SIMPLE: a proposal for a Synchronous Internet Music Performance Learning Environment

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1. **Abstract**

   This paper proposes an Internet based e-learning environment for building ensemble playing proficiency for musicians. With the growing availability of broadband connections, the Internet offers new opportunities for musicians to play together synchronously from disparate locations. An e-learning environment for ensemble music performance would facilitate and simplify the creation of ensemble performance skills by offering a number of services for musicians. It would emphasize the learning of tacit musical knowledge particularly important to improvisational music performances. The heart of this e-learning initiative is the use of a proposed new tool set to enable real-time synchronous rehearsals among musicians at different locations. Asynchronous Internet tools would support this learning environment for purposes of system training, ensemble creation, and performance evaluation. The proposed name for this toolset is SIMPLE: the Synchronous Internet Music Performance Environment. Using the SIMPLE System musicians will be better able to learn to perform music that "has a good beat and you can dance to it."

2. **Introduction**

   There is significant amount of pedagogy dedicated to teaching people to read music and play musical instruments. Most of this involves the classic lesson, practice and recital format for developing musical skills. However, there is little formal training for musicians to learn the craft of playing and performing in small popular musical groups, in particular those musical idioms that rely on group improvisation including jazz, blues, and some rock music.

   Improvisational music performance requires a tacit knowledge of musical elements which are difficult to describe. Playing music successfully in an improvisational setting involves more than just comping (playing rhythmically in the background) and soloing (an improvisational lead part). It involves a keen rhythmic sense, and the ability to play a part that fits with parts that others in the group are playing at the time. It's not only about knowing the meaning of unique popular music terms like "feel the groove" and "play in the pocket", but also being able to execute a performance that complements the other musicians and satisfies the listening audience.

   The traditional way for musicians to improve their tacit knowledge of playing in a small music group involves learning by doing. Once the budding musician has a basic proficiency on his or her instrument the next challenge is to find others that would be willing to let him "jam" (the process of creating music in an improvisational setting). This requires that the student locate other musicians willing to play in the same time and place. The "garage band" tradition is an outgrowth of novice musicians trying to learn playing in a private setting. Other learning opportunities include "open mic night" performances, and asking established groups for an opportunity to "sit-in" during a performance.

   All of these traditional ways musicians have used to learn about ensemble performance requires that musicians play together at the same time and in the same location. The SIMPLE system provides an e-learning environment that provides more synchronous rehearsal opportunities without the constraint of musicians needing to be together at the same physical location. Furthermore, it provides a tool set that facilitates the creation of rehearsal opportunities, as well as a mechanism for providing feedback on the progress being made to the individual users of the SIMPLE system.

3. **Key Concepts**

   There are a number of key music and technology concepts necessary to understand the problem of providing an e-learning solution for music ensemble playing. These key concepts are the concepts of musical performance, digital audio, media streaming, MIDI, and broadband. A basic understanding of these concepts will help us better understand the challenges of this e-learning problem.

   **Musical Performance**

   The act of arranging sounds in time to create music is one of humanity's oldest art forms. For millennia, the performance of music required that people be present in the same place, at the same time, to listen to music as it was being played or sung. The asynchronous nature of the World Wide Web now gives us the opportunity to provide new ways to create musical performances. However, our new Internet and digital media also present new challenges for collaboration and e-learning.

   **Digital Audio**

   The creation of the CD audio format began a rush to create recordings that could be stored as digital audio. The original digital audio format used for CD's created sound files that required approximately 10 megabytes of data for each minute of stereo sound. The slow modem speeds used to access the World Wide Web pushed the development of audio compression...
Media Streaming

A popular technique for delivering compressed digital audio over the Internet is audio streaming. Audio streaming delivers compressed digital audio data in packets timed to use a defined bandwidth. This defined bandwidth attempts to present the highest quality audio experience using minimal bandwidth. Audio streaming usually delays the transmission of digital audio using buffering techniques to present digital audio in a near synchronous format. A relatively high quality monophonic audio can be transmitted using streams of less than 64kbps. While this level of sound quality is nowhere near the quality of a music CD, for many listening purposes it is more than adequate.

