The Telematic Circle – a university based collaboration for music performances over the internet

Jonas Braasch

Communication Acoustics and Aural Architecture Laboratory (CA³RL), School of Architecture
Rensselaer Polytechnic Institute, Troy, NY 12180, USA, Email: braasj@rpi.edu

The drastic improvements of telecommunication systems over the last decade have made live music collaborations over the internet feasible. The ability to perform with remotely located fellow musicians as if they where at the same location might be the most interesting aspect for musicians to become engaged this type of music collaborations. Under these circumstances, it is not surprising that the term telepresence is often used in the context of art projects that involve telecommunication. With the expectation regarding telepresence being very high, musicians become frequently frustrated that their new virtual environment tends to offer much less than their real world.

The inevitable communication delay over long distances, for example, is often named as a major cause for frustration. It consists of two elements: the pure transmission delay (propagation latency) and a signal-processing delay of the telematic apparatus (system latency). While much has been achieved to reduce the system latency of the underlying transmission systems to almost negligible values, it is the physical distance between two collaborators that determines the achievable minimal propagation delay. Even though electric signals travel with the speed of light, the resulting delays often exceed several tenths of milliseconds.

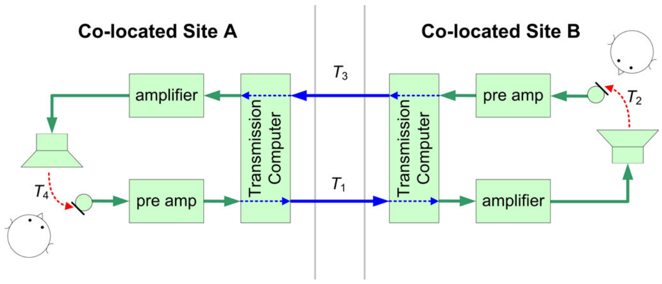

Figure 1: Feedback loop during a telematic transmission.

A simple calculation shows that a signal traveling on direct route between Rensselaer Polytechnic Institute in Troy, NY and our partner at CCRMA, Stanford University, Palo Alto, CA needs 14 ms for the distance of 4,111 km (direct line at the speed of light). The signal-processing delay, on the other hand, is determined by processes such as analog-to-digital conversion, data packaging, routing processes, and digital-to-analog conversion. With the adequate hard- and software, these processes altogether can take a very few milliseconds only. For traditional types of music, performers tend to agree that the threshold, above which it is difficult to play in sync between two remotely located sites, is about 50 milliseconds [1].

Audible colorations and echoes are the second big obstacle in two-way transmission schemes. The problem results from feedback loops that occur, when the signal of Microphone A at Site A is reproduced via one or more loudspeakers at the other Site B (T_1) and being picked up by Microphone B at this end (T_2), which is then broadcasted back to the original Site A (T_3) where it is re-captured by Microphone A (T_4, compare Fig. 1). Due to the transmission latency, the feedback becomes audible as echo at much lower gains compared to the feedback situation known from local public address systems. Music and other forms of art have been specifically designed to keep the problems of communication delays and feedback echoes under control. A relatively common approach is to combine music with dance [2,3]. The problems with regard to transmission delay and feedback echoes tend to disappear completely, if the music is performed only at one end, and the audience resides at the remote site which hosts the dance performance.

While the desire to interact with co-located musicians to the best possible extent as compared to an onsite performance is a legitimate goal, one could also have an alternative view on telecommunication applications for music performances. If we treat the telematic apparatus as a new type of musical instrument or instrument extension, the historical analysis of why other musical instruments have been well received in the past can help us to better understand how to optimize telecommunication systems for music collaborations. Retrospectively, every musical instrument that has been previously introduced has brought new affordances, which have made the instrument worthy to be developed, at the cost of other, negative features. The newly invented piano, for example, enabled musicians to play dynamically with a velocity-sensitive keyboard, but the lack of different registers for sound variation was often seen as a disadvantage, especially in the beginning. In the past, musicians and composers often coped with the new situation by writing music that would highlight the new affordances, while keeping an eye on its restrictions. By classifying the telematic apparatus as a musical instrument device, how can we apply the knowledge, gained from previous newly introduced musical instruments, to this type of system?

