# Using Wireless Sensors as Selection Devices for a Multimedia Guidebook Scenario

Montserrat Ros†, Matthew D'Souza*, Michael Chan*, Konstanty Białkowski*, Adam Postuła*, Neil Bergmann*, Andras Toth‡

* School of Information Technology and Electrical Engineering, University of Queensland, Brisbane, QLD, Australia 4072

{dsouza, mchan, ksb, adam, n.bergmann}@itee.uq.edu.au

† School of Mathematics, Statistics and Computer Science, University of New England, Armidale, NSW, Australia 2351

ros@mcs.une.edu.au

‡ Ericsson AB, Torshamnsgatan 23 164 80 Stockholm Sweden

andras.toth@ericsson.com

## ABSTRACT

This paper describes the implementation of a wireless sensor network for a multimedia guidebook scenario incorporating a pointer-sensor system for the selection of locality-aware information. An Information Point Station Network (IPSN) was developed and consists of several Information Point Stations (IPSs) placed at locations of significance, with access to information items on a centralized server. In the multimedia guidebook scenario, a user selects a particular information item to view, either by way of a menu system appearing on their mobile computing device (MCD) or a more intuitive pointer-sensor system as described in this paper. Laser sensors are placed next to prominent or relevant objects, and can be either directly connected to an IPS, or function as isolated sensor nodes. The pointer is attached to the MCD by way of a serial port and the user points the pointer at the laser sensor next to the object for which they require information. The information is then sent to the MCD via Bluetooth. The implementation was found to be successful and was tested with multiple users accessing information items from a given IPS as well as multiple IPSs attached to the centralized server. Still, there is further work to be done on the isolated sensor nodes.

## Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design – *Wireless communication*.

## General Terms

Design, Experimentation

## Keywords

Wireless Sensors, Bluetooth, Multimedia Guidebook.

## 1. INTRODUCTION

Wireless Sensor Networks have many uses. This paper introduces a wireless sensor network that was used for the purpose of selection for a multimedia guidebook application. The Multimedia Guidebooks scenario allows the user to access specific information related to their immediate surroundings and can be used in museums and other tourist facilities. This paper also presents the development of an interactive pointer and wireless isolated sensor node architecture used for the intuitive selection of information items sent to the guidebook.

The multimedia guidebook operates by allowing the user to select information to be viewed by aiming a pointer device at a laser sensor located near an object of interest, upon which information is sought. The requested information is then 'beamed' to the user's mobile computing device (MCD) via Bluetooth for the user to view. Bluetooth was selected as the medium of choice due to its prevalence on most modern mobile computing devices such as Personal Digital Assistants and mobile (cell) phones. This fact, coupled with the nature of Bluetooth communications lacking the requirement for line-of-sight meant users could retrieve location-aware information at the "locality" level. The user can also select the information by using a menu on their mobile computing device.

An Information Point Station Network (IPSN) was developed for use in the Kelvin Grove Urban Village located in Brisbane, Australia [2]. The network consists of information point stations (IPS) placed at specific locations of interest. A point of interest can be a monument, a building or any article of significance. Each information point station has access to media information relevant to its location and consists of a Bluetooth transceiver and system of laser sensors. The Bluetooth transceiver is used to transfer the requested information to the user's mobile computing device. The laser sensors are used to detect when the user is selecting information by using the interactive pointer device. As well as laser sensors connected to information point stations, the guidebook scenario provides for isolated sensor nodes. The isolated node is similar to the IPS-connected laser sensors in that it contains a laser sensor. However, the isolated sensor node also contains an infrared transceiver that it uses to communicate with the user's MCD.

This paper is organized into 6 sections. Section 2 presents a review of related work. Section 3 describes a typical user scenario. Section 4 discusses the implementation of the pointer and sensor multimedia guidebook network infrastructure. Future areas of investigation are discussed in section 5 and conclusions are drawn in section 6.


