JamSpace: A Networked Real-Time Collaborative Music Environment

Michael Gurevich
Institute for Infocomm Research
21 Heng Mui Keng Terrace
Singapore 119613
mgurevich@i2r.a-star.edu.sg

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Abstract
The motivation, design, implementation and analysis of a networked environment for real-time music collaboration are presented. JamSpace provides a simple hardware and software interface that allows novices to play music together anonymously from isolated locations connected by a local network. The low-latency conditions of a local network allow for real-time rhythmic collaboration. This in turn facilitates satisfaction of the design requirements of accessibility to novices as well as privacy and anonymity.

Keywords
Interactive music, interaction design, media space, social computing, virtual environment

ACM Classification Keywords
H.5.3 [Information Interfaces and Presentation (e.g., HCI)]: Group and Organization Interfaces---Collaborative Computing; H.5.5 [Information Interfaces and Presentation]: Sound and Music Computing.

Introduction and Rationale
The initial motivation for JamSpace was to create a distributed music application for a large local area network (LAN), to be used by amateur or novice musicians for recreation. Precedent network music applications are mostly created by musicians for their own use or are intended for experienced musicians [1].

Music is an inherently social activity. Recent technologically-mediated phenomena such as iPod jacking [18] and playlist sharing have begun to restore social aspects of music listening from a grassroots level. Technology can also mediate and improve the casual social nature of *making* music with interfaces that allow novices and amateurs to overcome inhibition and intimidation when jamming face-to-face. The design of JamSpace seizes this opportunity by stationing terminals in private spaces, and through an interface that ensures privacy and anonymity. Stations located in public areas also enable public performance.

Simple collaborative rhythmic musical scenarios, such as drumming circles, are among the easiest ways to engage musical novices. Technology has successfully enhanced this concept in a situated installation piece [4], but it does not appear to have been extended to a virtual space. The low-latency (delay) characteristic of a LAN allows JamSpace to address the challenge of rhythmic music in real-time over a network [9]. With this technology, we find an innovative solution to two key design criteria for an accessible collaborative music interface: 1) constraint over musical material, and 2) user control over the level of interactivity. The first criterion is necessary to ensure accessibility to novices [3]. The second addresses the amateur musician's paradox: "I want to play with other people, but I don't want to be embarrassed." In its intended environment of a hotel, apartment or office building, the ability to join the JamSpace from the comfort of one's own real private space becomes more than a cliché.

The fundamental novelty of JamSpace lies in its ability to provide real-time, anonymous musical interactions with enough constraint to be accessible by novices.

Context

JamSpace draws on a number of areas in the theoretical framework and formulation of its design. Its situation in the relevant context of the domains of network music and media spaces are described below.

Network Music

Music creation involving computer networks has existed for some time [1,7]. Previous efforts can be categorized by the use of local or remote networks; real-time ("live") or non-real-time ("offline") collaboration; and audio or synthetic sound material.

LOCAL VS. REMOTE

Applications for LANs tend toward customized avant-garde performance systems [2,7]. Distributed applications can potentially include large numbers of users via the Internet, and provide radically new modes of interaction [10,16].

REAL-TIME VS. NON-REAL-TIME

The temporal aspects of networks are continuous, and it is difficult to define a precise boundary between real-time and non-real-time (the terms synchronous and asynchronous are avoided, for these have a different connotation in music). For the purposes of this paper, real-time is defined as a best-effort attempt to have a local control change cause an immediate response on a remote computer. Inherent limitations of the Internet present a challenge to real-time performance. The Internet is currently better-suited for non-real-time collaborative composition, artificially-synchronized pseudo-real-time performance [14], or real-time pieces with synthetic sound that can account for latency in their design [10,16]. Real-time jamming is mainly restricted to live performance systems on LANs [2,8].

Recent experiments have shown that 10 ms of delay in sound transmission between remote performers is optimal for tempo consistency given a simple rhythmic task [9]. Average measured transit times of network packets on a LAN across a university campus are less than 1 ms. Trans- and inter-continental jams under significantly longer latency conditions have also been performed [15], but these tend toward free improvisations without steady tempo or meter. As in early experimental efforts using analog networks [13], these implicitly embody the notion that extending a collaborative environment to a virtual space creates a different set of affordances than face-to-face interaction [6]. Tanaka [16] makes an analogy to traditional music, where there is a strong coupling between genres or styles and the spaces in which they are performed.

