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A Multi-Device, Multi-User Music Experience

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Distributed Interaction: A Multi-Device, Multi-User Music Experience

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ABSTRACT
In order to take full advantage of the opportunities provided by an increase in consumer device interoperability, we need to explore the design of multi-device systems beyond data sharing between devices. This paper presents an approach to distributed interfaces as technology supporting social interaction in a non-work environment. It consists of a collaborative music system, which in addition to benefit from distributed music storage also distributes playback control onto several mobile devices and provides output through a common situated display. The system has been tested in three different real-life contexts in order to explore the interaction space of non-work multi-device, multi-user environments.

Categories and Subject Descriptors
H.5.2 [**User Interfaces**]: Graphical user interfaces (GUI); H.5.1 [**Multimedia Information Systems**]: Audio input/output; H.5.5 [**Sound and Music Computing**]: Systems

General Terms
Design, Experimentation, Human Factors

Keywords
Digital ecosystems, ubiquitous computing, distributed interfaces, music player, interaction design.

1. INTRODUCTION
An increasing number of interoperable digital devices are finding their way into our homes. These emerging networks of devices are no longer limited to desktop or laptop computers, but can additionally encompass devices like TVs, gaming consoles, smartphones, tablets, stereos etc. Such ubiquitous computing environments, also known as digital ecosystems [6], opens up for a lot of opportunities when it comes to media content. Broadband Internet connections and wireless network technologies provide the needed platform to support systems spanning multiple devices. Interoperability is however widely focused on data sharing and systems, distributed onto several devices, are often developed as adaptations of the same system and not as a complete system. One reason is, that most of these devices have *evolved into* network capable devices and are thus not inherently designed for multi-device interoperability[8].

Approaches to explore this new interoperability have been aimed towards specific trends in interaction design for multi-device environments. Ding and Huber [3] presents a conceptual framework for design of collaborative multi-device systems. They focus on multi-device web-browsing and evaluates a prototype of a developed architecture. Alternatively, Turunen et al. [10] focuses on different modalities. Through the development and evaluation of a multimodal media center interface, they explore the different input modalities, speech, physical touch and gestures. The work of Greenberg et al. [5] uses proxemics to create multi-device systems, which are aware of spatial relations between users and devices. Despite the very wide array of directions, they all share the common goal of contributing to a better understanding of the ubiquitous digital ecosystems that emerge through the increasing interoperability between devices.

We aim to explore the potential given by the diversity of the interconnectable devices. This can help us design systems that creates synergy, by taking device-specific strengths and weaknesses, as well as inter-device relations, into account. In order to do that we need to understand the challenges introduced when an interface is no longer isolated on a single device. One factor that greatly influences the interaction with multi-device systems is the relationship between displays in coupled display environments [1]. This issue is very important to the system facilitating this study, where a shared situated display, a tablet and smartphones have to provide input and output simultaneously. Different studies particularly looks at either attention [2] or user performance [4] issues introduced when interfaces are distributed onto a combination of large public and small private displays. An additional layer of complexity is added as multi-device systems furthermore offer the opportunity to allow several co-located users to interact simultaneously. This does not only influence issues concerning coupled displays, but inter-personal interaction as well.

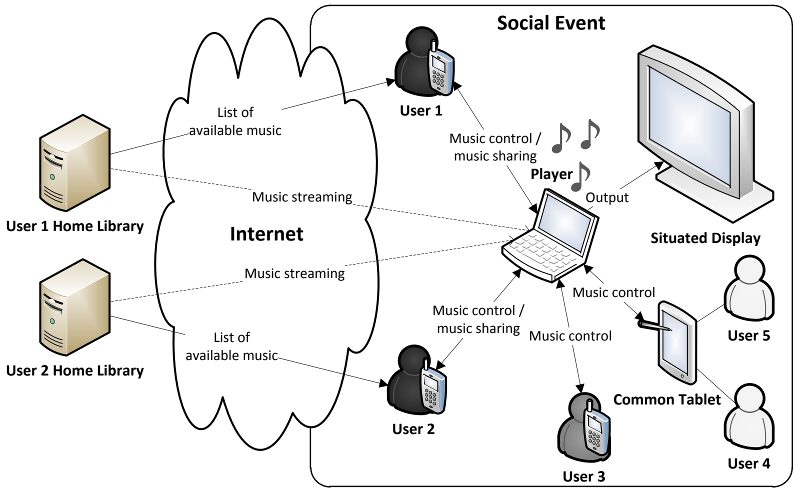

Figure 1: The architecture of the system showing the relations between system entities.