The biggest affordance of a telematic system is arguably that it offers to perform music with everybody across the globe. Unfortunately, its restrictions, which are to some extent unavoidabl, often outweigh the new affordances. In particular the previously mentioned bandwidth restrictions, transmission delays, and echo feedbacks are the most often named problems in music-based telecommunication. Under the rather simplistic concept of “telepresence,” one can hardly achieve a performance that is superior to the traditional on-site concept. While telepresence can help pragmatically to form collaborations across the globe without travel restrictions, this type of scenario will always be viewed as a flawed image of the real word, since many restrictions, most of all latency will always prevail. It can be assumed that high-budget projects will remain to have a budget to bring collaborators together physically, and once the initial pure technical excitement over this new technology will fade away, there is no longer the need to compromise for a telepresence collaboration, leaving this field to projects with lesser support.

In order to form a lasting genre out of the ongoing telematic music projects, we can no longer simply stay focused on compensating for the flaws of the telecommunication chain. Instead, we need to further elaborate the exciting affordances of the fairly new medium. A number of Media Arts projects are based on advanced concepts that emphasize the affordances of the telematic medium—take the classic video installation "Hole in the Wall" or Chris Browns "Teleson (2005)" [4] for example—, and we are confident that a similar road can be taken for contemporary music projects with traditional instrumentation.

Regarding my personal view, one of the most interesting aspects of our telematic collaborations was the exploratory aspect of the connection. The restricted communication certainly led to a high level of curiosity. On the one hand, we were able to exchange complex musical thoughts and perform together, but on the other hand we depend on the camera angle in a telematic scenario in contrast to an onsite performance where we are able to focus on preferred visual objects/musicians. A typical experience was to get a glimpse of an interesting event at the co-located site, and then having to wait a while for this event (e.g., a camera capture of an particular musician) to reappear. Privacy is another interesting issue in telematic collaborations. In an onsite performance, we are usually aware with whom we are sharing the space, but in a virtual environment participants sometimes appear out of "nowhere." Cultural exchange can be another important goal of telematic projects, and these type of collaborations have much in common with our desire to travel, namely to uncover unknown terrain. While travel is typically restricted to a limited amount in time, through telematic collaborations it has become easier to communicate with other cultures over a long period of time, without having to leave the own environment.

In order to improve the technical standard and accessibility of telematic systems, the Telematic Circle was founded in Summer 2007 between CCRMA, Stanford University (Chris Chafe), Deep Listening Institute (Pauline Oliveros), and Rensselaer Polytechnic Institute (Jonas Braasch). *Tele-Colonization* (performed at ICAD 2007 in Montreal) and *Dynamic Spaces* (performed at SIGGRAPH 2007 in San Diego) were two initial projects of the Telematic Circle. Meanwhile two further institutions, McGill University, University of California San Diego have joined the group. The low-latency audio transmission software *Jacktrip*, which is based on the low-latency audio server *Jack,* is used as a standard system *Telematic Circle* projects. Jacktrip was developed at CCRMA, Stanford University [5,6]. For the transmission of the visual data in DV quality, we commonly use video component of Ultra Video Conferencing, a software that has been designed by Jeremy Cooperstock's team at McGill University [7,8]. Although, Ultra Video Conferencing has been successfully demonstrated with a bi-directional A/V transmission of uncompressed HD quality, the immense bandwidth needed for this quality does not make it very practical for ongoing collaborations with weekly transmissions, and we decided to work with DV quality as an internal standard. Sound spatialization is performed using Virtual Microphone Control [9], and currently we are working on the realtime implementation of a microphone-based sound-source localization system [10] to track the musicians' positions for the spatialization procedure. The system can also be used to calibrate the sound pressure levels of the participating musicians at the remote end by comparing the measured sound pressure levels at both ends' microphone arrays. Jacktrip, Ultravideo Conferencing, and ViMiC can be executed on the same computer with the Linux *Distribution Fedora Core 6* as operating system.

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