

Information Sharing Environment with Tangible Devices Equipped with a BLE-module for Proximity-based Group Formation

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1 Introduction

With the spread of tablet terminals and smart-phones in the last decade, opportunities are increasing for co-located workers to use these devices for information sharing during their routine collaboration. For example, office workers might share information reported on the Web while preparing meeting materials, or students might exchange research papers that are relevant to a group discussion. The target of our work is therefore co-located collaboration where people share information present on mobile devices in a face-to-face situation.

Several methods have been proposed to support information sharing between co-located mobile devices. Memory Stones [1] provides ‘drag-and-drop’ sharing from one device to another, by introducing a metaphor of picking up an object on one device and putting it down on another device. Jokela et al. [2] give a comparative evaluation of touch-based group-binding methods which can be used to form an information sharing group. While these information sharing methods have been shown to be useful, people do still use conventional messaging services such as Facebook Messenger and LINE, or e-mail services such as Gmail, to transfer data from one device to another in face-to-face situations. This complicates the sharing operation by requiring collaborators to choose and exchange user names, or to search for and attach document files, before sending a message. Online file sharing services such as Dropbox can be used to share the information easily, but they also require users to configure their terminal device to use their file sharing account in advance, which is not well suited to supporting information sharing in an unplanned, informal gathering of people.

In this paper we describe an intuitive mechanism that uses tangible devices to form information sharing groups. Users carry two devices, a mobile terminal and a tangible device that is paired with that terminal. Several mobile devices form a group when their corresponding paired tangible devices are placed in close proximity to each other. Our prototypical tangible devices use the Bluetooth signal strength to detect whether or not each of them is participating in the group.

2 Information Sharing in Co-located, Informal Collaboration

An information sharing environment for co-located, informal collaboration would ideally support all three possible group formation scenarios: one-to-one, one-to-many and one-to-all.

Existing popular information sharing services include AirDrop (Apple) and Wi-Fi Direct (Android). With these services, however, every time information is to be shared the user must identify the name of the terminal with which they wish to share information, and then specify that destination by manually selecting it from a list. In addition,

every time information is shared with more than one user, it is necessary to perform this operation for each of the destination terminals, further complicating the process.

Several intuitive methods have been proposed to eliminate complicated operations and to enable users to select the target terminals easily. Shiomi et al. [3] propose using a camera and a gyroscopic sensor in the tablet terminal to indicate the target device. This method reduces the complexity of group formation, but only addresses information sharing on a one-to-one basis. The method proposed by Freitas et al. [4] uses various kinds of sensor to detect the similarity of context among devices in order to form them into groups. This method can be applied to information sharing between more than two devices, but forming a group from a subset of contextually similar devices is not addressed.

The use of external equipment to enable intuitive sharing of information has also been studied. In Toss-It [5], the positional relationship of group members is recognized in advance by using infrared markers and stereoscopic cameras. Information is then shared whenever an intuitive ‘swing’ gesture is detected on the sending terminal. Group membership depends on the magnitude of the swing, which is proportional to the physical range over which the information is to be shared. GroupTogether [6] forms a group of users by using Kinect to recognize their positions. These techniques rely on equipment pre-installed in the collaboration environment, making it difficult to extend them to unplanned, informal gatherings.

Our goal is to create an information sharing environment that can be used for all kinds of group formation, without requiring any pre-installed external equipment.

3 System Description

3.1 Group Formation Using Tangible Device

When sharing information among mobile terminals, the following questions need to be answered:

- Which mobile terminals will share the information?
- What information will be shared among those mobile terminals?

In our environment, the tangible devices that are paired with their corresponding mobile terminals are used to form a group which will share the information. After the group is formed, when one of the users in the group taps a button on the screen of their mobile terminal the information shown on their terminal will be transferred to the other terminals within the group.

