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Folkways in Wonderland: a cyberworld laboratory for ethnomusicology

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***Abstract*—In this paper we describe a musical cyberworld — a collaborative, immersive virtual environment for browsing musical databases — together with an experimental design launching a new subdiscipline: the ethnomusicology of controlled musical cyberspaces. Research in ethnomusicology, the ethnographic study of music in its socio-cultural environment, has typically been conducted through qualitative fieldwork in uncontrolled, real-world settings. Recently, ethnomusicologists have begun to attend to the study of virtual environments, including pre-existing cyberworlds (such as video games). However, in this paper, we adopt an unprecedented approach by designing a custom musical cyberworld to serve as a virtual laboratory for the ethnographic study of music. By constructing an immersive cyberworld suitable for ethnomusicological fieldwork, we aim for much greater control than has heretofore been possible in ethnomusicological research, leading to results that may suggest better ways of designing musical cyberworlds for research, discovery, learning, entertainment, and e-commerce, as well as contributing towards our general understanding of the role of music in human interaction and community-formation. Such controlled research can usefully supplement traditional ethnography in the real world.**

***Keywords*-Ethnomusicology, ethnography, fieldwork, cyberworlds, world music, collaborative virtual environment, groupware, Wonderland, spatial music, immersive environment, hypermedia**

I. Ethnomusicology of — and through — Cyberworlds

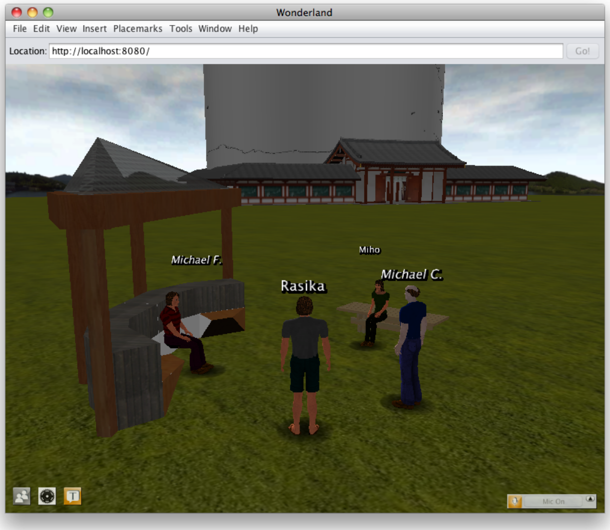
Ethnomusicology can be defined as a branch of the human sciences that studies music in its social-cultural contexts, especially the ways in which people interact through shared musical experience and discourse about music, and how music thereby facilitates the emergence of social groups and communities [1]. Methodologically, ethnomusicology typically centers on qualitative research, mainly ethnographic fieldwork relying upon participant-observation and informal interview techniques [2], [3]. Variables typically cannot be controlled.

Cyberworlds open new avenues for ethnomusicological research. A cyberworld is typically a social space, with important ramifications for real social interaction and culture-formation, and thus of tremendous concern to many scholars working in the social sciences and the humanities [4], [5]. As social cyberworlds incorporating music become increasingly prominent, the important task of studying them falls to ethnomusicology. The ethnomusicologist seeks to comprehend the social dimensions of musical cyberworlds, to enhance their musical functions, and to further the understanding of music in social-cultural context more generally, since cyberworlds are closely related to the real world, and impact it strongly.

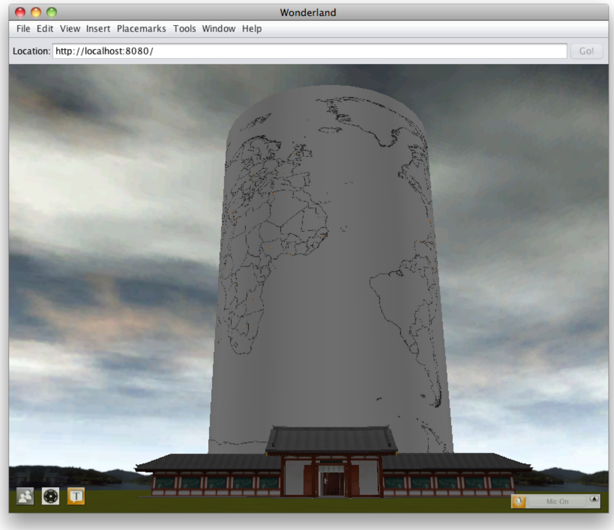
Indeed, this task has already begun, with several recent ethnomusicological studies of online communities and virtual gaming [6], [7], as well as reflections on the virtual fieldwork enterprise [8]. However until now ethnomusicologists have studied "naturally occurring" cyberworlds, rather than constructing cyberworld laboratories for research. For the most part, ethnomusicology has not relied on controlled experimentation at all. Subject matter, methodology, and technological limitations have largely precluded ethnomusicologists (like historians) from this sort of scientific research, by which variables may be manipulated and their relationships examined.

