INTUITIVE INTERACTION FOR HOME ICT ENVIRONMENTS USING RFID AND BLUETOOTH WIRELESS TECHNOLOGY

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Abstract: Different forms of interaction with RFID and Bluetooth enabled devices allow users to access various services. This paper explores intuitive mechanisms for use in the home environment using Bluetooth and Radio Frequency ID (RFID) tag technology. Our approach combines the mobility of wireless communication and the ability to detect user commands by localisation. We discuss the implementation of embedded access points that facilitate the intuitive mechanisms for use with interactive devices such as the digital pen/paper, interactive information board and mobile computing devices. A form of interaction includes the access of web content or services by a user's mobile computing device by placing it on one of the regions of the interactive information board. Implicit and explicit modes of interaction are also discussed in this paper.

1 INTRODUCTION

In recent years, the common use of wireless technologies such as Bluetooth, IrDA and RFID has enabled various devices to faciliate wireless connections. These devices can be mobile computing devices such as personal digital assistants (PDA) to RFID tags and human interactive devices such as a digital pen. The use of wireless enabled devices is creating new types of intelligent services for users to interact with each other and with their environment. This paper presents pervasive interaction research work supported by the Suburban Communities Project associated with the Australian Cooperative Research Centre for Interactive Design. The Suburban Communities Project aims to build an Information Communications Technology (ICT) infrastructure to allow residents in a community to access information and access services using mobile devices.

This paper shows the use of Bluetooth and RFID enabled devices for pervasive and interactive applications in a home ICT environment. The implementation of a Bluetooth Interactive Information Network (IIN) infrastructure that allows Bluetooth enabled devices that can be used to access information services is presented. RFID tags are also used as an alternate mechanism of accessing information via physical regions on the Interactive Information Board. Bluetooth enabled devices that can be used are PDAs, mobile phones and digital pens. Information services supported are a messaging service and internet access. The information services consist of web-pages that are accessed via a web browser on a user's Smartphone or PDA. An example form of interaction involves a user accessing web content by putting their Smartphone within range of a specific region of the interactive information board. Electronic information media can be uploaded to the IIN by the user's Smartphone via Bluetooth. The IIN also provides the Bluetooth infrastructure required to use a digital pen and paper. The digital pen and paper is an interaction that allows handwriting to be captured digitally and transferred as an image file to a Bluetooth access point. The digital pen can be used to post messages to other users via the network, as a virtual note-on-fridge scenario. Although a physical 'fridge note' may be lost, the virtual note is stored safely in the user's inbox.

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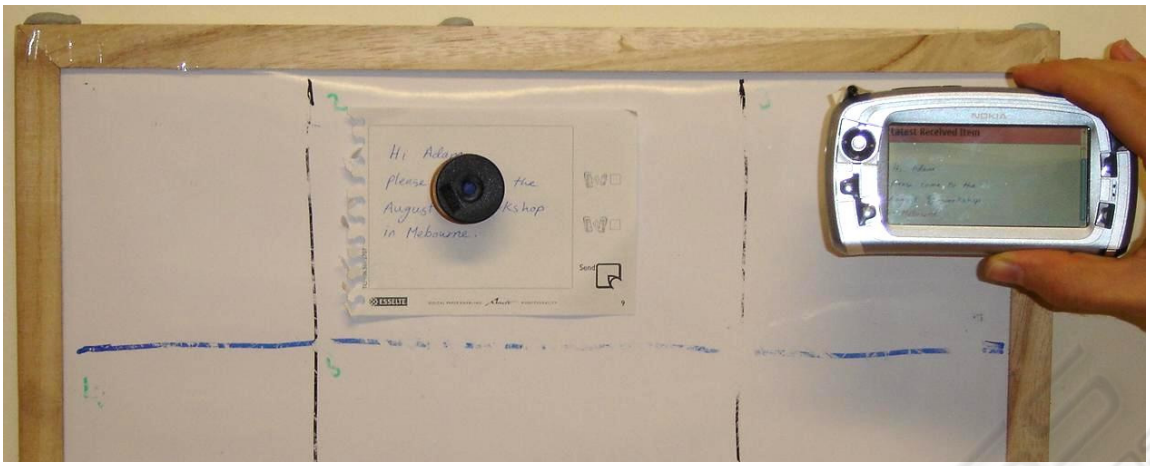

Figure 1: Usage of the MCD and IIBoard in Implicit Mode.

