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Integration of Near Field Communication (NFC) and Bluetooth Technology for Medical Data Acquisition System

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Abstract: - Medical Data Acquisition System is a new invention that helps an easy and efficient data management system in medical world. This wireless system could allow medical staff to monitor and update patient's database easily and will increase the productivity of medical staff. The system is invented to collect personal and medical data from patient, which is stored in the Smart Card given to each patient, using Near Field Communication (NFC) technology that is embedded in Remote Unit. The data are transmitted from the Remote Unit to Base Unit over wireless communication. The data are stored in the Base Unit database. Bluetooth technology has been chosen to carry out the transmission process between Remote Unit and Base Unit. This study explains the Bluetooth programming implemented in the Linux operating system using BlueZ, Bluetooth protocol stack and libraries. The program for Medical Data Acquisition System is written in C language on Base Unit side and C++ implementation on Remote Unit side. This study shows an excellent result in every medical data acquisition test conducted.

Key-Words: - Near Field Communication (NFC), Bluetooth protocol stack, BlueZ, Smart card, Signal processing, Wireless channel, Telemedicine application.

1 Introduction

The proposed Medical Data Acquisition System is designed to acquire and store data and confidential medical reports safely and accurately. This system will eliminate problems with handwritten paper medical records, which are liable to be misread, damaged or lost especially in medical emergencies and as a result of physical damage, rain, earthquake or fire.

A projected solution of Medical Data Acquisition System consists of two state-of-the-art technologies; Near Field Communication (NFC) and Bluetooth, which manages the tracking, transmission and storage of the patient's medical data. Near Field Communication technology has been used to acquire information from a smart card and store it in memory. The data is then wirelessly transferred to the central database system via Bluetooth for easy-tracking on a record.

2 Experimental Theory

2.1 Bluetooth Technology

Bluetooth was designed as universal interface for wireless communication that provides power-efficient, short-range communication for ad-hoc network, low cost radio modules and has matured into powerful technology widely available today. It is also aim to reduce the manufacturing cost by eliminating the necessities of supplying the cables attached to the particular devices, at the same time, increase the convenience for the user to operate that device. Based on a market research, the manufactured of Bluetooth-enabled equipment and semiconductor are extensively increased every year with 69 million units of Bluetooth ICs shipped in year 2003 which were doubled compared to 2002 and are forecasted to grow up to 720 million in 2008 [1].

In Bluetooth network, the devices can operate in two modes; Master or Slave. This Master and Slave concept means that at least one device will act as a Master which connected to one or more Slaves. Master is the device in a network whose clock and hopping sequence are used to synchronize all Slaves in the network. All devices other than Master are called Slaves. It has to synchronize in terms of time and frequency with the Master by following the

Master's hopping sequence. Two or more Bluetooth devices form a Bluetooth network is called a piconet. The Bluetooth devices in a piconet could communicate in either point-to-point or multipoint application. Point-to-point means that there is just one Master and one Slave at one time as shown in Figure 1 (a), whereas for a collection of Slaves (up to 7 active Slaves) that controlled by one Master within a network is called point-to-multipoint as shown in Figure 1 (b). The Slaves in a piconet only have links to the Master and there is no direct links between Slaves.

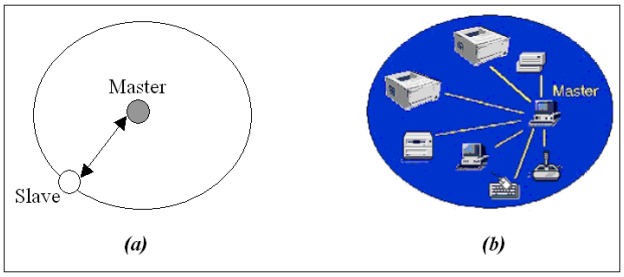


Figure 1: Point-to-Point and Point-to-Multipoint Piconet [2]

Bluetooth specification defines some protocol of its own and also reuses some existing standards. It is an agreement about the way data is exchanged. The elements include Bluetooth Radio, Baseband, Link Manager Protocol (LMP), Logical Link Controller and Adaptation (L2CAP), Radio Frequency Communication (RFCOMM), Object Exchange (OBEX) and Service Discovery Protocol (SDP).

