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A Bluetooth based low cost electronic guidance for museum visitors[1]

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Abstract: Bluetooth is a data communications method that is designed as a short range radio connectivity solution for personal, portable and handheld electronic devices. Due to the low cost of a Bluetooth chip, this technology is used in several fields, telemedicine, tourism, office etc..

A Bluetooth based system for voice and data transmission in museums is presented in this work. Using the proposed system new innovative services will be offered to the museum visitors. The paper analyses the hardware, the protocol stack and the topology of the proposed system.

1. Introduction

Bluetooth is a short-range radiocommunication technology intended to create ad-hoc wireless connectivity between portable and/or fixed electronic devices like computers, cellular phones, printers etc. The development of the Bluetooth industry standard [1] started in the winter of 1998 when Ericsson, IBM, Intel, Nokia and Toshiba formed the Bluetooth Specific Industry Group (SIG). The Bluetooth system can manage a small number of low cost and low consumption point to multi/point communication links in a range up to 10 meters with a transmission power less than 1mW. It operates in the worldwide unlicensed ISM band in the frequency of the 2.4 GHz and it uses frequency hopping for transmitting data over radio with a rate up to 1 Ms/s.

The Bluetooth technology acts additional in short range to the already second-generation wireless systems, as well as to the future third generation systems. It is the leading technology between the other proposed technologies such as IrDa and HomeRF, for wireless indoor short range personal communications. Given the small size of a Bluetooth chip it can be easily embedded in any of the existing portable devices with a low cost (5€/Bluetooth unit) Some applications based on the Bluetooth technology could be found in the following fields:

- **Telemedicine**: Regular logging of patient's diagnostic information, remote monitoring of patient's from the internet, automatic signaling to doctor in case of emergency, data transmission e.g. remote system for ECG patient monitoring.

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- **Automotive:** Sharing capabilities between portable and embedded devices e.g. using a car embedded user interface, maintenance applications, enabling car e-commerce.

- **Smart house:** Telecontrols, hot water geysers, CD players, TVs alarms, movement detectors can be managed by Bluetooth based systems.

- **Office:** Data transmission, printers, access to photocopy machines, access to places, Internet access, VoIP office environment , wireless meetings etc.

- **Tourism**: Information systems based on voice or data transmission with distributed joining points in museums, fairs, etc.

In this paper a Bluetooth based low cost electronic guidance for museums is presented. The museum visitors can effortlessly receive location-based, rich media information about museum exhibitions. Location-based delivery ensures that visitors receive only information that is relevant and enables easy navigation of the museums' permanent and temporary exhibitions and resources, while receiving rich media and hyperlinks, visitors are drawn to the most precise details, encouraging more in-depth, independent learning. As a result new and exciting methods to learn and experience sites and attractions draw more visitors and raise interest at the museum. The proposed Bluetooth network can be used to display and market other raise interest at the museum. The proposed Bluetooth network can be used to display and market other museum services and products that can be purchased directly from the PDA.

The remainder of the paper is structured as follows. In section 2 the Bluetooth technology aspects are presented. Section 3 analyses the hardware architecture of the proposed system while in section 4 a brief description of the Bluetooth protocols stack are presented. Section 5 analyses the topology of the network and finally some conclusions are done in section 6.

2. Bluetooth Aspects

Bluetooth standardization [2],[3] contains the definition of the radio-interface like the software architecture that supports the necessary protocols to offer different services. The standards also include some profiles that support interoperability between devices with the same type of applications. In this way in a Bluetooth system compatibility between devices and services is assured. Therefore, Bluetooth turns out an appropriate technology to facilitate the wireless connectivity between equipment (susceptible to be connected) in two basic types of scenes: applications within the telecommunications and applications within PCs and electronic equipments or between electronic equipments.

A Bluetooth terminal displays the following properties:

- Low weight and electrical consumption (one/two Chips).

- No radio licence is required worldwide ISM band in the frequency of the 2.4-2.5 GHz.

- Robust to interferences (e.g. microwaves ovens and other Bluetooth terminals).