The information network infrastructure uses access points placed at various locations. The access points are implemented using embedded Linux device platforms and are connected to a central server via a local area network.

This paper is organized into 6 sections. Section 2 presents a review of related work. Section 3 describes a typical scenario/s. Sections 4 and 5 discuss the hardware implementation and software architecture of the interactive information network, respectively. Conclusions and Future areas of investigation are discussed in section 6.

2 RELATED WORK

Previous research has explored the use and mobile services with different wireless technologies and pervasive interactive devices for use in e-work and instrumentation applications. Wireless RFID and IrDA beacons have been used for interaction with various devices and to provide links to web content. Various works (Cheng et al., 2005, Hsi and Fait, 2005, Pering et al., 2005) discuss how RFID and IrDA beacons can be used to access web content and to update web content (e.g. blogs) with mobile computing devices. In (Hsi and Fait, 2005, Ho et al., 2005, Pering et al., 2005) RFID beacons are used for interaction with objects in e-work, museum exhibits and homecare e-health environments. RFID technology is as suitable for interactive situations as its more widespread usage of logistical applications.

Belotti et al. (Belotti et al., 2005) describe an experimental platform for the investigation of interaction and information access and delivery within a mobile context. To that end, they developed a web publishing platform (OMSwe), mobile client controller and cross-media server (iServer).

Siegemund and Flörkemeier (Siegemund and Florkemeier, 2003) showed how Bluetooth and RFID technologies can allow users with mobile phones to interact using SMS, with smart objects. The authors categorise the interactions as being initiated by either the user or the smart objects and use an implicit pre-selection of potential smart object partners by way of monitoring behaviour using RFID.

Klimchynski (Klimchynski, 2006), presented an embedded web server (iotaServer) architecture for applications based on Internet data acquisition and control for smart home monitor and web based virtual instrumentation. Rouhana and Horlait (Rouhana and Horlait, 2002) introduced a Bluetooth web server for the purpose of acting as a gateway between Bluetooth-enabled mobile devices and the Internet.

3 SCENARIOS

The Interactive Information Network (IIN) allows users to interact with others and their environments using a variety of wireless enabled devices. The typical environment discussed in this paper is the home ICT environment. The IIN could be applied to other work environments. The IIN provides an infrastructure and a range of services to assists users in their home tasks and for inter-family communication. The IIN services consist of internet webpage access and peer to peer messaging. The IIN has three mechanisms for user interaction: mobile computing devices, digital pens and the Interactive Information Board (IIBoard).

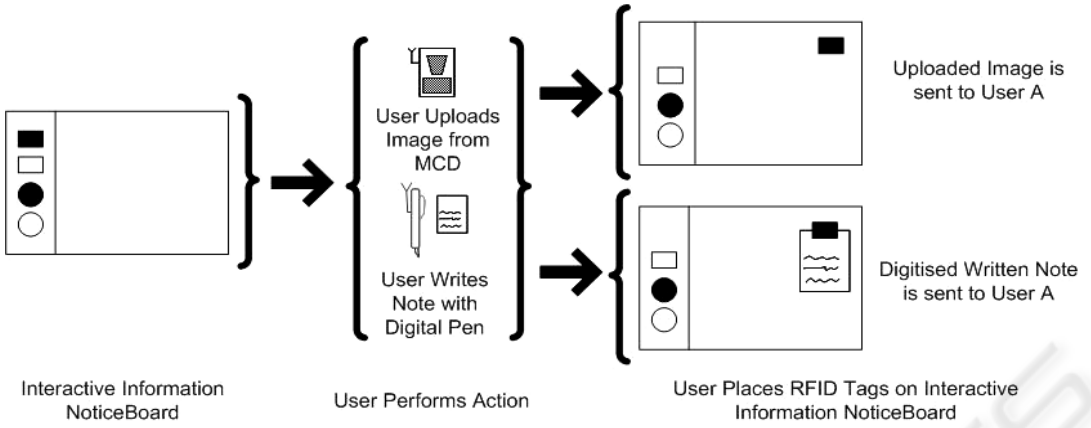

Figure 2: IIBoard Explicit Mode Usage Scenario.