MIDI

Created in 1983 by musical instrument manufacturers, the Musical Instrument Digital Interface (MIDI) was originally conceived as a way to have one electronic keyboard control another. However, the data format created for the MIDI standard has become one of the most important standards for storing data about the performance of a musical work. MIDI data does not record sounds; instead it records performance information such as note on, note off, program change, and velocity of a key strike. Since only performance information is recorded, MIDI files typically require substantially less data storage than digital audio. MIDI was designed to transmit a data stream of less than 32kbps.

Broadband

There are now a number of network technologies that provide more affordable, higher speed Internet network access to homes and businesses. These network technologies include DSL services, cable modems, and satellite Internet services. These services typically provide Internet connectivity in the range of 256kbps to 1Mbps. Collectively these higher speed services are referred to as broadband connections. The SIMPLE solution requires that users of the system have a broadband connection to the Internet.

4. Previous research

The advent of music recording techniques in the last century gave us the opportunity to listen to musical performances some time after the actual creation of the musical performance. Along with the development of technologies for music recording and playback, came innovations to use these new technologies to aid musicians in developing their instrument playing proficiency and their ability to perform in musical groups.

Initial efforts to use technology for music instruction focused on asynchronous approaches study of the same piece of music at different times. A well-known effort to develop an asynchronous way to aid helping musicians learn to play in an ensemble setting was the "Music Minus One" series of recordings. Originally popularized in the 1950s, "Music Minus One" records were recordings of popular songs with a single part missing. Musicians could play along with the records and develop their playing skills (a.k.a. "chops"). This approach has been updated by software like "Band in the Box" that plays music on a computer with the advantage of using various keys and tempos. The development of the Internet offers additional promise for musicians to learn ensemble playing skills.

Network systems present problems and opportunities for music instruction. Technical problems most often affect attempts at providing synchronous instruction (at the same time, but in different places.) These problems result from limited networks speed and capacity and include the possibility of network delays caused by network congestion, packet switching and routing. Attempts to use networks for music instruction have approach the problem in four ways: asynchronous solutions, synchronous solutions using MIDI, synchronous solutions using dedicated networks, and near synchronous Internet solutions. Before we examine the details of the SIMPLE system, a look at previous efforts to provide music instruction via e-learning will help frame the context for the proposed solution.

Asynchronous Internet solutions,

In 1996 David Beckstead described a method for using e-mail and the Internet to teach music composition. Students would send files of MIDI data to Beckstead for comments and critique, and revise their compositions based on his suggestions.

In 1999 Young and Fujinaga described a system for using the Internet MIDI performance data from two MIDI pianos to conduct piano master classes. This approach essentially has the student and teacher in different locations, each taking turns at playing and transmitting MIDI data of their performance.

Rocket Control by Rocket Networks is a commercial application that uses digital audio software and the Internet to create an asynchronous virtual recording studio. Musicians in disparate locations can use Rocket Control software and services lets musicians record tracks on a digital audio recording as if they were working in the same recording studio. While not an e-learning system, this system is notable for its use of the Internet to record performances destined for CD quality audio.
Synchronous solutions using MIDI

In 1996, the Multimedia Network Group at the University of Virginia described a system under development using the Mbone multi-cast Internet protocol to provide near-synchronous transmission of a modified MIDI data stream called Mmidi. Mmidi negotiates an optimal delay for all players at the start of a session. At each end connected to the session, the Mmidi software plays MIDI data it receives and then transmits MIDI created locally to other players. While this approach is limited to performances with MIDI instruments, it does outline an approach that could be useful for e-learning.

A more recent (2000), and ambitious project using MIDI is a system called PODIUM. The PODIUM system also uses a multi-cast approach to synchronizing MIDI performances, but also sends graphic avatars of performers to musicians using the system. This type of visual feedback attempts to overcome limitations of audio only ensemble playing. Designers of PODIUM report that in their tests they were able to keep network latency to under 30 milliseconds for up to 15 performers, each playing up to 5 note polyphony in a local area network environment.