This paper uses the specific case of *listening to music together*, to explore such environments. The concept for the distributed music control is influenced by the work of O'Hara et al. on the music system Jukola [7]. Jukola distributes control onto separate devices using nominations and votes to create a democratic music player in public space which was tested in a bar environment. PartyVote [9] is another system that similarly provides a democratic music jukebox, but focuses on private social gatherings and minimal interaction. We have used a music system as means of further studying the dynamics of interaction in digital ecosystems and not particularly the music domain.

2. CONCEPT AND ARCHITECTURE

MEET aims at enhancing the experience of listening to music together in a social context. The main idea of MEET is to enable several users to influence the music played on two levels: First of all, to allow users to share selected parts of their personal digital music collection. Secondly, to allow the group of users to jointly control playback through a distributed interface. Interaction is thus spread across several devices each playing their distinct role. The concept development is the result of a technology analysis, where unexplored concepts in current systems were identified, followed by a design workshop. One of the results of the workshop is a set of overall guidelines for the system interaction:

- The music never stops: Songs are never interrupted and there is always a song ready to be played next.
- The system is secondary: MEET is not designed to be the center of attention, but rather a music system playing in the background.
- Different levels of participation: It should be possible to influence the music on different activity levels.

An important aspect is to avoid the need to keep portable devices synchronized with the music collection at home, in order to access this music elsewhere. Instead MEET relies on an access-granting token and streaming. The access granting-token lets the users connect to a player and share a selection of their music at home. At the player, this constitutes a combined set of music where songs are streamed directly from each user's home libraries per demand. The system architecture comprises five different system entities. The entire architecture can be seen in Figure 1, showing an example setup of users and devices.

Player: Basically any computer running the player part of the software. This is the part that maintains the shared set of music and handles music playback. The player also handles connectivity to both handheld devices and home libraries.

Situated Display: Shows the primary user interface of the player and is shown on a large flatscreen TV or a projector. The situated display is the common output device for all users.

Home Library: The home library part of the software handles information about the chosen music from a user's personal digital music collection and makes it available for direct streaming to a player.

Smartphone Application: Acts as both an access-granting token and an interaction device for the distributed player control. The idea is that users use their own smartphone for this purpose.

Common Tablet: Hosts a modified version of the smartphone application which allows users without a compatible smartphone to influence the music. It furthermore creates an explicit physical interaction space around the system.

The design guideline of enabling different levels of participation and the nature of the setup, creates the notion of the three types of active users seen in Figure 1: Users who have a running home library and a compatible smartphone, enabling them to both share music to the player and take part in the music control, using their own personal device

(Users 1 and 2). Users who do not have a running home library but have a compatible smartphone, enabling them to participate in music control from their own personal device (User 3). Users who do not have a compatible smartphone, who can use the common tablet as their control device (Users 4 and 5). It is important to note that there is no inherent conceptual limit to the number of users of each type.

3. IMPLEMENTATION

The user interface of MEET is distributed across several devices and thereby to several users. The situated display serves as the only common output device for the player and although it does have an additional part of the user interface on a small screen, this is primarily used for connecting users to the system. All input happens through the handheld devices. Output concerning individual actions, such as keeping track of personal nominations and votes, is provided directly on the handheld device and the current state of the system is summed up on the situated display (see Figure 2).

Figure 2: The situated display depicts the current state of the system.

3.1 Nominating Songs

One of the primary functionalities of MEET is to enable users to browse the composite set of music and nominate songs. Nominating a song means that it will become a candidate for the next song to be played. It also means that it will be represented in one of the nomination slots of the situated display and be made available for voting. Nominations are placed randomly in one of the available slots and stays there until it is either played or eliminated, to avoid confusing the users. A set of rules has been implemented to make the system comply with the concept guidelines. The system will always make sure that there are at least three songs nominated, by nominating random songs from the music set if the number drops below. This will ensure that there is always a song ready to be played and furthermore encourage interaction by always having songs to vote for.