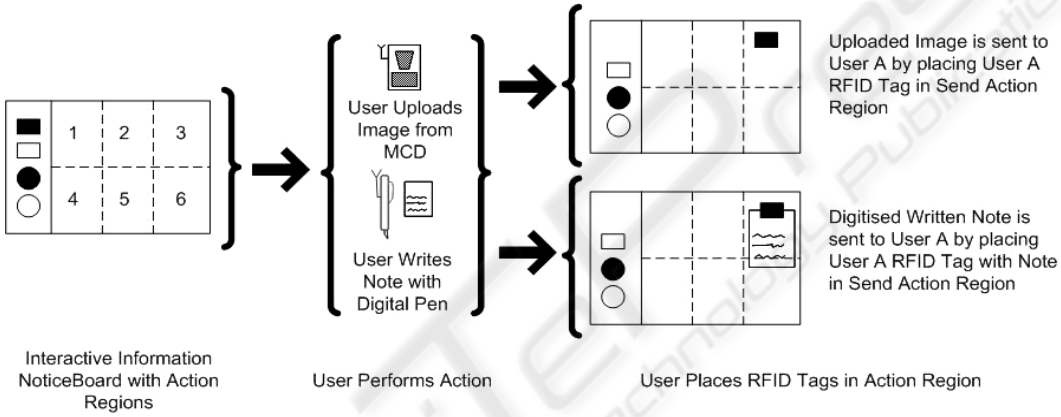

Figure 3: IIBoard Implicit Mode Usage Scenario.

Figure 1 shows a user's mobile computing device accessing content by being put on a region of the IIBoard. A user can upload messages such as text or multimedia. An example is a user can send an image of a shopping list taken with their Smartphone's camera, as a message to another user.

The Nokia SU-1B digital Pen (Nokia) electronically records handwriting stokes as an image file. Special digital paper is required. The digital pen allows a user to send written notes or sketches as messages.

A user can access services simply by using the Interactive Information Board (IIBoard). The IIBoard operates in two different modes: explicit and implicit. The explicit mode involves the use of RFID tags to represent service commands or user identification. As shown in Figure 2, for user A to send a message or written note to user B, User A places the note with the "send to" service tag onto the IIBoard. User A then puts User B's identification tag on the IIBoard. The advantage of using RFID tags to represent a service or user identification is that it allows any service to be associated with a single user or a group of users.

Implicit mode involves the user accessing the services by locating their RFID tag equipped mobile device close to one of a number of regions on the IIBoard as shown in **Error! Reference source not found.**. Each region of the IIBoard corresponds to a different service or command and the user may simply place their mobile device in one corner to receive any new messages, or a different corner to download the latest news to their device on the way out the door. Figure 1 and **Error! Reference source not found.** shows usage of the board using the second method. In this case, the user is reading the received note in their inbox by placing their RFID equipped mobile device on the view inbox region of the IIBoard.

The advantage of the implicit mode is that the RFID-equipped magnets (tags) are only used to identify individual persons or objects with which to communicate, and regions of the IIBoard are associated with commands. This allows the use of

the RFID tags for multiple services. As illustrated in **Error! Reference source not found.**, if user A places user B's RFID tag in the "send message" region, then a message, previously uploaded by user A, will be sent to user B's inbox. User B can access the message from User A by placing their MCD (with RFID tag attached) onto the "view inbox" region.

The implicit mode has an advantage over the explicit mode since only one RFID tag attached to their MCD is required to view and access the services provided. For the explicit mode, the user has to place the corresponding service view tag (i.e. "view inbox" or "webpage 1") on the IIBoard rather than intuitively placing their MCD on the IIBoard.

4 IMPLEMENTATION OF IIN

Figure 4 shows the Interactive Information Network (IIN), made up of access points connected by a local area network to a central server. The access points perform the services provided to the user.

An access point (AP) can be placed anywhere within a home and is assigned an IP address on the IIN. The access points have at least on wireless Bluetooth transceiver to communicate with mobile computing devices (MCDs) and other devices. The central server provides file space for each access point to store or retrieve files.