Today, however, it is not only possible to build a cyberworld as the focus for ethnomusicological research, but necessary as well, as cyberworlds represent contemporary musical reality to an increasing degree. Musical cyberworlds can enable a new paradigm for ethnomusicology. Instead of observing musical interactions in the world-as-encountered, one can study a virtual world whose parameters are, to a great extent, under the researcher's control. Such a cyberworld becomes a laboratory for ethnomusicological research, a means of better understanding other musical cyberworlds, and providing — for the first time — a controlled environment for the ethnomusicological study of virtual community.

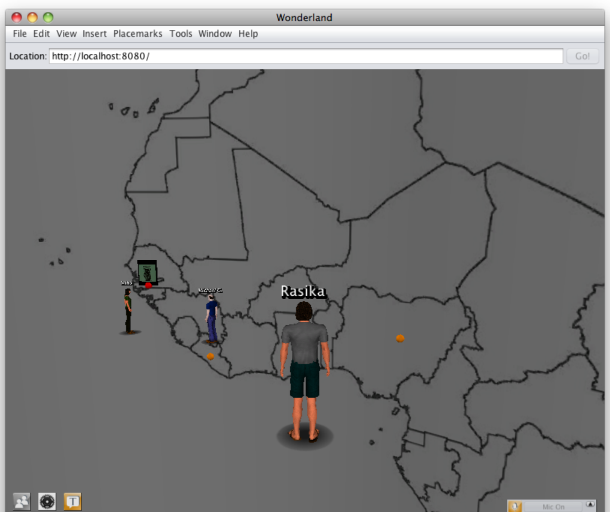
In this paper we describe Folkways in Wonderland (FiW), a cyberworld laboratory for ethnomusicology, and its deployment for the controlled study of musical interaction and community-formation in an immersive 3D collaborative virtual environment (CVE).



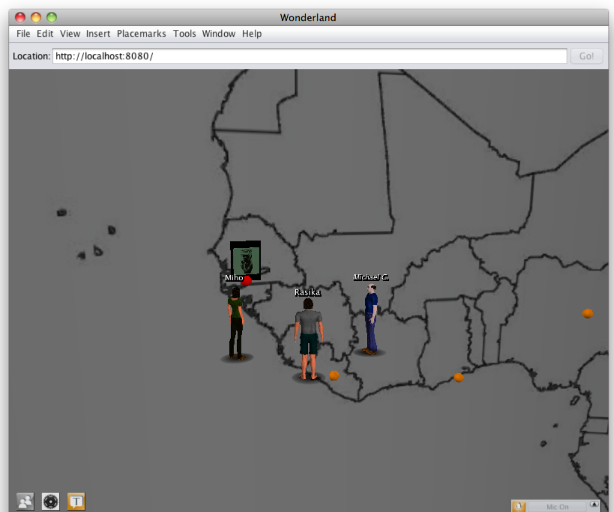
(a) A discussion park enables quiet conversations among avatars populating the cyberworld.



(b) Exterior view of the cylindrical map



(c) Inside the cylindrical map, showing West Africa. Tracks are represented by colored dots.



(d) Collaborative listening. The red dot (located in Senegal, below the album cover) represents the track currently selected by our avatar (Rasika).

Figure 1. Entering Folkways in Wonderland

II. Browsing Music Databases through an Immersive Cyberworld

As immersive 3D virtual environments and online music networks become increasingly popular, it behooves researchers to explore their convergence: groupware music browsers populated by figurative avatars. Using Open Wonderland,[1] a Java open source toolkit for creating collaborative 3D virtual worlds, we developed an immersive virtual environment (similar to the "Music in Wonderland" proof-of-concept developed by Sun Microsystems) where user avatars can interact freely while browsing a musical database.