AUDIO VS. SYNTHESIS

Until recently, real-time processing and delivery of high-fidelity audio were limited by computing power and network bandwidth. Most early network-based music efforts therefore used synthesized sound that could be rendered locally on each machine or on a separate synthesizer [2,11]. The network then only had to transmit much more compact control information, usually in the form of MIDI. Among the humblest systems was NetJam, which allowed users to edit MIDI files by email [11]. A now-defunct system known as ResRocket claimed to allow users to jam in real-time via the Internet using MIDI, though they had to cope with long and unstable delays inherent to the Internet.

Current systems using audio either make use of the high bandwidth and low latency of a LAN [8] or of a dedicated research network [15] in order to facilitate interaction in real-time, or else use non-real-time (or "fake-time") technology [14]. While it does not provide the opportunity to jam with live instruments, synthesized sound has the advantage of engaging users who do not have musical instruments. Furthermore, it allows a deeper level of interaction design, where the sonic content and available controls can be appropriately designed for the spatial and temporal characteristics, as well as the users of the system. This can foster novel interactions, as in [10].

Media Spaces and Virtual Worlds

Media spaces typically consist of isolated locations linked by audio and video connections in order to create the metaphor of a seamless physical space for the purpose of collaborative work. Similarly, virtual online gaming worlds generally use simulations of real-world places and interactions. While these environments provide users new personas and possessions in a virtual space, the interactions essentially try to mimic those of the real world. It has long been recognized that media spaces are distinct from their real-world counterparts and therefore afford different types of interactions [6], but network-based interactions are still criticized as being "unnatural" or inherently inferior to face-to-face actions [12]. Many such interactions are indeed unsatisfactory, but this can be attributed to the fact that these systems do not adequately exploit the unique capabilities of their underlying technologies. There is a clear need for new interactive experiences that exploit the particular affordances of collaborative network tasks. Distributed music is a natural example.

Implementation

Hardware

Each JamSpace terminal has a JamPads hardware interface consisting of a flat surface with 12 raised

pressure-sensitive pads. The pads can be pressed or struck with the user's hand, triggering a note with loudness proportional to force. The pads are mapped to percussion instruments or to the notes of the musical scale, depending on the instrument selected by the user. An LED below each translucent pad is illuminated when the pad is struck. Any track in the JamSpace or another player's real-time jam can be assigned to the LED display on the pads, helping the user to visually and aurally learn other parts. Novices can learn to "play along", the first step in creating, in very little time.

Software

The JamSpace software consists of a client GUI application and a separate server application. The client GUI consists of 5 components: a scratch track for the local user, a set of tracks from the JamSpace, an interface for making connections to the server, tempo and metronome settings, and a matrix for maintaining real-time jams with other clients.

TRACKS

Users have one scratch track, into which they can privately record and play back one phrase. A user may also choose to submit this track to the JamSpace. Tracks in the JamSpace have a duration of one phrase, and loop until they expire after a period of time, but may be renewed through a voting mechanism. A server queue manages the finite number of active tracks in the JamSpace. Whenever there are less than 4 tracks in the jam, computer-generated tracks are added. Track data is displayed on a timeline interface.

TEMPO

A global tempo is maintained by periodic sync messages from the server. 8 beats make up a phrase, and there is a cycle of 4 phrases. Each user can activate any of 3 click tracks which tick at the phrase, beat, and half-beat time scales. Any user can request a tempo change by typing a new tempo in the box. Like track renewals, tempo is managed by user voting.

REAL-TIME JAMMING

Users can jam to their custom looping track mixes or with other live users in the JamSpace. Users may also broadcast their jams, in which case all other users can choose to listen to them in real-time. Users choose an icon from a pre-defined list to represent themselves in the jam. A unique icon appears beside all tracks that a user has submitted to the JamSpace, as well as beside her place in the connection matrix. This affords direct musical communication and development of taste, style and identity, while protecting privacy and anonymity.

Analysis

JamSpace's key feature is that it can flexibly represent a spectrum of spaces, from private to personal to shared to public. JamSpace does not use the spatial metaphor of remote collaboration literally. There is no graphical representation of the space or its occupants as in a virtual 3-D world, but like an Internet chat room or message board, it represents a place where people can go to exchange information. In Buxton's terms, it represents a shared *task space*, rather than a *person space* [5]. Unlike real places and most media spaces, the JamSpace user has the ability to define his or her own version of the space and level of interactivity within it. A normal user remains completely anonymous but may engage in a variety of interactions within the JamSpace: passive listening, mixing, privately playing along, contributing self-recorded tracks, broadcasting a jam, and potentially playing in a public place.