4.1 Access Points

Although transparent to the user, there are two types of access points: Web and File Transfer. Each access point offers different Bluetooth services. This allows multiple users to access the system at any one time. The Bluetooth radios used on the access points currently do not support Piconets and hence only one Bluetooth connection to an access point can be supported at any time. However, Piconet Bluetooth connectivity will be addressed in future developments of the IIN.

The web Access Point provides an internet over Bluetooth connection. The web AP is implemented on a Gumstix embedded Linux (Gumstix Inc) platform. The web AP allows Bluetooth Dialup Network (DUN) access profile connections (Bluetooth SIG) to accept Point to Point Protocol (PPP) connections. The PPP connection allows TCP/IP connections to be facilitated over a serial link. A web AP's web host process responds to HTTP requests sent by a user's MCD.

The File Transfer Access Point accepts Bluetooth file transfers and connects via Bluetooth to the Interactive Interaction Board (IIBoard). The file transfer AP has a Bluetooth transceiver module is used to accept Bluetooth OBEX FTP (Bluetooth SIG) connections for file transfer. And a Bluetooth serial profile module to connect to the IIBoard. The file transfer AP allows users to upload files such as text or multimedia files with their MCDs. When activated, the digital pen will transfer its captured strokes image file via Bluetooth OBEX Push Transfer to the file transfer AP.

4.2 Interactive Information Board

Users access the services provided by the IIN by manipulating the Interactive Interaction Board

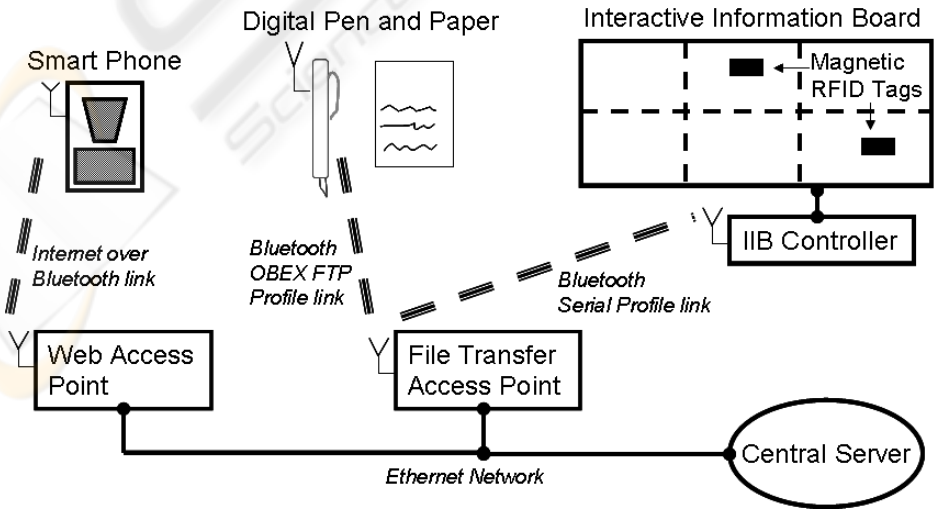

Figure 4: The Interactive Information Network (IIN).

(IIBoard). Users or objects are identified by RFID tags. Embedded within the IIBoard are six RFID reader antennas to determine which region the RFID tag was placed in. Each service command was assigned to a particular region. When RFID tag is detected in a region the RFID reader will transmit the RFID tag ID number and the antenna number via Bluetooth to the file transfer AP. For using the IIBoard in explicit mode, the antenna number is ignored.

5 OPERATION OF IIN

Figure 5 shows a flow diagram of the Interaction Information Network (IIN) software architecture. Software entities that make up the IIN are described in this section.

5.1 RFID Tag

As shown in Figure 5a) the RFID Tag message is located on the Interactive Information Board (IIBoard). This entity determines when and where an RFID tag is detected on the IIBoard. Once detected, the RFID and activated IIBoard region number are transmitted using a custom protocol to the RFID tag interpreter.

The RFID tag interpreter resides on the file transfer AP and connects via a serial Bluetooth link to the RFID tag message entity on the IIBoard. The RFID tag interpreter translates the received RFID tag ID into user identification and the detected region numbers into service commands. For example, if a user's MCD with an RFID tag is detected in region 2 the RFID tag interpreter will instruct the web access controller to link the MCD's web browser to the user's inbox webpage. When the IIBoard is operating in explicit mode, the antenna number is ignored and the RFID tag is translated into both user identification and service command.