Our cyberworld music browser comprises a cylinder upon which a rectangular map of the world is texture mapped. Musical tracks are geotagged (according to location of performance, performers, or style), and a track marker (a red or orange dot) is appropriately positioned on the map at the correct latitude and longitude. This marker is simultaneously a sound source, a virtual stereo speaker that

[1]http://openwonderland.org

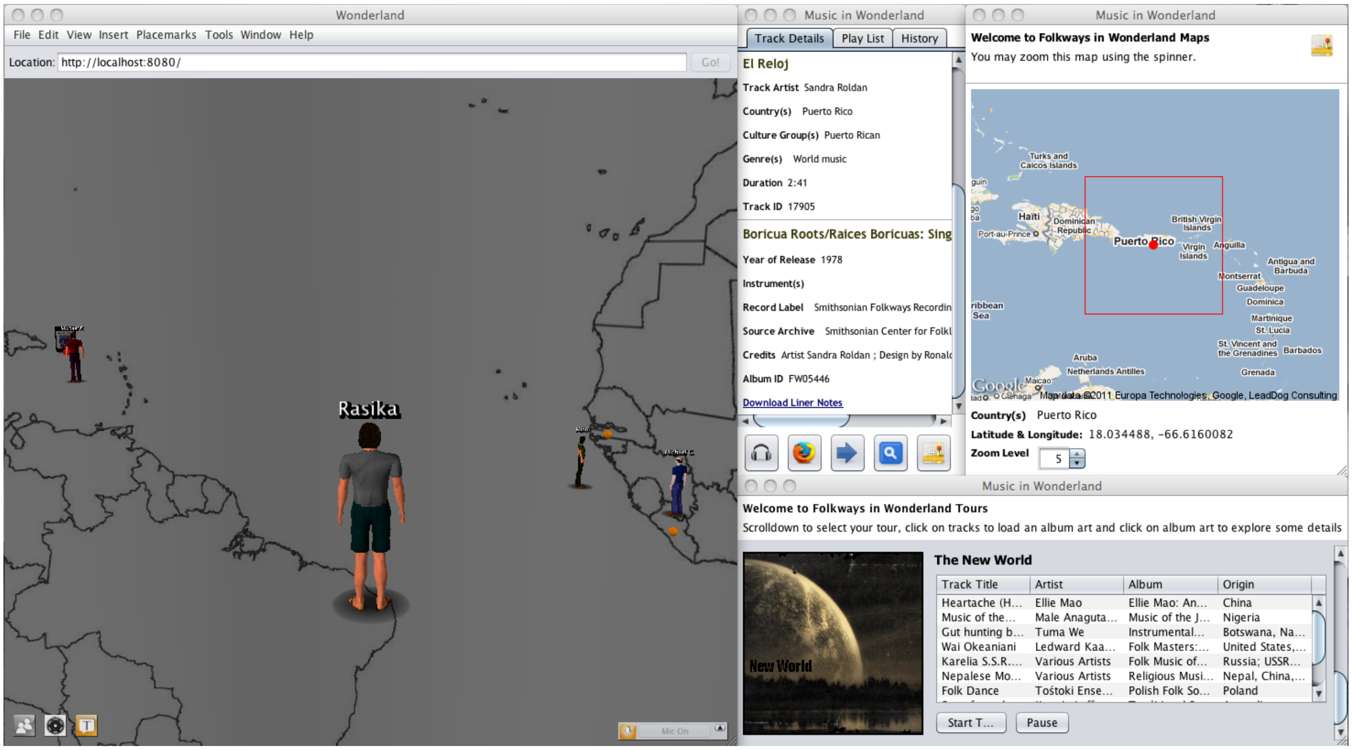


Figure 2. In the upper-center window, the user browses metadata for the track (located in Puerto Rico) selected in the left window; buttons allow the user to view liner notes; listen via virtual headphones (excluding competing sounds); locate the track on the Smithsonian Folkways website; teleport to the track; search for other tracks; or view track location on a zoomable Google map (upper right). The user may also embark on a tour using the lower right window.

loops the corresponding audio track, enabling location-aware multisensory browsing. Multiple avatars can enter the space, listen to these virtual speakers, and contribute their own sounds (typically speech) to the mix via voice chat [9]. Avatars hear all sound sources (tracks, and sounds produced by other avatars) within the space, attenuated for distance, and combined according to a spatial sound engine that emulates real-world binaural hearing. (See Figure 1.)