Users nominate songs using their handheld devices. The interface for browsing the music set on the player is straight forward. Filtering is done through a four-level hierarchy where users can go through genres, artists or albums, tapping to reach lower levels until they can choose from a list of songs corresponding to their choices. These songs can be nominated by swiping to the right. It is possible to begin browsing at any level. Nominations can be withdrawn if no users have placed a vote, in case a mistake is made. An additional feature instantly shows 15 random songs to pick from and can, e.g., be used if a user is not looking for something in particular and wants to be inspired. The songs are chosen from the entire music collection available and not only the specific user's songs.

3.2 Voting

An important concept characteristic is that no person can single handedly decide what songs to hear, hence another primary functionality is to vote for nominated songs. Like the nominating functionality, voting is done using the handheld devices. The interface presents users to a list of the nominations where they can vote for each nomination (see Figure 3). A plus or minus vote will simply add or subtract one point from a total score respectively and the song with the highest score will be played next. Additional elimination rules are implemented and are enforced at the end of each song, to make the system more dynamic. The first rule removes nominations with a negative total score. The second rule removes nominations that have not received votes (positive or negative) after three songs.

Figure 3: Voting is done from a list of the current nominations.

Representations on the situated display change continuously according to votes, where size is used to visualize the current ranking. In order to maintain a consistent and structured layout, each nomination has a maximum and minimum size and individual sizes are computed relatively. A plus vote on a nomination is therefore not necessarily causing this particular representation to grow in size, but could instead make other nominations shrink. There is no indication of ranking on the mobile vote page and nominations are listed in the order they are added to the system.

4. USER STUDY

The ultimate purpose of MEET is to facilitate a study of systems where the interface is distributed across several devices and where multiple users interact simultaneously. The study consists of three in-situ field trials which made it possible to explore the use of MEET in realistic settings. In practice this means setting the system up at social events as a direct replacement for what would otherwise be used to play music. For each trial, the prototype was set up on available hardware, as there are no mentionable hardware requirements and basically any desktop or laptop PC/Mac, with a stable broadband Internet connection can be used. The home library and player software is developed in Java to support various operating systems as well. Various data collection methods were used. The primary methods were observations and semi-structured interviews while video recordings and embedded data logging were used to back up findings made. The intention of having three trials is not to replicate the experiment, but rather to experience the system in different physical and contextual settings. General information about the three trials can be seen in Table 1.

Table 1: Interaction with the system during the three trials. *Connections* are unique connected devices including the tablet.

Trial ID	Duration	Connections	Nominations	Votes
1	4 hours	10	81	258
2	3 hours	15	97	522
3	5 hours	8	164	915

5. RESULTS

The interface is based on a combination of common and individual elements that allow for simultaneous interaction by multiple users. This gives rise to a lot of challenges that are both caused by the distribution of the user interface, as well as the social aspects of the system use. Findings directly related to the multi-device interaction design was primarily concerning user feedback on the situated display and the hand-held devices relatively. Results pointed out complications of user attention spread across different devices, as well as issues regarding common displays for multi-user feedback. Another important aspect discovered was that the physical settings of each trial turned out to influence the system more than expected. This was both concerning position of devices relative to each other and the placement of individual parts of the system relative to the users. Other findings were concerned about the role of the technology in a non-work social context. Observations suggests that not only does a system provide means to relocate some responsibility from social interaction onto a technical solution, it also provides means to either anonymize or accentuate users in social contexts.

6. CONCLUSION

This paper presented a system exploring distributed interaction through a multi-device multi-user system in non-work settings. It consists of a working prototype of a music player and by using it to conduct trials in different real-life environments, we have obtained greater insight into areas of concern, in relation to design of user interfaces distributed onto multiple devices with multiple simultaneous users. What the study have illustrated, is especially the complexity introduced, when a user interface is distributed to multiple co-located devices and users. This is both concerning the actual interaction design of the distributed interface, but also the role of such technology in a non-work environment.

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