- Each terminal has an exclusive identity

- Reach of 10 ms with 1 Mbit/s (nominal) and 0 dBm of power.

- Connection of up to 7 simultaneous terminals.

- Software architecture interconnection based on existing protocols. (PPP, TCP-IP, Serial Port)

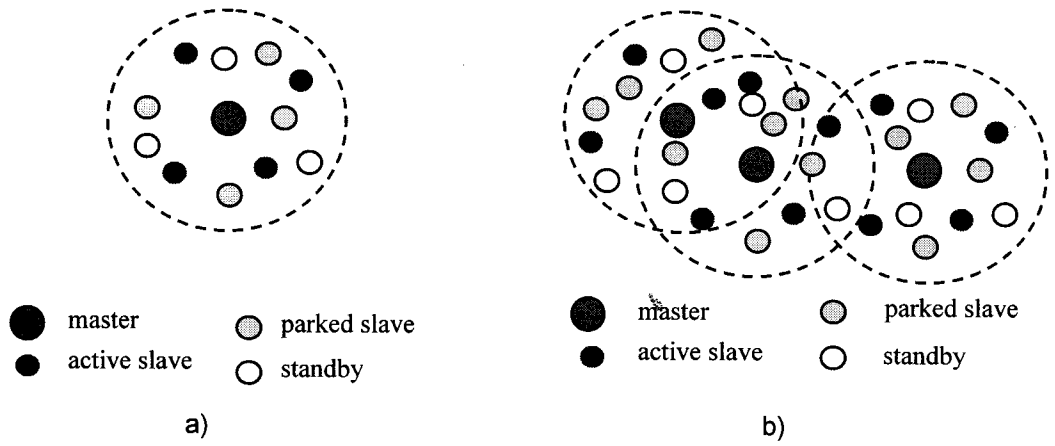

Figure 1 Bluetooh network topology

Bluetooth systems using a combination of circuit and packet transmition can establish up to three synchronous channels (voice) with a transmission rate up to 64 kb/s or one asynchronous channel (data) supporting data rates up to 723 kb/s of asymmetrical transmission or up to 433 kb/s symmetric.

A Bluetooth network consists of Piconets, each one contain a main unit (master) and up to seven secondary (slaves) units (Figure 1a). A main or a secondary unit can belong in more than one Piconets, allowing thus the creation of a larger range network, which is named Scatternet (Figure 1b).

3. Hardware description

As shown in Figure 2 the baseband module of a Bluetooth systems consist of five units: the microcontroller subsystem, the baseband unit, the Universal Asynchronous Receiver Transmitter (UART), the Universal Serial Bus (USB) and the audio CODEC.