Avatars are free to explore the cyberworld, using keyboard and mouse controls to navigate throughout the cylinder, and in the surrounding virtual environment (including a building, and a verdant park), while interacting with one another and listening to music. Wonderland supports multiple perspectives, including endocentric (1st person) and egocentric (2nd person) points of view. While inside the cylinder, a user may click a marker to select a particular track (only one track may be selected at a time, for each avatar). The selected marker changes color (from orange to red), the track's album cover appears above the marker, and its metadata is displayed in a separate window, together with a Google map providing detailed, zoomable, topographic information. Buttons are available allowing the avatar to teleport to the selected track's location, to don virtual headphones connected to this track (in order to exclude competing sounds), to search for other tracks by metadata (users may teleport to a search result by clicking), or to purchase a track. Liner notes may be downloaded as a PDF file. (See Figure 2.)

Avatars can also join any one of several configurable tours, which automatically leads them through a sequence of tracks in a predefined order. While visiting a particular track its metadata is displayed; the visiting period is user-configurable, and users can also elect to leave the tour at any time. In addition, two track lists can be displayed: a playlist containing the complete track population, and a track history listing tracks that have been visited in the current session. Items on either list may be clicked to teleport directly to the selected track.

The system is collaborative, since multiple users can hear music together, as well as hear and see each other, communicating through speech and text-chat. Wonderland also provides in-world collaborative applications, such as a shared web browser or whiteboard. Thus users are provided with a realtime, immersive, audio-visual representation of their virtual social environment.

III. Folkways in Wonderland

Our musical cyberworld is called "Folkways in Wonderland" (FiW) because it is populated with track samples from Folkways Recordings, founded by Moses Asch and Marian Distler in 1948, directed by Asch until his death in