2.2 Near Field Communication (NFC)

Near Field Communication, or NFC, is a wireless connectivity technology based on short-range RFID technology, which evolved from a combination of contactless identification and interconnection technologies. NFC permits short-range communication between two electronic devices to exchange small amounts of data when both devices are placed next to each other. NFC offers a great solution for controlling data by offering rapid and easy communication for all types of consumer devices [3].

NFC is an RFID based communication method on 13.56 MHz combining various aspects. As peer-to-peer communication protocol is concern, they must have two NFC-enabled devices involved in communication with the protocol. NFC is an open platform technology standardized in ECMA 340 as well as ETSI TS 102 190 V1.1.1 and ISO/IEC 18092. These standards specify the modulation schemes, coding, transfer speeds and frame format of the RF interface of NFC devices, as well as initialization schemes and conditions required for data collision-control during initialization - for both passive and active NFC modes. Furthermore, they also define the transport protocol, including protocol activation and data exchange methods [4].

NFC protocol distinguishes the NFC devices as Initiator and the Target of the communication. The Initiator generates RF field at 13.56 MHz to initiates and control the data exchange. The Target is the device that responds to Initiator command. The NFC communication differentiates between two modes of operation:

- Active NFC Mode: means both devices, Initiator and Target, generate their own RF field to enable the communication.
- Passive NFC Mode: means that only one device generate RF field while other devices uses load modulation scheme to transfer the data. The Initiator responsible to generate RF field.

Figure 2 and Figure 3 show communication diagram for Active and Passive NFC communication mode.

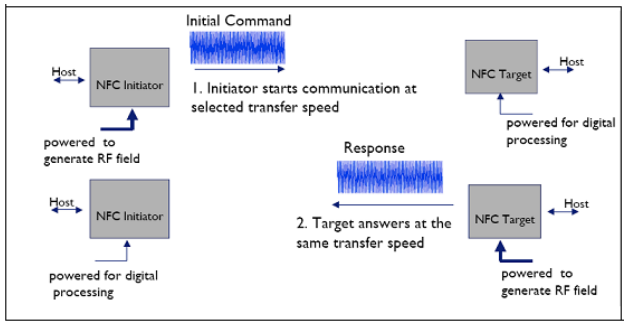


Figure 2: Active NFC Mode [5]

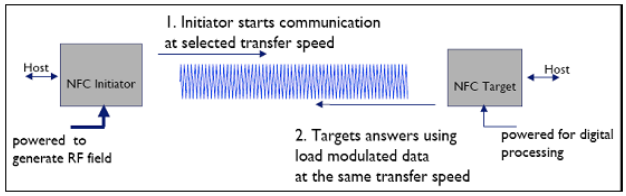


Figure 3: Passive NFC Mode [5]

2.3 Contactless Smart Card Technology

Contactless smart card technology is used in applications that need to protect personal information or deliver secure transaction. The physical appearance is similar to a standard plastic card, e.g. credit card. The cards are produced by lamination of a coil, which acts as an antenna and an IC inside it as shown in Figure 4. When the card, which does not possess its own power supply, is not within the interrogation zone of a reader, it is totally passive. It is only activated when it is move towards the reader. The power required to activate the card is supplied to the electronics inside the card and enable Radio Communication between reader and the card.

The data capacities of the contactless smart card normally range from a few bytes to several kilobytes. Current and emerging applications using contactless smart card technology include identifying card user, payment card, documents such as electronic passports or visas, and as an electronic purse. Applications using contactless smart cards support many security features that ensure the integrity, confidentiality and privacy of information stored or transmitted.

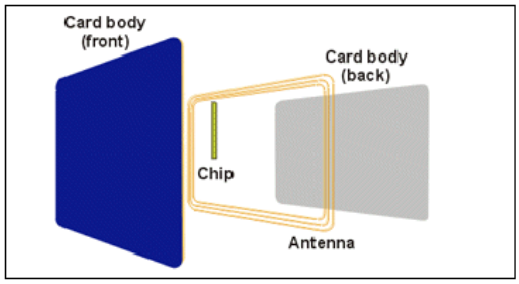


Figure 4: Basic Layout of Contactless Smart Card [6]

2.4 BlueZ

BlueZ is the official Linux Bluetooth stack that consists of the Host Control Interface (HCI) layer, Bluetooth protocol core, Logical Link Control and Adaptation Protocol (L2CAP), SCO audio layer, other Bluetooth services, user space daemons and configuration tools. Figure 5 shows an overview diagram of BlueZ. The BlueZ kernel modules, libraries and utilities are working prefect on architectures supported by Linux. BlueZ makes it possible for the Linux user to connect with other Bluetooth devices such as Bluetooth USB-dongles, mobile phones with Bluetooth, access point and so on. BlueZ is flexible, efficient and uses a modular implementation.