**Figure 1 – a) Menu Browser on the IPAQ – b) Pointer prototype – c) Sensor prototype**

## 2. RELATED WORK

Multimedia Guidebooks wireless networks are found in museums and other tourist attractions. There are two main types of multimedia guidebook wireless networks. One type involves the information being transferred to the guidebook on request. The second type already has the information stored on the mobile computing device. Examples are the Exploratorium [7] and the Cyberguide guidebooks [3]. These guidebook wireless networks have been developed for older PDA platforms. No guidebooks have yet been developed for the latest smart mobile phones using interactive pointers. Existing guidebook wireless networks tend to use older short-range wireless protocols for information transfer such as infrared communications. This is due to the widespread usage of infrared transceivers on older PDA platforms. Infrared is not as widely integrated into mobile computing devices as Bluetooth [4] has become. Infrared has been surpassed by Bluetooth in many applications because it does not require line of sight, supports ad-hoc networking and has more robust data communications.

The Exploratorium guidebook provides the user with information about exhibits in a museum. The Exploratorium guidebook deploys Radio Frequency ID (RFID) nodes, 802.11b wireless LAN and HP Jornada PDAs. When a user with a PDA comes within range of an exhibit that has a RFID node, the node's ID is sent to the PDA via infrared. Information about the exhibit is requested by the PDA and the result is returned via the 802.11b LAN. The Cyberguide is a map guide that allows the user to find their location on the map of a venue. It uses customized infrared sensors to determine the user's location and PDAs. The infrared sensors are at known locations on the map of the venue. When the user comes with in range of an infrared sensor, their location can be displayed on their PDA's map.

Interactive pointer devices are more commonly known as remote controls and are used in everyday life to control devices such as television sets. Pointers can be classified in terms on the communication medium used. Most commonly used pointers use infrared. There are projects to develop pointers that use laser light. One such project described in [8] developed a laser pointer linked to a PDA so that it can control devices remotely. One of the reasons for using laser rather then infrared is that it provides the user with a better visual mechanism to point at a device as suggested by [5]. So far pointers have not been used with guidebook wireless networks or other similar wireless network applications that require the user to select information.

## 3. WIRELESS SENSOR NETWORK SCENARIO

The scenario of a Multimedia Guidebook gives the user the opportunity to experience locality-aware information on demand in various multimedia formats. The user can choose to interact with the Information Point Station Network (IPSN) and request their chosen information item in a number of ways. Other than by selecting from a menu (Figure 1a), the user can also intuitively point for the information they desire, without the need of connecting to a particular Information Point Station (IPS) and searching through a menu. As the user roams around the Kelvin Grove Urban Village site, he/she may choose to use the pointer device attached to their mobile computing device (MCD) (Figure 1b) when approaching an object of interest with a laser sensor or isolated node (Figure 1c).

In the case of an IPS-attached laser sensor, only one-way communication between the pointer and the laser sensor is required. When the pointer is connected to the serial port of the MCD and the user points to the laser sensor, the pointer transmits the MCD's identification information (currently the Bluetooth address of the device). Upon reception of this information, the laser sensor transmits a command message consisting of both the user's identification and the sensor's own identification to the IPS. This is so that the IPS can send the requested item for the corresponding object of significance to the MCD.

In the case of an isolated sensor node, two-way communication is required between the pointer and the sensor. Hence, these isolated nodes require an infrared transceiver to facilitate the return communication. When the pointer is connected to the serial port of the MCD and the user points to the laser sensor, the pointer transmits the MCD's identification information as per an IPS-connected sensor. However, upon reception of this information, the isolated sensor node transmits the command message back to the MCD using infrared. Once equipped with the sensor's identification, the MCD software automatically connects to a nearby IPS to request for the information item associated with that sensor node's identification details. Although the isolated sensor node requires line-of-sight to communicate its identification details via infrared, this is not a problem, as the user is already pointing the pointer directly at the sensor.