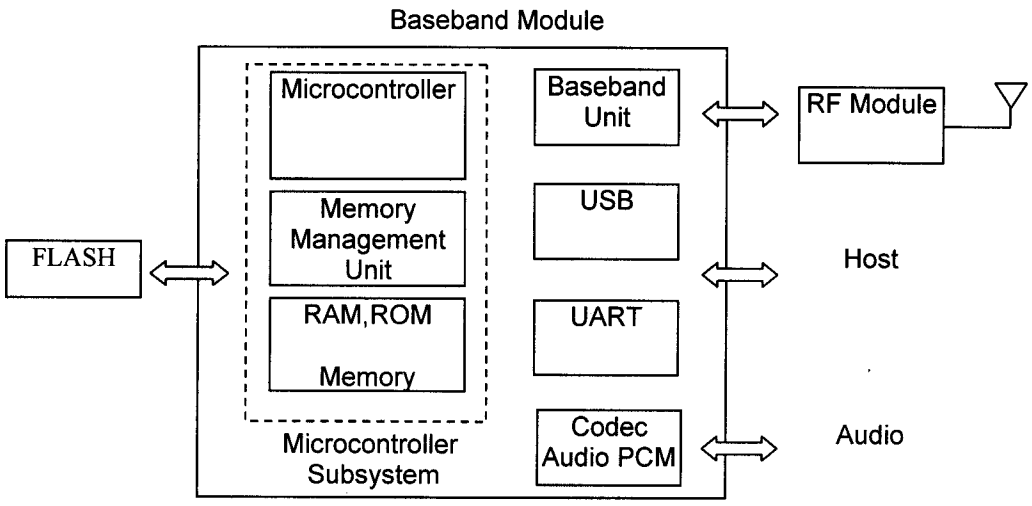

Figure 2 A typical Bluetooth hardware implementation

The microcontroller manages the other units, executes Bluetooth link manager, host control interface and some part of link controller protocol. Known microprocessors that can be used in a Bluetooth module are those from Arm7 family, such as Advanced RISC Machines ARM7TDMI. These 32bit microcontroller cores are suitable for the application, because they offer small hardware size and great flexibility. **The Baseband Unit** performs the bit-intensive baseband protocol functions that are power efficient if implemented in hardware i.e. Bluetooth bitstream processing and encryption. In addition, the most time-critical portion of the

link controller tasks, such as low-level timing control and frequency hop calculation, are processed by this unit. Furthermore, it controls the RF module using a boundary scan serial interface.

The USB and UART implement Bluetooth **Host Control Interface** (HCI) physical transport layer. The USB unit complies with USB specification v1.1 and HCI USB transport layer specification of Bluetooth v1.1 and supports full speed 12Mbit/s host controller interface. The UART unit is designed based on industry standard 16C450 and it supports bitrates from 300bit/s to 1.5bit/s. **Audio CODEC** processes voice data and supports all three Bluetooth audio coding: A-Law, μ-Law and CVSD (Continues Variable Slope Delta Modulation). For simple audio applications, the audio unit interfaces directly to PCM audio devices without using HCI. For PC-application, coded audio bitstream can also be transmitted via synchronous HCI data packets through USB or UART.

4. Bluetooth Protocols stack description

In Figure 3 the protocols stack of a Bluetooth device is presented. The baseband control layer (layer 1) is charge to manage the transmission in the radio interface (format of packages, management of the frequency jump, etc.). The connection manager LMP(Link Manager Protocol) in layer 2 allows the creation and the configuration of radio connections with other devices. So and as it is shown in the Figure 1, a typical configuration hardware of the present Bluetooth modules consists of locating the layer 1 & 2 in one only chipset. The communication between these layers and the higher protocols are made by means of an interface, the HCI (Host Controller Interface). The standards specify the accomplishment of this interface through a UART, RS-232 or USB.

The higher layers could be located in an external microprocessor; the L2CAP layer allows multiplexing of the higher layers and manages the segmentation and the resegmentation of the packages, the RFCOMM emulates an interface series of type RS-232 and the SDP (Service Discovery Protocol) allows the Bluetooth devices to discover automatically available services that are in other Bluetooth devices of their radio electric surroundings. The TCS (Telephony Control Signaling) provides telephony services. The rest of layers presented in the Figure 3are not exclusive in a Bluetooth module and they depend on the service.

