capable of invoking multiple channels of MP3 format audio streams from the music generation engine. These multiple musical sources can be mixed by the onscreen GUI or by gestural input. The multichannel audio stream can then be mixed on each client with the touchscreen interface.

4. DISCUSSION

The projects described here allow groups of users to enter shared creative spaces. The network orientation of the systems poses tangible problems in attaining this goal to recreate the dynamic of "real" music making. Inasmuch as the participants are contributing to the evolution of a single piece of music in real time, the latency effects of network data transmission are inevitable. The question here is not whether latency can be eliminated, but in what ways it can be tuned to maintain musical satisfaction.

There is an inevitable delay before users hear results of their operation on the client side. It can hamper user's feeling of participating and controlling the process. In order to avoid this shortcoming, we put an indication of the delay on the client software. When a user made a change on these parameters, a timer comes up and shows the remaining time until the result of the operation will be audible. The delay time is estimated based on the buffer size of streaming audio decoder. This timer gives users a notion of network delay.

Although remote collaboration allows users to span geographical separation, it is not distance that is collapsed to zero. Instead, it is the network that enables long distance communication and collaboration. The sense of distance, then, needs to be apparent to the user. If distance somehow is not encoded in the participation of each member, not only is the appreciation of remote collaboration lost, but it becomes difficult to distinguish which musical part is contributed by whom.

These two needs, one of immediacy and the other of representing distance, seem to be diametrically opposed. One serves to provide the user a sense of *agency* for his own contribution to the music. The other serves to distinguish and give a *sense* to the remote partners' input [11]. To attain musical satisfaction, these two needs must be met.

In Social Computing the term *translucence* is used to describe the use of social information to support collective action [42]. Here we apply these concepts to music, and extend them to distinguish *reflexive translucence*, where an agent is endowed with a sense of his actions within the collective whole. Ultimately, a dynamic interactive music system will exhibit technical agency providing musical means for channeling humanistic agency of an individual within his community. The ability of the listener to distinguish his own contribution within the total resulting music is a crucial element in granting musical agency to individual users.

Concepts fundamental to building online communities that are relevant to music making include

- Shared goals
- Reciprocity
- Engagement
- Awareness
- Belonging

In the case of the systems presented here, shared goals are inherent in the common musical activity, and the live interaction allows reciprocity among the users. Engagement is a challenge with no guarantee – it is through the richness of musical experience that the listener can be drawn in. In an interactive system, this is contingent on a sense of agency, as described above, that creates the awareness of one's contribution to the whole. By building systems that are capable of reflexive translucence, we catalyze this awareness. When successful, the listeners will have a sense of belonging to the shared activity.

These are notions that are instinctive to musicians. This is the rationale in our taking an artist's approach to conceiving systems for end-users. Still, there is the question of how the activity is actually experienced, and how the resulting music sounds. We have conducted pilot studies of both systems under controlled conditions, with informed users. These results will be published separately.

The success of such systems is predicated not just on system design, but on the quality of the content – in this case the musical source material. We used well known pop songs as source material to maximize familiarity. From this, we wanted to leave the possibility for wide variation in mixing and collage. We found that it is not necessarily a required condition that every sound fits perfectly with another. An occasional cacophony leads users to try to find better combinations. In other words, it is effective to leave room for users to explore. What is clear is that system and content go hand in hand. If the electronics and media industries have been staking claims on the convergence of service and commodities, here is a creatively driven case where the musical "device" cannot exist independently of the musical content that is made for it.

5. CONCLUSIONS

Artists have always invented new forms in response to new media. Communities of users have a tendency to self-organize and create new forms of communications. Here we try to catalyze future creativity along these lines – this is the idea of *facilitating serendipity* applied to cultural production.

We feel that notions of social computing coupled with artistic creation can combine to point out ways in which technology evolution can be assimilated directly in cultural production, ultimately leading to possible new forms of musical content. We discuss how network and community infrastructures affect the musical creative process, and the implications for artists creating new content for these formats.

While the Creative Commons provides a legal structure for contribution distribution, it does not provide the means for content creation. The CC Remix project described here is a musical creativity tool that is consistent with the Creative Commons model. Malleable Music is based on the principle that music is a dynamic, living form of cultural expression. The human dynamics observed in social networks and mobile infrastructures are leveraged to become input to real time generative music creation.

The projects described here look at the creative potential of sensor systems, network infrastructures, and collaborative systems. They create new contexts for artistic practice that redefine the respective roles of artist and spectator. They respond to the claims of the democratizing force of technology by using such architectures to conceive works that open up the creative process in such a way that they include the end-user in a process that is not completed until the moment the work is beheld.

Despite these changes or shifts in the role of the author, composer, or artist, this does by no means obviate their existence nor put in question the notion of an artistic work. The goal is not to create totally user driven systems, nor random processes. Instead, the act of authoring for such systems requires the artist to conceive of open forms that nonetheless articulate his original creative vision, that become an act of creative expression all while letting go of absolute control, and forsaking making a frozen art object. Instead, the creative vision must remain intact through shifting contexts and situations while the work is rendered at run time as a function of environmental variables. The work of music is not finished until perceived, but is nonetheless an artwork, and is a work of the artist in question, albeit with the participation and contribution of the viewers and listeners.

This for us is the true notion of interaction – not a simple technological consideration, but a social one where deterministic and hierarchical processes are opened up to shared processes. By conceiving of artistic structures in this way, we open up the possibility for conceiving of new forms and formats. These forms are characterized by a modularity, where structure and asset are separated, where open forms allow for an implicit form. It becomes an act not just of empowering the audience, but of sensitizing the artist to a new set of responsibilities, one where the locus of the creative act is displaced. Creating work for these new contexts requires a coming to terms with the notions of sociability and community and their representations in abstract creative works.

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