The user's experience of an information item once it is downloaded via Bluetooth is the same regardless of how the user selected it – whether it be from an onscreen menu, or by selecting a sensor or node with the laser pointer. The goal of offering locality-aware information is achieved by ensuring that retrievable information is the information suited to the object of interest for which the sensor is a selector.

# 4. WIRELESS SENSOR NETWORK IMPLEMENTATION

The Multimedia Guidebook wireless network consists of information point stations (IPS) placed at specific locations of interest. Each IPS forms part of an Information Point Station Network (IPSN). The IPSN is shown in Figure 2. The IPSN consists of a central server, information point stations, isolated sensor nodes, mobile computing devices and pointer devices. The server controls the IPSN. It communicates to each information point station (IPS) via Ethernet. Each IPS contains a wireless Bluetooth transceiver and laser sensors. The Bluetooth transceiver is used to communicate to the mobile computing device. The mobile computing device (MCD) can be a Personal Digital Assistant or a mobile phone. The MCD is used by the operator to select and view information from the IPS using either the menu or the interactive pointer by aiming it at a laser sensor.

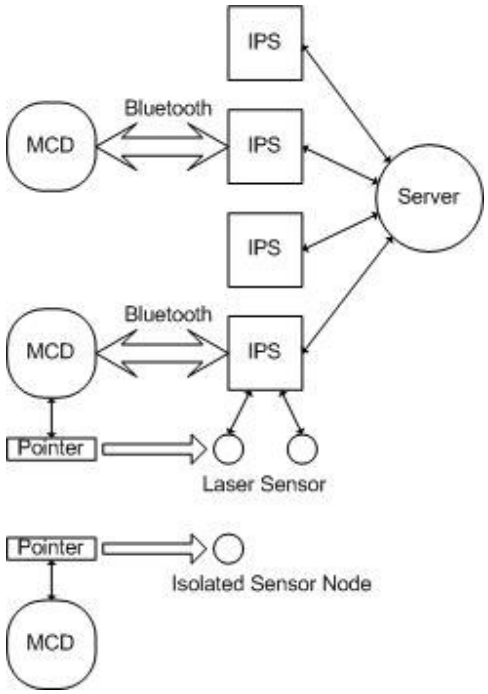


**Figure 2 – IP Station Network.**
**(MCD = Mobile Computing Device, IPS = IP Station)**

Sensor nodes can also be used to by the user to select information. When a sensor node is selected by the interactive pointer, it responds with the sensor node's identification which is transmitted by infrared to the pointer. The pointer then relays the sensor node's identification to the MCD which will connect to a nearby IPS to request for the information item associated with that sensor node's identification details.

## 4.1 Communications

Figure 3 and Figure 4 show the different communication protocol channels used for IPS-attached sensors and isolated sensor nodes, respectively. For the Bluetooth connection between the IPS and the MCD, the Bluetooth serial port (SPP) and Object Exchange File transfer (OBEX-FTP) profiles are used. The Bluetooth serial port profile is used as a control channel where a specialized control protocol was designed and implemented to request information from the IPS [6]. The OBEX-FTP profile is used to transfer information items in the form of files from the IPS to the MCD.

The IPS communicates with the server via a standard Ethernet connection and with attached laser sensor/s via conventional RS232. As shown in Figure 3, the pointer communicates to the IPS-attached sensor using the laser optical channel and the IPS must be connected to the laser sensor for this to occur. For an isolated sensor node, the pointer communicates with the node using the laser optical channel and the node responds to the pointer using the infrared optical channel. Figure 4 shows these communication channels.

## 4.2 Network Infrastructure: Server and Information Point Stations

The backbone of the IPSN infrastructure consists of the centralized server and the collection of Information Point Stations. The main functions of the server are to maintain the information items database, monitor each IPS and control the user identifier database. The information items database contains all information items associated with each IPS as well as individual sensors and sensor nodes. The identifier database contains the user Identifiers (UID) and preferences of all registered users. The server can monitor the status of the IPSN which includes displaying statistics such as the number of active users or the number of requests for a particular item. The server consists of a Linux computer with an Ethernet hub. Communication to each IPS is done using the TCP/IP networking protocol.