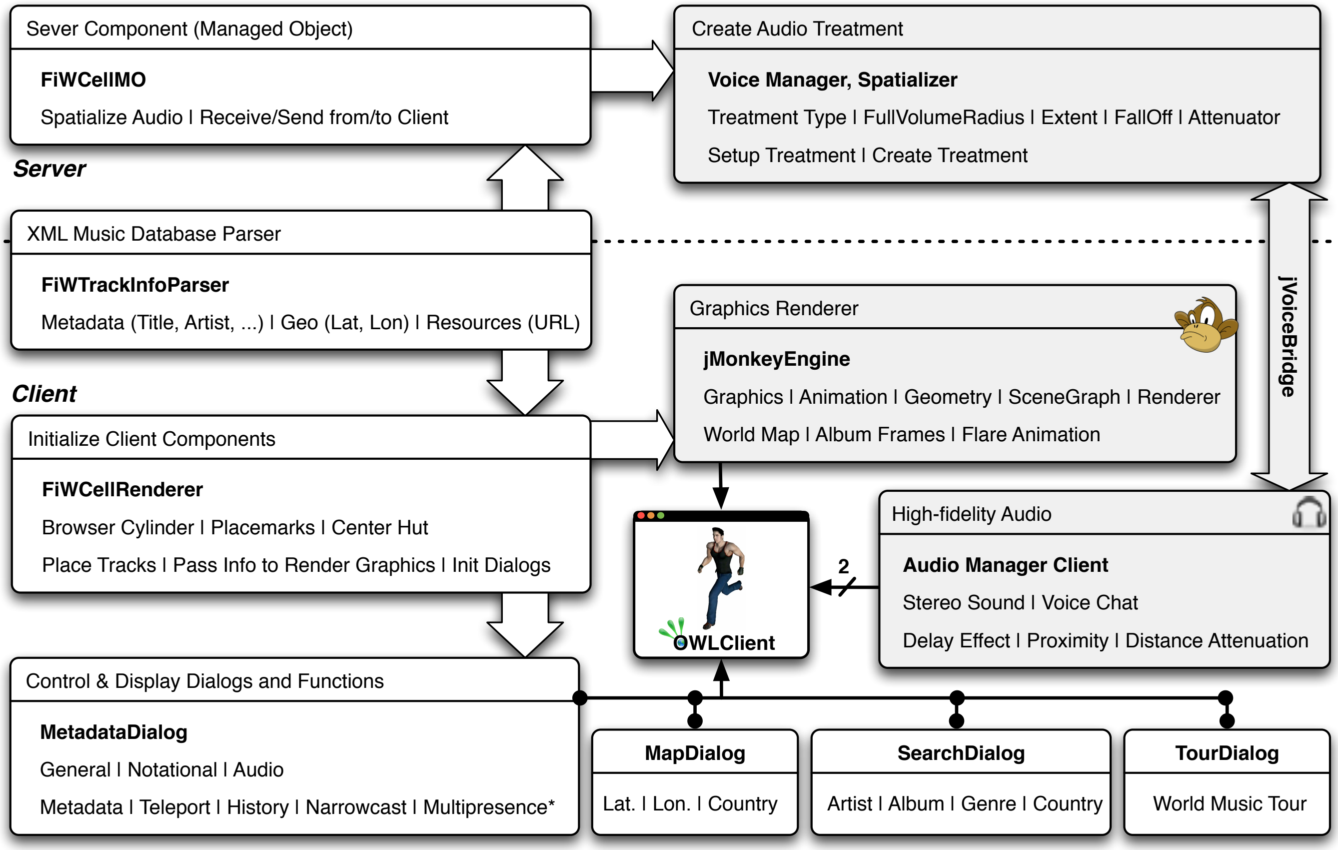


Figure 3. FiW System Schematic: An OpenWonderlandClient (OWLClient) connects to the server for simple client messaging among other clients, while audio mixing is done at jVoiceBridge, which is built into the Wonderland server. The `FiWCellMO` server (top left) generates a list of track samples by parsing an XML database using a common `FiWTrackInfoParser` when the server starts up. A `Spatializer` (top right) creates spatialized audio for the track list and `VoiceManager` is responsible for handling communication between clients. An `AudioManagerClient` at the client provides stereo audio for the client. `FiWCellRenderer` (left lower center), also using `FiWTrackInfoParser` (left upper center), generates the list of track samples at the client side. The generated track list is used for rendering track markers with JME, displaying metadata of a selected track, and searching for a particular keyword. The `FiWCellRenderer` is also responsible for rendering Java2D Swing dialogs including Metadata, Map, Search, and Tour.

1986, and thereafter published and curated by Smithsonian Folkways,[2] the non-profit record label of the Smithsonian Institution, located in Washington D.C. During Asch's remarkably productive tenure, the Folkways label produced 2,168 albums containing over 40,000 tracks representing a stunningly diverse gamut of recorded sound from around the world, including musical, spoken, and environmental. Since acquiring the label in 1987, Smithsonian Folkways has expanded and digitized the Folkways collection, while enhancing and organizing its metadata, all of which is now available electronically. The Folkways collection thus offers a number of distinct advantages: it is large, diverse, global, well-documented, and digital. Furthermore, it is, in itself, one of the most important and enduring products of ethnomusicological research ever assembled.

From the full Folkways collection, we have selected, encoded, and geotagged a set of 1,166 music tracks, carefully chosen for aesthetic and cultural interest and geographical distribution, to represent the full spectrum of world music. Out of this set only several dozen populate the FiW cyberworld at any one time; the selection of track population is easily configurable, as track pointers, geotags, and other metadata are all stored in an XML file.

IV. Architecture & Implementation

Wonderland uses a client-server model with various networking protocols for different data types [10]. TCP is used for communicating object properties and positions, while SIP & RTP are used for audio communication. The Wonderland server consists of several services that can be distributed across multiple machines to increase scalability. The web administration server provides authentication. The Darkstar server provides a platform for Wonderland to track the frequently updated states of objects in the world. JVoiceBridge, communicating with Darkstar directly, is responsible for providing server-side mixing of immersive

[2] http://www.folkways.si.edu

audio. The Wonderland client acts as a browser for different Wonderland servers. FiW has been developed as a module in Wonderland, which is the mechanism for packaging, including objects, and adding new functionalities. A module consists of server code, which is installed in the Darkstar server, and client code, which is made available to clients.

The system architecture is diagrammed in Figure 3. In the following sections, we highlight a number of design considerations.

A. Arranging Music Tracks in 3D Space

FiW enables music browsing in a multidimensional multimedia CVE rather than through textual lists, enabling a sonic, spatial, and social experience. We propose the cylinder as a structure well-suited for representing collections in collaborative 3D spaces. From a user perspective the cylinder provides a readily navigable structure onto which symbolic representations of collection content can be easily mapped. Since Wonderland does not currently permit recumbency, a virtual sphere, limiting angle of view near the poles, is not suitable.