Synchronous solutions using dedicated networks

Recording studios today can set-up point-to-point ISDN connections for recording a musician's performance at remote location. These one-to-one connections can transmit a single audio stream at a rate of 64-128kbits per second. Starting in 1995, Finland started using ISDN video-conferencing technology to deliver instruction to remote classrooms in Finland. This included specialized instruction in music. Researchers reported good sync between and audio for music instruction was achieved at data rates in the range of 256-384kbps. With good planning and preparation both teachers and students reported satisfaction with video-conferencing for music instruction.

Researchers in Germany and Switzerland conducted even more extensive testing of high speed video conferencing technology to conduct rehearsals of student and professional music groups in Geneva and Bonn in 1999. Using a 24megabit ATM telecommunications link, researchers report success using a remote conductor as well as rehearsing orchestral musicians in different locations. Clearly this level of network performance is currently out of reach of the vast majority, but this study does report that this technique can be successful for providing actual rehearsal time before a live performance.

Near synchronous Internet solutions

In 1998, the Robust Audio Tool developed at the University College London demonstrated the use of the telecommunications conference call model for simultaneous transmission of audio using the Internet MBONE protocol. Researchers sought to overcome real-time network problems of end-to-end transmission time, packet loss, other Internet problems, while at the same time optimizing audio quality.

Perhaps most germane to our discussion of the SIMPLE System is the Orchestra! System developed at the University of Florence in 1998. Orchestra! was designed to emulate a music rehearsal environment over the Internet. Orchestra uses user produced audio streams to deliver near real-time synchronous audio. Starting with a single source (typically drums), successive audio tracks are mixed into the audio stream and passed along. Orchestra is targeted at amateur musicians, and includes a number of tools to support the collaborative learning environment:

- Contact and registration tools for creating and registering for ensembles
- Music processing tools for playing recording and mixing
- Session Tools for managing an interactive session including text chat capability.

Although Orchestra! is a prototype, it appears to address many of the technical requirements for providing synchronous audio for the SIMPLE system. Additional investigation of Orchestra! is clearly needed to determine if it can play a role within the SIMPLE System.

Another approach to using audio streams to create synchronous musical performances over the Internet has been proposed by Marko Provosnik (2000). Provosnik proposes a system of centrally communicating servers connected to client computers that listen and record audio in a near synchronous environment. This approach to audio streaming also merits investigation as a possible technique for incorporation into the SIMPLE System.

The principle technical challenge for the SIMPLE system is to facilitate an audio streaming solution that allows the creation of a music stream from multiple players at different locations with minimal network delay. My own experiments with digital delays indicate that it is nearly impossible to hear delays of less than 20ms using highly percussive sounds such as drums. Less percussive instruments such as horns may be able to tolerate delays of up to 100ms. Whether the Orchestra!, Provosnik, or some other Internet streaming audio solution will be able to deliver this level of performance in a broadband Internet environment remains to be determined.

5. The SIMPLE System Scenario

The principle e-learning challenge is to create a learning environment that is truly simple. The technology should be easy to use and largely transparent to the task of improving ensemble playing proficiency. It needs to include mechanisms to provide
technical support as well as provide feedback so that learners can evaluate their progress. Here is a hypothetical case to help illustrate how the SIMPLE system would work in practice.

Reed the music student

Reed is a freshman at a small liberal arts college in the Mid-West, with an "undecided" major. Reed plays saxophone, and played in his high school band, but now finds he would like more opportunities to perform in a small musical group. As a Freshman in college, Reed has a found a guitar player friend he can jam with, but finding a bass player and drummer willing to play with a guitar and saxophone player with little performing experience has been difficult.