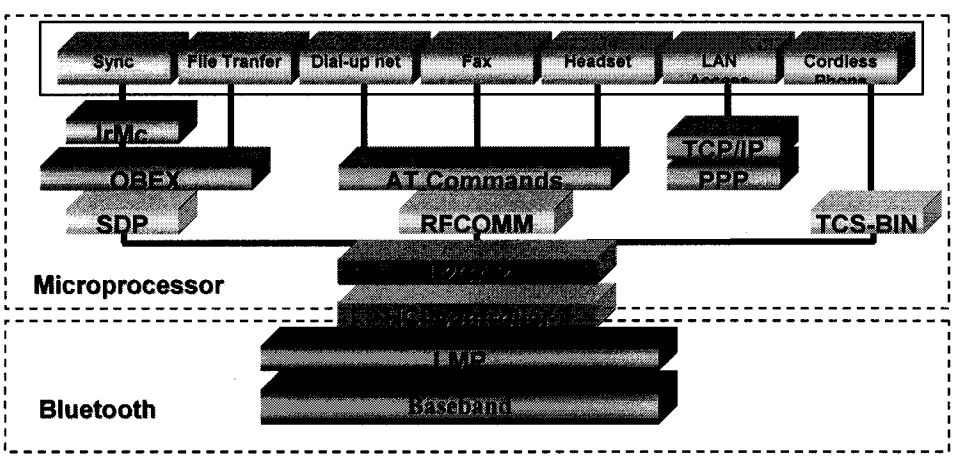

***Figure 3** Bluetooth protocols stack*

5. Museum Topology

The Bluetooth Museum network consists of the museum central server, the HTTP server, the Bluetooth Access Points (AP), the Local Area Network and the wireless Bluetooth based terminals. The central server is a computer that holds the database and manages all the information requests from the visitors. The HTTP server contains all the Museums WebPages relevant with the Museum's tour. The APs provide in each wireless connected visitor access at the local network. APs are wired connected to the museum LAN in one side and to the Bluetooth terminals over radio in the other side. The museum LAN connects all the Access Points with the central server. The wireless Bluetooth terminals could be PDAs and headphones.

The Bluetooth devices, APs and mobile terminals, compose a Piconet consisting of a signle master device, an AP, and up to seven slave devices PDAs or headphones. Every Piconet are very distance limited, so every museum room has at least one Piconet.

The PDA terminals moving from one Piconet to another, in every Piconet they receive a local IP and after they disconnect from a Piconet they roam and try to reconnect. The estimated standby time of every connection trial is approximately 100ms and in this case the network is not overloaded. The visitor can interactively use the PDA as his private guide, choose a tour by his field of interest and tour through the museum's rooms while reading relevant information at his PDA. This information varies from the visitor's demand, the visitor's current position, general information about the museum and of course specific details about the different exhibits.

The AP of each room holds every Bluetooth headphones with a Device Address, (BD_ADDR), that correspond to headphones devices only. When a Bluetooth headphone enters in the range of an AP, the headphone is automatically recognized and a media sound file is being downloaded to the headphones flash memory. This media sound file will supply the visitor with all the necessary information about the particular room and it's exhibits and will be played at the headphone until the next room, where the above procedure is being repeated.

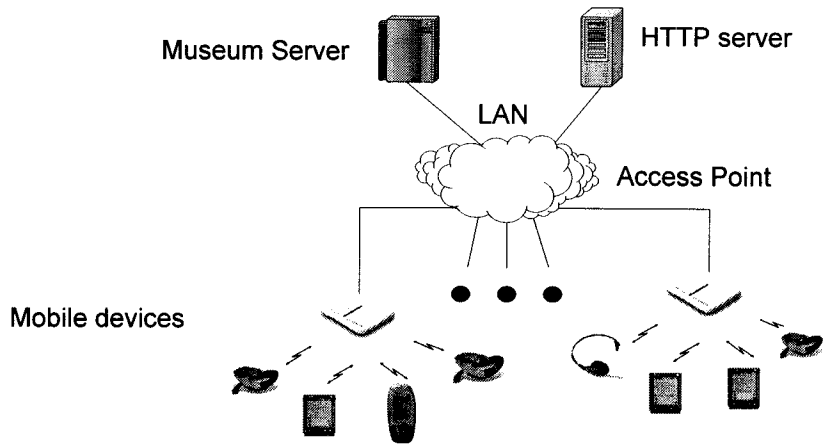

Figure 4 *Topology of the Bluetooth based system*

6. Conclusions

Bluetooth technology is a specification for short-range, low-cost that enables user friendly connectivity among portable and handheld personal devices. As more and more manufactures adopt Bluetooth and create devices that support it, developers find new ways of applying its power.

In the article a Bluetooth based, low cost system for voice and data transmission in cultural centres has been presented. The hardware requirements have been specified while the protocols stack and the network topology have been analysed. The propose system offers new innovative services, in voice and hyperlink format to the museum visitors.

References

[1] www.bluetooth.org

[2] Bluetooth Special Interest Group. *Core Specification of the Bluetooth System ver.1.1*, Nov 2000.

[3] Bluetooth Special Interest Group. Profiles Specification of the Bluetooth System ver.1.1, Nov. 2000.