The music browser is, therefore, a cylinder upon which a rectangular world map is texture mapped. In general, flat maps are derived by projecting a sphere onto a plane, with associated transformation of spherical to rectilinear coordinates. A flat map can preserve only certain features of the sphere (e.g. direction, distance, area, or shape), while necessarily distorting others. We selected the Mercator projection, a rectangular map preserving rhumb lines but distorting distances and areas, especially near the poles. While modern cartographers have rightly critiqued this projection, the cylinder necessitates a rectangular map. The Mercator projection also harmonizes with Google Maps [11], with which we hope to immersively integrate in a future release. Finally, as few Folkways tracks are geotagged near the polar regions, Mercator distortions do not affect the spatial representation of music too adversely.

B. Cell Renderer and Scenegraph Architecture

Cell Renderers in Wonderland facilitate the ability to create visual representations of cells using jME (jMonkey Engine), a high performance scenegraph-based graphics API.[3] Each jME Cell Renderer provides a scene graph which is added as a child of an "attach point" node in the Cell Renderer of its parent cell, so each child cell can inherit its rendering state from the parent scene graph.The populated cylinder is a geometric 3D model rendered by jME; music tracks are children nodes of the cylinder. Each track is also a 3D model with the album cover image set as the texture when the corresponding marker is clicked, and positioned according to its geotag (latitude and longitude).

[3]http://www.jmonkeyengine.com

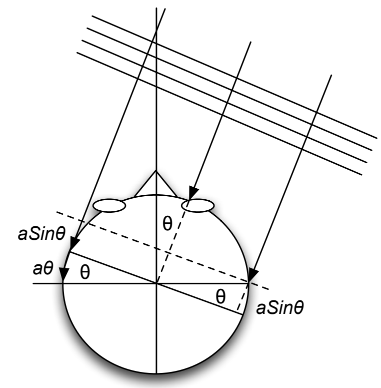


Figure 4. Woodworth's Formula: Assume round head of radius a and speed of sound c. Then sound from a distant source travels extra distance $a(\theta+\sin\theta)$ to reach the contralateral ear. When $\theta = 0$, ITD$= 0$, and when $\theta = \frac{\pi}{2}$, ITD$= \frac{a}{c}(\frac{\pi}{2}+1)$. Thus, the ITD vanishes when a source is directly ahead, and reaches a maximum when the source is directly to one side.

C. Sound Localization in Wonderland

Sound localization refers to a listener's ability to judge a sound's source location, including distance and direction [12], [13], [14], [15]. ITD (Interaural Time Difference) is the difference in arrival time of a sound between two ears, as the sound arrives at an ipsilateral ear before the contralateral, since it must travel an extra distance around the head (see Eq. 1 and Figure 4).

$$ITD = \frac{a}{c}(\theta + \sin\theta), -\frac{\pi}{2} \leq \theta \leq \frac{\pi}{2} \quad (1)$$

FiW, providing stereophonic (2 channel) audio communication, supports users' sound localization through two kinds of audio spatialization: (1) amplitude attenuation, suggesting distance; (2) interaural delay, suggesting direction. These effects are computed on the server side by an "Audio Treatment" component in the VoiceBridge. Two interleaved channels are sent in each packet, one delayed by 0–0.63 ms (Eq. 2), depending on the location of the source relative to the avatar.

Approximating head radius as 0.08 m and the speed of sound as 300 m/s, maximum ITD can be estimated as

$$ITD \approx \frac{0.08}{300}(\frac{\pi}{2}+1) \approx \frac{0.2}{300} \approx 0.6\,\text{ms}. \quad (2)$$

By performing spatialization on the server, it is possible to mix many audio sources appropriately for each avatar, while also reducing required bandwidth with more than four avatars. Letting n be the number of avatars populating FiW, the linear function (Eq. 3), representing bandwidth required for client–server mode, exceeds that required for peer-to-peer mode (Eq. 4) when $n < 4$. However, when $n > 4$, peer-to-peer mode starts requiring more bandwidth than client–server mode (as shown in Figure 5), indicating

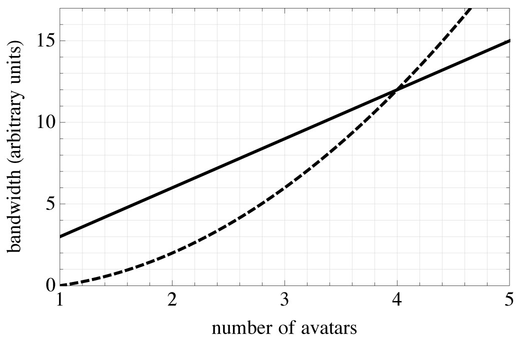


Figure 5. Client–Server (solid line) vs. Peer-to-Peer (dashed)

the reduction of network usage when spatialization is performed at the server side, since quadratic functions grow faster than linear.