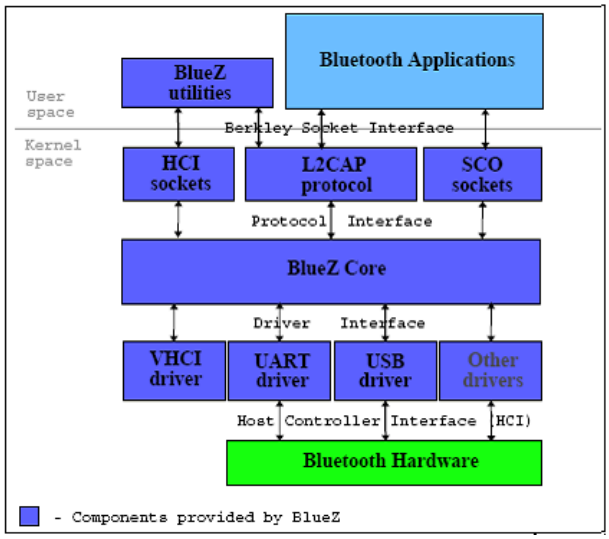


Figure 5: BlueZ Overview Diagram [7]

3 Methods and Approach

In Medical Data Acquisition System, there are several devices and equipments involved; Linux PCs, MIFARE® Smart Card, PN531 NFC called TAMA, and D-Link DBT-120 Bluetooth USB Adapter.

Medical Data Acquisition System can be classified into three parts; Smart Card, Remote Unit and Base Unit. Figure 6 shows a block diagram for the whole concept of the Medical Data Acquisition System.

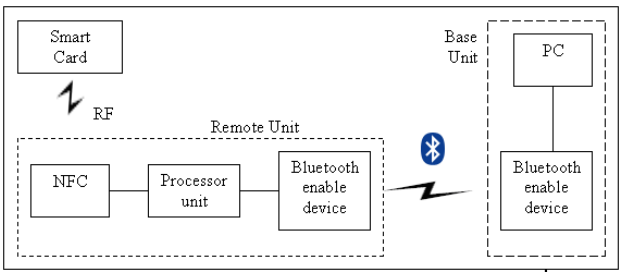


Figure 6: Block Diagram of Medical Data Acquisition System

3.1 Remote Unit

Remote Unit consists of processor unit that integrated with NFC technology and Bluetooth enable device. In this study, Linux PC is going to be used as the processor unit. A Development board of NFC-enabled are connected to the Linux PC using serial port cable.

The NFC technology in the Remote Unit are programmed to write, read and delete the data to or from the Smart Card within dynamic range of the NFC technology, which is 10cm. Then, the data obtained will be stored in processor unit and display it on the screen before being transmitted to the Base Unit using Bluetooth technology. The software for NFC application is integrated with Bluetooth application in one program.

3.2 Base Unit

The Base Unit comprising of a Linux PC with a Bluetooth-enable device are fixed in location. Information or data are received from the Remote Unit through Bluetooth technology. The data are saved in the database file. The Base Unit is able to read the database file. This could help the medical staff to access and monitor the data easily. If the patients need medical treatment, the medical staff who in-charge on monitoring patient's medical data will contact respective doctor for further action.

4 Results and Discussion

4.1 Remote Unit Results

After compiling and running the Remote Unit program, a list of options available will be displayed on the screen as shown in Figure 7. User can choose any option to perform the task that they required.