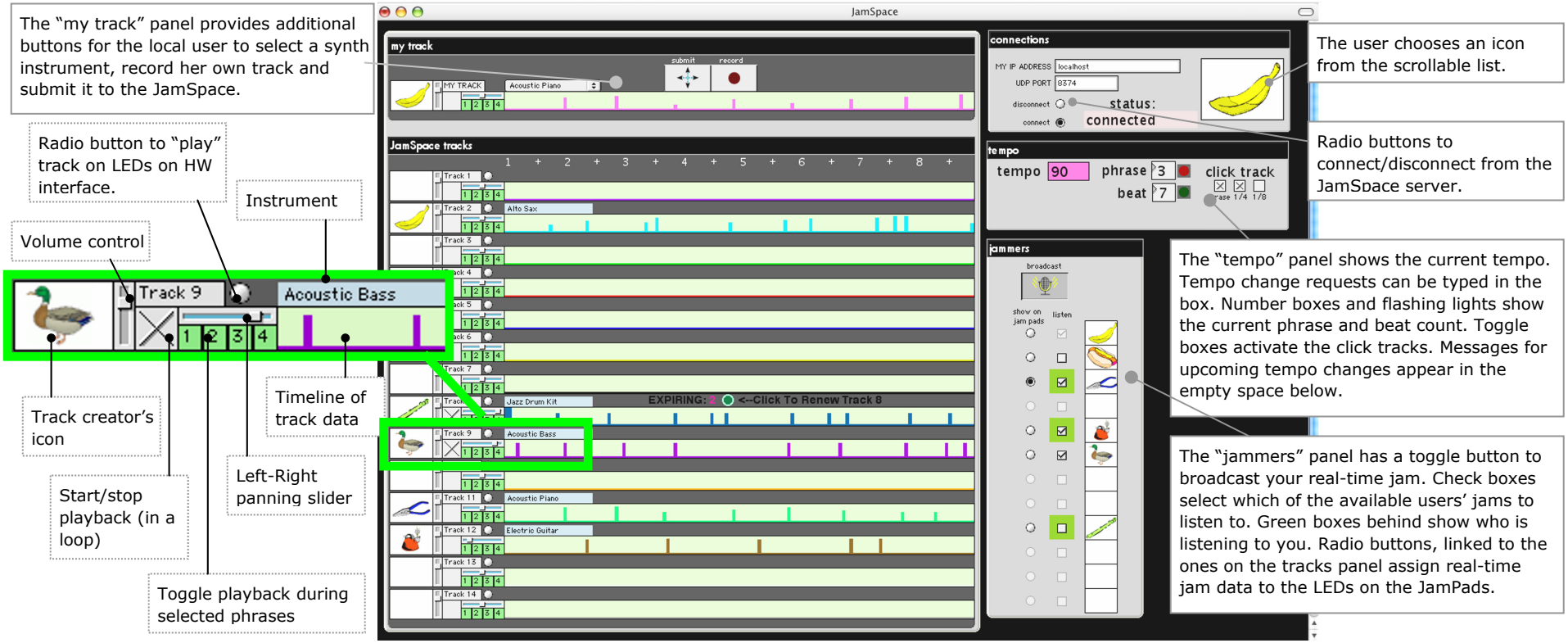

figure 1. JamSpace Client GUI

The information that can be exchanged in JamSpace is extremely constrained. A user's identity is limited to an icon selected from a pre-defined list. The repertoire for communication consists of a collection of sound synthesis models with simple controls. To the extent that it is practicable, JamSpace tries to follow the principle of "low entry fee with no ceiling on virtuosity" for computer music interfaces [17]. This implies instant gratification, as in a toy, along with the simultaneous ability to sustain interest over long periods of time.

Blaine and Fels [3] argue that this principle becomes less applicable in publicly-situated collaborative interfaces, where the pattern and period of engagement make ease of learning paramount and virtuosity irrelevant. Being collaborative and oriented toward novices but not publicly-situated and therefore available for longer periods of engagement, JamSpace targets a more modest tempering of the ceiling than Blaine and Fels advocate. Low entry fee is assured by both constrained content and user-defined levels of

interaction. These in turn allow for enough complexity to sustain longer periods of engagement.

Evaluation and Conclusion

The motivation, context, and design of a real-time collaborative virtual music interface have been presented. The overall design philosophy was to begin with an available technological platform (local network) and application area (recreational music), and then leverage their affordances to find novel interactions that address the requirements of the scenario. JamSpace is a work in progress. The system is currently being deployed for evaluation with two actual hardware interfaces, along with a number of others using a software emulation of the hardware. Initial impressions show the system to be engaging for both novices and experienced musicians. A systematic evaluation is forthcoming.

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