tunA: Synchronised Music-Sharing on Handheld Devices

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ABSTRACT
tunA is a mobile peer-to-peer application that allows users to share their music locally with others who happen to be in their physical proximity. Playback is synchronized on all tunA devices that are "tuned into" the same source. These handheld devices are connected via ad-hoc 802.11 wireless networks formed as they come into and out of range with each other. With tunA, *music* constitutes the primary focus around which new social connections can be made and existing ones maintained. The localised dimension of the application aims to enable the creation of links between the virtual world of digital communication and file exchange and the physical reality in which users are immersed every day. In this paper, we briefly describe the tunA technology and a user study that we undertook to analyze its potential impact within a specific target group.

Keywords
Shared experience, social networking, ad-hoc networks, wireless devices, personal music players

INTRODUCTION
Peer-to-peer Internet-based applications allow users to share their resources without the aid of central servers. This type of communication has been highlighted to a great degree in recent years because it enables the creation of large networks where "free" resources can be accessed by any user. For the same reasons, it has been hotly criticized by those involved in copyright protection.

Technologies like Wi-Fi, Bluetooth, mobile phones and PDAs have made it possible to form peer-to-peer networks in mobile settings, resulting in radical changes to the whole concept of peer-to-peer. These changes are poised to have a significant impact on the way people communicate and exchange information and ideas with each other, and on social and cultural behaviours in general.

> "'Mobile ad hoc social network' is a longer, more technical term than 'smart mobs'. Both terms describe the new social form made possible by the combination of computational, communication, reputation, and location awareness. The mobile aspect is already self-evident to urbanites who see the early effects of mobile phones and SMS. Ad hoc means that the organizing among people and their devices is done informally and on the fly […] social networks means that every individual in a smart mob is a "node" in the jargon of social network analysis, with "social links" (channels of communication and social bonds) to other individuals. Nodes and links, the elements of social networks made by humans, are also the fundamental elements of communication networks constructed from optical fibres and wireless devices – one reason why new communication technologies make possible profound social changes." [1]

While the mobile Internet was supposed to become the "next big thing", mobile peer-to-peer seems to have many characteristics that might better adapt to existing social mobile interactions. tunA is a mobile peer-to-peer application, focused on the concept of a local shared music experience, that aims to situate itself in this domain.

DESIGN OF tunA
The core aspects of tunA are the following:

- *Shared music experience:* A person can listen to their own music just like a normal Walkman or portable MP3 player, but they can also tune in and listen to what other people are listening to on their tunA devices, resulting in a shared music experience.
- *Handheld devices:* The device itself (prototyped on an iPaq / Pocket PC platform) is small and meant to be holdable in the hand, like a Walkman, iPod, or other such music player. It is not, for example, meant to operate on a laptop computer or on some other kind of "installed" audio hardware in a building or car.
- *Ad-hoc Wi-Fi network connectivity:* tunA devices communicate and stream MP3 encoded audio via ad-hoc 802.11b wireless network connections.
- *Audio synchronization:* The audio stream timing/delay algorithm enables the audio playback to be closely synchronized on the source and any destination devices, so that people tuned into a particular person's device can be listening to exactly what the other person is listening to. This enables someone to be, for example, sitting across a train or a bus from someone they are tuned into, and each person could be nodding heads, gesturing, or dancing in perfect synchrony, just as if they were both listening to the same standard FM radio station. We believe that listening to the same song in synchrony could better enable people to feel like they are part of a community even if they are strangers to each other.
- *Multi-hop connectivity/synchronization:* A person (X) might tune into someone else (Y) that in turn is tuned into someone else (Z) who is out of range of the original person (X), and the experience would remain

synchronized. (This has not been implemented yet, but is part of our concept.)

- *Personal profile:* Users can store personal profile information in their tunA players and set permissions for which parameters can be shared with other tunA players that might be tuning in.
- *Bookmarking a song:* tunA users can "bookmark" a song that they hear while tuned into someone else's player, and later review these bookmarks, or download them to a computer where they might purchase the song for themselves.
- *Bookmarking a person:* tunA users can "bookmark" another person they've come into contact with through tunA, and, for example, be notified if that person comes into range again.
- *Instant messaging:* tunA users can send instant messages, similar to SMS text messages, to each other while they are in range.
- *Buying, selling, sharing songs:* tunA users could purchase new songs from web-based song download sites (like iTunes) or via services offered by record stores, for example, that the tunA user might be standing near or inside at the time they wish to buy songs.

RELATED WORK

Soundpryer [2] is a close relative of tunA that focuses on music sharing between nearby cars. tunA focuses more on personal mobile handheld music devices as used in urban settings and, unlike Soundpryer, includes tight synchronization of the shared audio as a part of its concept and implementation. Bubbles [3] is another mobile music player that allows users to exchange audio files with nearby peers via HTTP, but without joining their audio experiences as in tunA. Sotto Voce [4] is an electronic guidebook which attempts to promote a shared activity between museum visitors by allowing them to 'eavesdrop' on the descriptive audio passages that another is listening to, but the system is a 'hack' in that no content is actually streamed – all devices have identical local content.

SYNCHRONISATION TECHNIQUE

The synchronisation method we employ is essentially a three-part process, applied for the full duration of the shared audio experience, the data for which we include in the header of the packets of MP3 frames we multicast as the audio stream. First, we establish a common reference logical clock or 'heartbeat' by using any of a number of algorithms - for example: Christian's, Berkeley, NTP etc. Next, we compute the track position of the remote source. Finally, if the local buffer is determined to be out of sync by more than a pre-determined amount, we remove frames or insert blanks to bring the local and remote players in synch. We could also dynamically adjust the frequency of the local player until the peers matched.

The human ear will assume two audio signals are 'coherent' (i.e. from the same source) if they arrive within 30ms of each other. On the Pocket PC platform, this level of synchronisation is difficult to maintain over time due to variances in manufacture (audio crystals), clock skew, OEM dependent timing information, unreliable network protocols and the lack of a real-time operating system. Despite these obstacles our algorithms are reasonably successful, and should see further improvements were they implemented on a dedicated tunA device.

EVALUATION

We evaluated our current prototype of tunA in a hybrid process that involved the following steps: 1) Observation of a target community, 2) Survey/questionnaire, 3) Semi-structured interviews, 4) Talk-aloud interface evaluation, 5) Field study, and 6) Post-study interviews. The target community chosen was one that was a source of inspiration for tuna in the first place: local college students. Specifically, we focused on a local art and design school.

Completed questionnaires were received from 76 students and revealed a high penetration and use of portable music devices and a substantial amount of interest in both music and in the notion of meeting new people nearby. In general, the respondents were comfortable with the idea of sharing their music with people nearby, even if they were complete strangers. However, none of the respondents owned a PDA, and on the whole they said they didn't invest much in new technologies, which suggests there could be significant barriers to overcome in enabling an application like tunA to become widespread. Though the respondents also largely reported feeling happy with their social networks, they also expressed curiosity about people they see nearby everyday who they don't know personally.

Six subjects were selected from the questionnaire respondents to participate in the subsequent phases of our evaluation which included a one-day freeform field trial on the college campus itself. Since they were just recently completed, the results of these phases are still being analyzed and compiled and will be reported in an upcoming submission.

NEXT STEPS

We are planning a more extensive trial in which there will be greater than 100 tunA devices distributed among members of a different college community to investigate the effects of greater penetration of the devices. We are also working on a dedicated hardware platform and multi-hop networking capabilities to enhance range of sharing.

ACKNOWLEDGMENTS

Thanks to the respondents of the questionnaire. This research has been supported by Media Lab Europe partners.

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