Figure 1 shows an example scenario of sharing within our environment. Each of the four users (labelled A–D) has a tangible device paired with their tablet terminal. The tangible devices are placed on the table top. If user A finds a useful Web site that could be shared with the other users, and user B wishes to share the information from user A, users A and B place their tangible devices together on the table. (Users C and D meanwhile keep their tangible devices apart from any others.) User A then presses a ‘share’ button on

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their screen, causing the Web site shown on their terminal to be opened on user B's terminal. If more than two users want to share the Web site, they all put their tangible devices in close proximity before the user in possession of the original information presses the 'share' button.

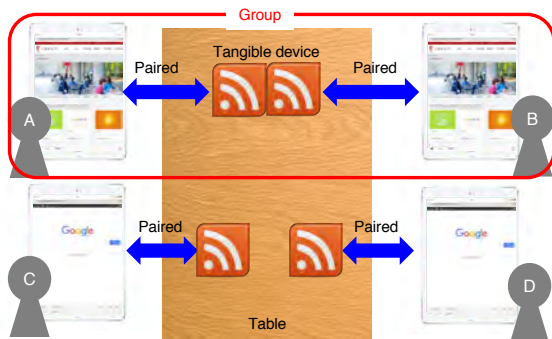


Figure 1: Typical usage scenario

The use of visually distinguishable tangible devices in our environment would make it easy for users to see who is part of the group when sharing information.

3.2 Implementation

For our prototype implementation we used Apple iPad mobile terminals. Pairing and communication between the terminals and tangible devices was achieved using Bluetooth communication. Tangible devices were built using the RedBearLab's 'BLE Nano v2' platform, a Bluetooth 4.2/5 Low Energy (BLE) development board. Communication between multiple iPads was provided using the MultipeerConnectivity framework of iOS.

The tangible device that we assembled is shown in Figure 2. Each tangible device scans the BLE beacons transmitted by other tangible devices and also measures the RSSI (Radio Signal Strength Indication) value, to detect whether tangible devices are placed in close proximity.

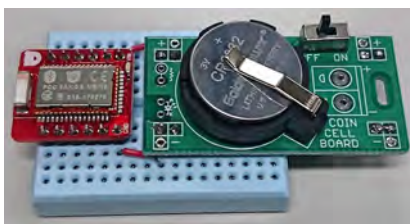


Figure 2: The tangible device with the Bluetooth module

Figure 3 shows the system structure of our environment. Each tangible device both advertises its existence and scans other devices in turn. When scanning other devices, it stores the device identifiers if their RSSI value exceeds a threshold value (which means they are placed closely). When the 'share' button is pressed on an iPad, the iPad gets the device identifiers stored in its paired tangible device and sends the URL of the Web site to be shared to corresponding iPad terminals using the MultipeerConnectivity communication channel. When an iPad receives the URL it opens the Web site corresponding to the URL that was received.

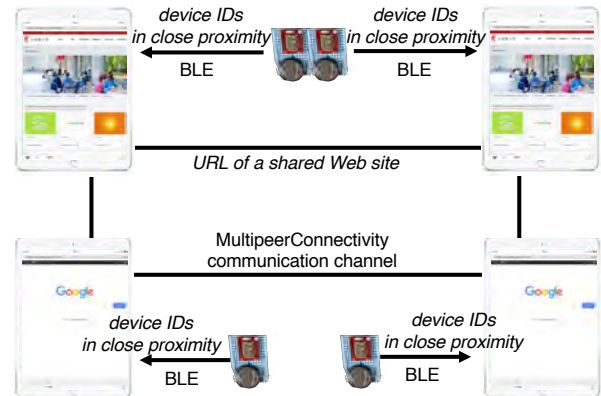


Figure 3: System structure

4 Conclusion

In this paper, we described an information sharing environment using tangible device to form groups. We implemented prototypical tangible devices using Bluetooth to identify other devices in close proximity and communicate with a paired iPad.

For future work, tangible feedback showing the status of each device, such as whether or not it is currently part of a group, could be provided by adding (for example) a LED indicator to each device.

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