Client–Server:

$$1\ upstream\ +\ 2\ downstream\ =\ 3n:\ O(n) \quad (3)$$

Peer-to-Peer:

$$Many \rightarrow many\ =\ n(n-1):\ O(n^2) \quad (4)$$

D. Navigation

Besides basic movement functions (moving forward or backward, stepping left or right, and turning), Wonderland allows each avatar to run, fly, and teleport, and to look up or down, via keyboard and mouse controls. One can also change one's point of view, including first person (endocentric), front camera, and chase camera (egocentric).

V. Experimental design

Using Folkways in Wonderland as a virtual laboratory, we pose the following question: how do social actors, represented by avatars, interact in such an immersive cyberworld, when presented with a specific collaborative task? What sorts of virtual social groups and communities of taste emerge through virtual world music interactions, and how do these depend on the kinds of music and actors populating the cyberworld? A laboratory environment enables us to control variables to an unprecedented extent, and thus answer — at least within this restricted environment — questions about such dependencies with a rigor that cannot be achieved in the real world. In particular, we are concerned with two primary clusters of independent variables known by ethnomusicologists to shape the emergence of musical community: the *social* and the *musical*. Here, social variables include the number and demographic profiles of participants populating the cyberworld, while musical variables include the number and kinds of music tracks populating the cyberworld.

Variables within either cluster can be manipulated: the former through participant selection; the latter by loading different collections of music tracks into Folkways in Wonderland. Participants are selected from among a volunteer adult population, subject to informed consent and the availability of a common language for communication. Prior to entering the space, each subject is profiled, by recording age, gender, educational level and specialization, musical tastes and abilities, and ethnic background(s), all considered as variables within the social cluster. Divergences in musical taste and ethnic background are particularly important, as they are hypothesized to be key factors in the emergence of social groups.

Participants are directed to enter the cyberworld simultaneously during a prescribed two-hour-long period, in order to carry out a collective task: they are asked to learn as much as possible about the tracks embedded in the cylindrical map, decide which ones they prefer and why, then work together with other cyberworld denizens for the remainder of the period to assemble a partially-ranked list, the goal being to reach as much agreement as possible in ranking as many tracks as possible (in order of preference) within the allotted time.

The criteria for the ranking (aesthetic power, musical preference, geocultural interest, recording quality, etc.) are left open, to be negotiated among the virtual participants, who must attempt to reach consensus regarding both criteria and rankings. In this way participants are forced to interact on the basis of musical experience. At the conclusion of the experiment, each participant is asked to submit a report detailing the ranking and explaining the criteria used.

One of the participants is a cyber-ethnomusicologist from the research team, participating in, and observing, social interactions among avatars in FiW, and reporting on the processes of community formation by means of traditional ethnomusicological tools, especially ethnographic fieldnotes, and informal unstructured interviews. For ethical reasons, the identity of the ethnomusicologist-participant will be disclosed. Such cyber-participant-observation is necessary to document and interpret the listening, communicating, and consensus-building processes, and also affords a novel approach to ethnomusicology.

Analysis then proceeds as follows:

- Clustering participants on the basis of their rankings, using theories of partially ranked data and rank aggregation (e.g. [16], [17]). Divergences between rankings indicate the emergence of subgroups, communities of musical taste.
- Thematic coding of qualitative research, namely the cyber-ethnomusicologist's fieldnotes, and reports filed by other participants, followed by qualitative research analysis, in an attempt to understand the bases for consensus and the social processes leading to the formation of subgroups.

Research will at the outset be exploratory, but we anticipate that this preliminary phase will quickly lead to the formulation of hypotheses and, subsequently, more focused experimentation designed to test them. We believe that this process will produce results suggesting better ways of designing musical cyberworlds for research, discovery, learning, entertainment, and e-commerce, as well as indicating broader principles underlying the role of music in human interaction and community-formation in general. In this way, controlled research in and about a custom-built musical cyberworld can usefully supplement, without supplanting, traditional real-world fieldwork in ethnomusicology.

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