The function of the IPS is to provide a Bluetooth access point to the IPSN. The IPS will authenticate the user and supply the requested information items. Statistics such as the number of active users or the number of requests are recorded and sent to the server. The current implementation of the IPS is a Linux computer with a wireless Bluetooth USB. The open source Linux Bluez Bluetooth stack[1] is used to facilitate the Bluetooth

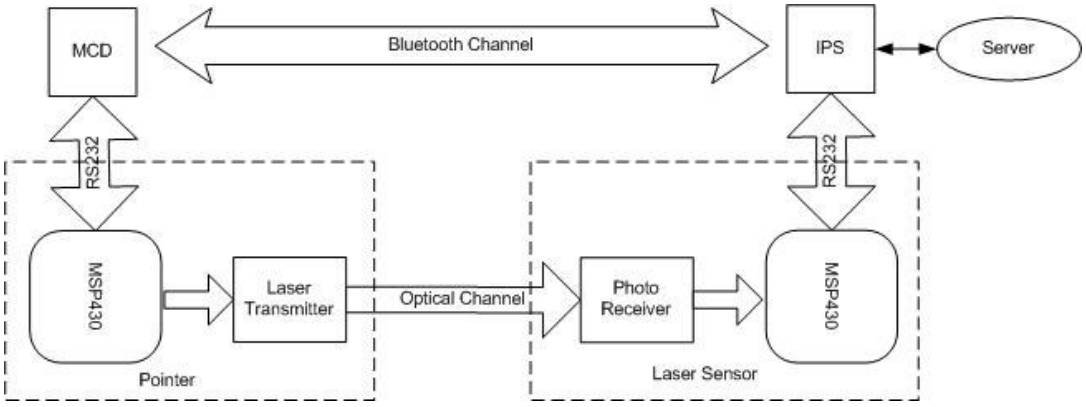


**Figure 3 - Communication channels of IPSN with IPS, Laser Sensor, Pointer and MCD**

connectivity to the mobile computing device. Using the Bluez Bluetooth stack was ideal for this project because it was easily customized to suit the project requirements.

## 4.3 Network Infrastructure: Pointer and Sensor/Node Implementation

The purpose of the interactive pointer device is to request data from an IPS. When the pointer is activated, it continually transmits the user identifier of the MCD, as shown in Figure 3. The pointer transmitter circuit is realized with a laser diode and associated driving circuit. A laser diode was chosen for its exceptional range, and directionality. Because binary signaling is used, the power output of the laser transmitter doesn't need close regulation, which simplifies the design and reduces power consumption of the driver circuit. The MSP430 [12] micro controller from Texas Instruments encodes the data stream using Manchester encoding, and manages communication with the MCD via RS232. This micro-controller was chosen for its ultra-low power consumption.

### *4.3.1 IPS-attached Laser Sensors*

The laser sensor receives the modulated data stream via two OPT101 [11] monolithic photo-diode receiver circuits. This integrated circuit consumes minimal power, and includes an internal amplifier, leading to a simple receiver design. Two receiver circuits are employed to increase the effective viewing angle of the sensor. The MSP430 is used here to demodulate the waveform, and to forward requests containing the MCD's identification and the sensor's own identification to the IPS via RS232.

### *4.3.2 Isolated Sensor Nodes*

The wireless sensor node is a standalone entity. It consists of the laser detector and an infrared transceiver. This can be seen in Figure 4. The laser detector design used is the same as that described in section 4.3.1. The infrared transceiver is used to convey identification information about the node to the user's MCD via the pointer device. The pointer device also contains an infrared transceiver.