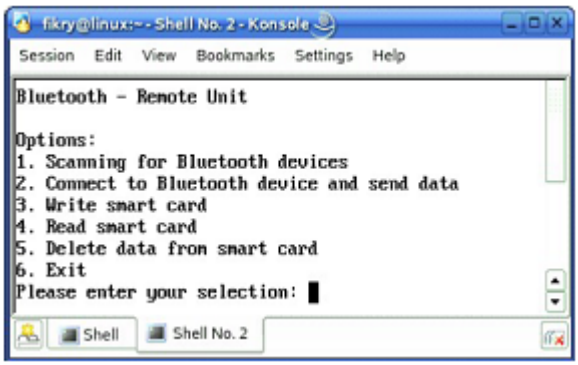


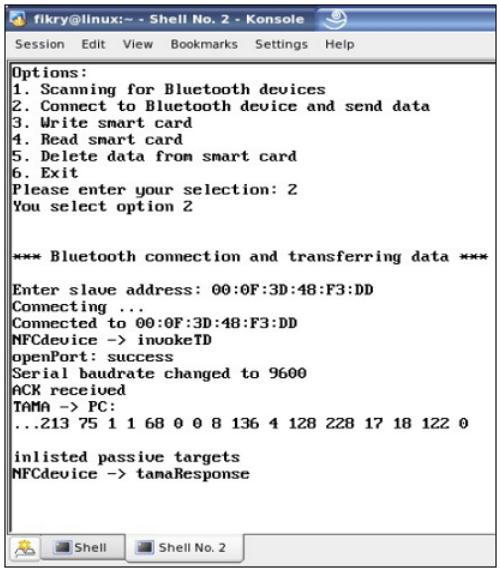
Figure 7: List of Options Available for Remote Unit

Option 1 will invoke the program to perform scanning process. It will discover any Bluetooth devices nearby and display the name and Bluetooth address of the respective device on the screen. The "Scanning complete" message will appear to indicate that the scanning process is done.

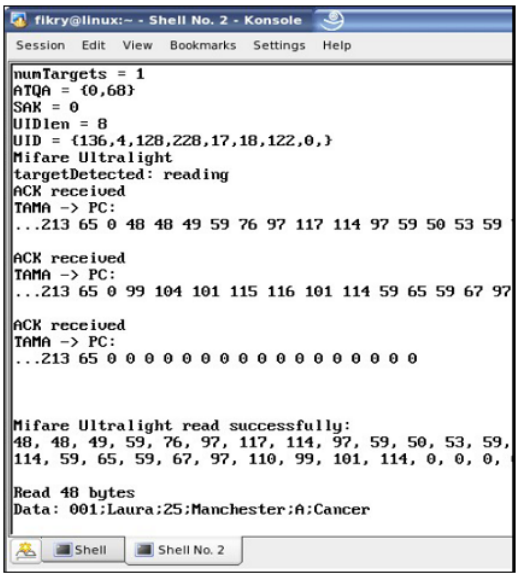
After obtaining the Bluetooth address of the Base Unit, Option 2 is selected to establish a connection with Base Unit and send the data read from the Smart Card. Once the option is selected, user is requested to enter the Bluetooth Address of the Base Unit.

Then, the program will execute a command to open port on the host for serial cable connection between PC and NFC-enable device (TAMA) with the serial baudrate changed to 9600. At this moment the user can touch the TAMA to the Smart Card in order to read the data. TAMA will read the whole cards in ASCII as shown in Figure 8 (a) and Figure 8 (b). The program will translate it to characters and send it to Base Unit. If there is no data read by TAMA for more than 15 seconds (TIMEOUT), the connection will be terminated and a "(null)" is transmitted to the Base Unit to inform that there is no more data will be transmitted (Figure 8 (c)).

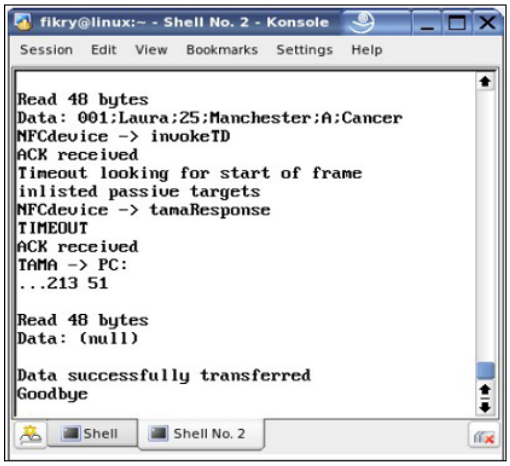
The Remote Unit also can write medical data to the Smart Card by selecting Option 3. Once the option is selected, the user will prompt to enter the data that going to be stored in the Smart Card. After entering the data, place the Smart Card near to TAMA and all the data will be transferred.