Reed found out about the SIMPLE system just over a month ago. After completing the on-line tutorial, Reed successfully played in two on-line jam sessions, and was so excited by the opportunities that he signed up for a six month support and evaluation subscription. This subscription includes one music workbook, up to four synchronous sessions per month, and one master session per month with an experienced music professional. The subscription also lets Reed submit two performances per month to his music advisor for evaluation. Reed submitted his last performance to his music advisor. The feedback from his advisor was encouraging, and earned Reed a level two proficiency certificate.

Today Reed finds himself with about three hours of free time and has decided to log onto the SIMPLE system to see if it might be possible to pick-up a one hour jam with like minded musicians. Before he looks at the bulletin board for other like minded musicians looking to put together an impromptu jam session, Reed decides to see if there are any openings in the master sessions scheduled for today. He's in luck! There's an opening for level two saxophone player in a jazz/blues master class starting in about half an hour. This master class features professional guitar player Paul Barrere. Barrere is renowned as guitarist for the rock band Little Feat, and recently toured with Phil and Friends. Paul is using the SIMPLE System from his home in Los Angeles.

Reed enrolls for the open seat in the ensemble that is limited to a maximum of six players. Reed notices that the other players are in places such as Boston, Tokyo, Swope, Virginia, and even someone else from his own campus!

Reed gets his saxophone, microphone, and computer system prepared for the session that will begin in just a few minutes. He gets his SIMPLE workbook "Jazz and Blues Favorites, volume 1" ready. Next, he tests his connection to see if he has an acceptable network connection. He's never had a problem before, but this time the system reports a 120ms delay. Reed goes to the support chat room and reports the problem to the technician on duty. The tech checks the network connection to Reed's PC and, not finding a problem, ask Reed if he can log onto Reed's computer remotely. Reed agrees and the tech discovers that another application running on Reed's machine is causing the delay. Reed quits that application, and sees he now has acceptable network response.

Within a few minutes, the other members of the group meet in the chat room. Barrere suggests they start by playing Miles Davis's jazz classic "All Blues", starting with an 8 count. The musicians hear 8 ticks from their computer establishing the beat, and then begin to play.

After the session, Reed is elated! After some initial confusion about who would play which solos when, Barrere got the group to slow down, listen to each other, and really start to play like an ensemble. While most of the tunes the group played were fairly simple selections, Reed felt that his solos had really worked for the music. He decided to send the archived performance to his advisor for an evaluation. He included a note to his advisor asking for suggestions on things he should practice that would help him prepare for his level three proficiency certificate.

6. The SIMPLE Innovations

The scenario above describes a number of innovations included in the SIMPLE system. While building on technical developments for real-time audio streaming applications, the major advance of the SIMPLE system is to position these technologies as part of a comprehensive e-learning solution designed to promote the advancement of music ensemble playing skills.

The SIMPLE System includes a number of tools and approaches that help facilitate e-learning for music ensemble playing. The e-learning approaches include the opportunities for synchronous group learning, mentoring and advising for evaluation, a certificate program for demonstrating achievement, as well as training, organization, and support services. The technical tools include web services, on-line chat, bulletin boards, and, most important, a synchronous multi-point Internet audio streaming solution.

The SIMPLE Solution provides a value-added approach to providing e-learning services for aspiring amateur musicians. While student feedback will be important to developing and refining the system, the ultimate evaluation of the SIMPLE System's success will be its ability to develop and sustain a business model for ongoing operations and development. A subscription model is one possibility, but other models need to be tested to determine the best approach.

7. Conclusions
The proliferation of broadband Internet connections and audio streaming technologies suggest that the development of the SIMPLE System is feasible. The Simple System includes e-learning solutions and suggests a possible business plan to support the on-going development and delivery of the system. Clearly, more investigation and development is needed. The proposed SIMPLE System describes a possible e-learning solution for developing ensemble playing skills and the tacit musical knowledge particularly important to group music performance.


[2] For more information about the history of audio recording techniques see the Audio Recordings section of the Recording Industry Association of America web site at [http://www.riaa.org/Audio-History-1.cfm](http://www.riaa.org/Audio-History-1.cfm)