## 4.4 Mobile Computing Devices

In the scenario of a guidebook application, the mobile computing device (MCD) functions primarily as an item requester. The guidebook software was implemented on a HP IPAQ 5550 Personal Digital Assistant running the Pocket PC 2003 operating system; and a SonyEricsson P910i SmartPhone [9] running the

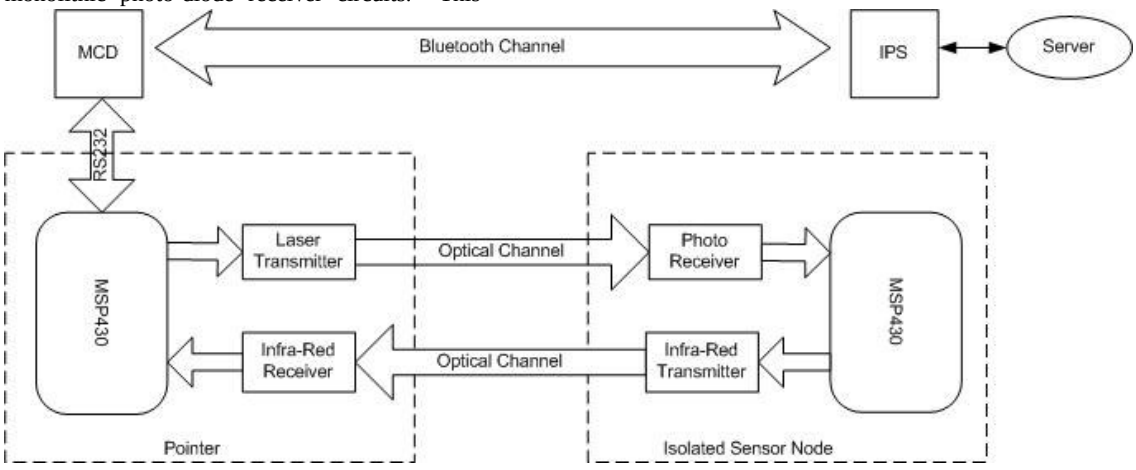


**Figure 4 - Communication channels of IPS, Isolated Sensor Node, Pointer and MCD**

Symbian operating system with Java 2 Microedition (J2ME) compatibility [10]. The software on the HP IPAQ was created using the C# language from Microsoft Visual Studio .Net for Pocket PC 2003.

The IPAQ software was integrated with the pointer and IPS-attached sensor system. This was done by physically connecting the pointer to the MCD using an available RS232 serial port and sending the device's Bluetooth address to the pointer. This is the user identification that the pointer then uses to send to the sensor for item requests.

## 5. FUTURE WORK

Although functional prototypes were created of all components of the Multimedia Guidebook wireless network, some areas are highlighted for future work. The information point stations will be converted to an embedded processor platform solution that runs the uClinux operating system. Another area of future work is the further development of the isolated sensor nodes. The functionality of the isolated sensor node will also be expanded to include other sensors. The sensor node will also be redesigned to be low powered and to use remote powering techniques such as Radio Frequency powering. This will allow the sensor node to be powered or charged without a physical connection, thus enabling it to be placed in unreachable positions.

## 6. CONCLUSION

A Multimedia Guidebook wireless network system was created to allow users to access specific information related to their immediate surroundings using their mobile computing devices. The Multimedia Guidebook was designed to provide information about the Kelvin Grove Urban Village in Brisbane Australia. Users can request to view information by using either an interactive pointer device or by software menu selection. The Multimedia Guidebook wireless network consists of information point stations and isolated sensor nodes placed at locations of significance. The information point stations consist of a Bluetooth transceiver and a series of laser sensors. The Bluetooth transceiver is used to transfer the requested information to the user's mobile computing device. The isolated sensor node consists of a laser sensor and an infrared transceiver. The infrared transceiver is used transmit the sensor nodes identifier to the interactive pointer device. The user can use the interactive pointer to select information items to view by aiming it at a laser sensor on either the information point station or the isolated sensor node. Future areas of investigation include creating an embedded platform for the information point station and investigating remote powering mechanisms for the isolated sensor node.

## 7. ACKNOWLEDGEMENTS

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