(a)



(b)



(c)

Figure 8: Option for Bluetooth Connection and Transferring Data

4.2 Base Unit Results

Same as Remote Unit, upon compile and run the Base Unit program, a list of options will be displayed on the screen. There are four options available for the user to choose, Listening, Read file, Delete file and Exit as shown in Figure 9.

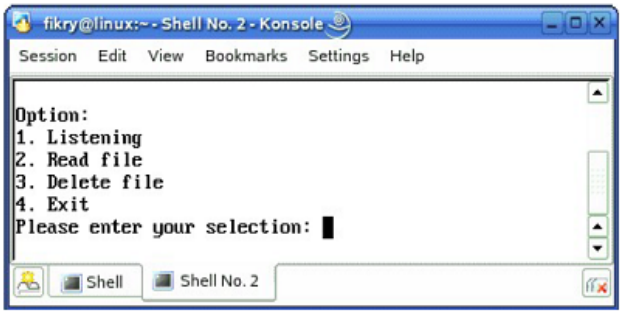


Figure 9: List of Options Available for Base Unit

Option 1 is use to put the Bluetooth device on Base Unit into Listening mode, where it waiting for a connection from the Remote Unit. Once the connection established, the screen will display which Bluetooth address of Bluetooth device is connected to Base Unit. Then the Base Unit will wait for the Remote Unit to transmit the data read from Smart Card. When the data received, it will be displayed on the screen and save it in the file. There are two units of Smart Card read by the Remote Unit and the data is directly send to the Base Unit as shown in Figure 10. The connection will be disconnected when the Base Unit received "(null)", which means there is no data left going to be transmitted.

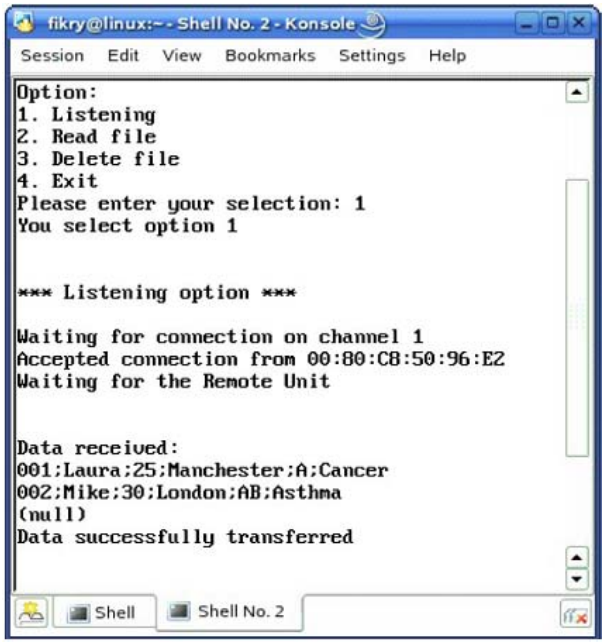


Figure 10: Establish Connection and Receiving Data

Bluetooth air sniffer, which is a Bluetooth protocol analyzer, was used throughout the study to monitor Bluetooth packet transmitted between Remote Unit and Base Unit. Here, FTS4BT Bluetooth Protocol Analyzer and Packet Sniffer was used. It is important for troubleshooting when there is any error occurred in the Bluetooth communication. With air sniffing, it can see exactly what is going on the software developed for both Remote Unit and Base Unit.

There are two FTS for Bluetooth windows were observed when the air sniffer was used; Protocol Navigator window and Frame Display window. The Protocol Navigator window illustrates decodes of multiple protocol layers within multiple data frames. It simplifies the process of understanding the complex relationship between protocol layers and multiple data frames. The results obtained were analyzed and if there is any error occurs, it will display the decoded data frames in red colour. After identifying the error, some modifications have to be done on the software.

Frame Display window displays data at varying level of granularity, from frame level to bit level, including all significant fields associated with the selected protocol layer. It provides protocol related information of selected data frame. Frames containing errors are highlighted in red.

5 Conclusion

The aim of this study was to design and develop a system integrating Near Field Communication (NFC) and Bluetooth technologies which can be implemented for hospital. A Medical Data Acquisition System was successfully developed and the result obtain is very impressive. The initial objectives set at the beginning of the system development, which were to develop a Medical Data Acquisition System using Near Field Communication (NFC) and Bluetooth wireless technologies, provide user-friendly and simple data acquisition mechanism and introduce a low-cost and effective system application are achieved.

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