5.2 Access Point Controllers

When the MCD connects to the web AP, it is assigned an IP address which allows access to other elements of the network. Once connected, the user will see the IIN's home webpage in their MCD web browser. The home webpage is changed depending on the actions taken by the user when manipulating the IIBoard. The home webpage is a Common Gateway Interface (CGI) script that is dynamically altered by the web access controller. The home webpage uses HTML frames to display two web-pages: header and body. The header webpage displays the title of the service and the body webpage displays the requested service webpage. The web access controller alters the links to the header and body WebPages in the home webpage CGI script depending on the view service action required by the user. The home webpage currently refreshes periodically to reflect changes made by the web access controller.

On the central server, the information service controller performs the peer to peer messaging service when instructed by the RFID tag translator.

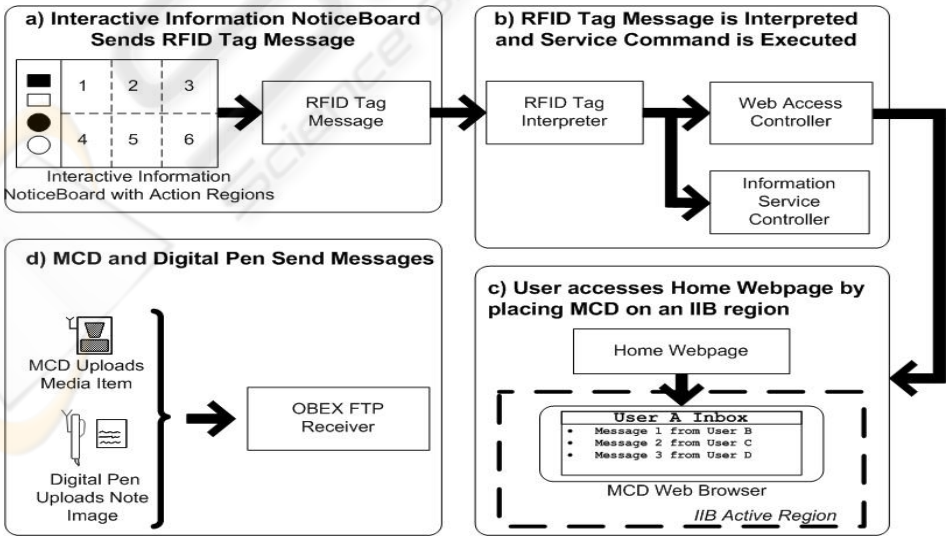

Figure 5: Software Architecture of the IIN.

If the requested action is to send a recently received message to a user, the information services controller will then move that message file to that destination user's inbox.

The OBEX FTP Receiver resides on the File AP and is used to receive media files or messages via the Bluetooth OBEX FTP protocol from the MCD and the digital pen. Once a file or message has been received, the OBEX FTP receiver places it in a received folder on the server. Any files placed in the received folder can be accessed by the information service and web access controllers.

6 CONCLUSION AND FUTURE WORK

A wireless Bluetooth Interactive Information Network (IIN) infrastructure that allowed users with various Bluetooth enabled devices to interact with other users and their environment, was successfully created and tested. Bluetooth enabled Smartphones and digital pens were used as interaction devices. The IIN supported two information services: messaging service and internet access.

Two types of access points were developed to accommodate different types of Bluetooth connections. The web access point facilitated an Internet over Bluetooth Link while the File transfer Access point accepted Bluetooth OBEX-FTP connections. Users could connect their Smartphones or other MCDs to either access point.

An Interactive Information Board was developed to allow RFID tags to be used to control the information services provided by the IIN. A user was able to access the information services such as web content, by placing their MCD on a region of the interactive information board. The file transfer access point provided a Bluetooth connection to receive the image output from a digital pen. The digital pen was used as an input mechanism for users to write messages.

The future work for this project involves integrating other Bluetooth enabled devices particularly devices that support the Bluetooth HID profile. Extra information services such as SMS and MMS messaging using the IIN will also be considered and developed in future developments of the IIN. Future applications of the IIN involve e-work and e-health environments.

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