Design and Implementation of Medical Android Tablet featuring Zigbee

Sodkhuu D[1]., Bayar Ts[1]., Tserendavaa O[1]., Enkhzul D[2]., Amartuvshin T[2]., Enhkbaatar T[2].,
[1]Research and Development Center, Ametros Solutions LLC, Philadelphia PA, USA,
{sodkhuu,bayar}@ametrossolutions.com
[2]Department of Electronic Engineering, SICT, Mongolian University of Science and Technology, Ulaanbaatar, Mongolia
{enkhzul,amartuvshin,enkhbaatar}@must.edu.mn

***Abstract*—This paper serves as an introduction to design and development of medical android tablet implementing Zigbee technology. Nowadays, there are wide spread use of information technology products, including PCs, notebooks and tablet PCs, in clinical environment. However, they have severe limitations in mobility, cost and custom development possibilities. This device offers the advantages of existing technology while simultaneously eradicating the aforementioned limitations. Texas Instrument's CC2530 based Zigbee module, the Samsung Exynos4412 ARM Cortex-A9 quad cores embedded processor and Android 4.4 KitKat operating system are utilized in the device. Furthermore, it has an integrated patient registration, monitoring and management system.**

Keywords—Embedded Android; medical tablet; embedded processor; Zigbee;

I. INTRODUCTION

The rapid development of information technology and competition within the medical industry has brought us to the development of mobile medical devices. The 'hospitalized-placed' nurse has more demand than other medical workers [1]. Nowadays, a trend in medical digital convergence is to develop embedded systems integrated with application programs and web server based systems such as Desktop PCs, Tablet PCs and so on. In recent years, 'Hospitalized-placed' nurses use Windows platform based Desktop PCs and Tablet PCs the most. Their main functions are to search, check data, record medical care action and so on. The characteristics of Tablet PCs, Notebooks, PDAs and PC are shown in Table 1 [1]. It shows that Tablet PCs have better functions in terms of mobility, carry-on and touch panel than Desktop PCs, and are higher on functions such as peripheral integration, writing recognition and battery capacity than PDAs. Moreover, they place emphasis on file security and user-friendly interfaces, which means the Tablet PC has marketability with regards to medical applications. However, most medical Tablet PCs are expensive and based on Windows platform, which makes it harder for further development.

On the other hand, nurses and physicians are unable to frequently enter medical information into Desktop PCs or research patients' information and record immediately whilst taking care of patients. This condition not only causes inconvenience for nurses and physicians but also influences the accuracy of anamnesis, and subsequently decreases the quality of the treatment.

TABLE I. COMPARISON OF TABLET PC, NOTEBOOK, PDA AND PC

Characteristics	Tablet PC	Notebook	PDA	PC
Operating System	Same as PC	Same as PC	Different with PC	x
Wireless	Very good	Very good	Hard	Very good
Mobile	Very good	Common	Good	Hard
Carry-On	Very good	Good	Very good	Hard
Touch panel	Very good	Good	Very good	No
Peripheral Integration	Very good	Very good	Hard	Very good
Writing recognition	Very good	No	Common	No
Battery capacity	Common	Common	Good	Very good
File security	Very good	Very good	Common	Common
Interfaces	Very good	Common	Hard	Common

Herein, we present a tablet that combines resolves these issues. The tablet offers a possibility to improve treatment quality through a quick information access for nurses and physicians.

II. SYSTEM DESIGN

The proposed tablet features a system that integrates direct clinical processes, such as patient registration and monitoring, with management processes. Figure 1 shows the structure of the hardware architecture of mobile clinical android tablet.

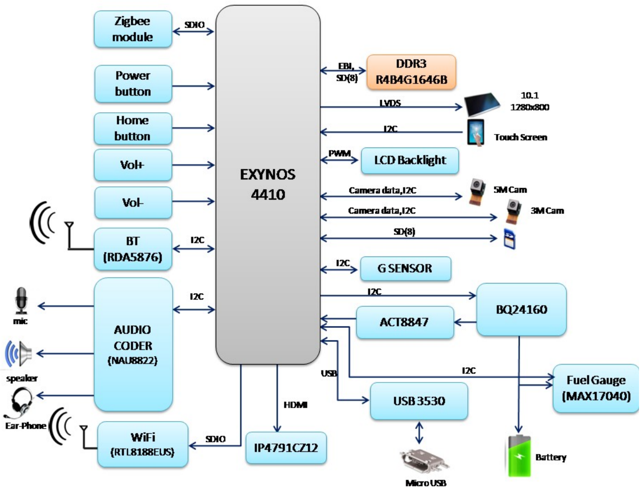

Fig. 1. Structure of the hardware architecture of mobile clinical android tablet.

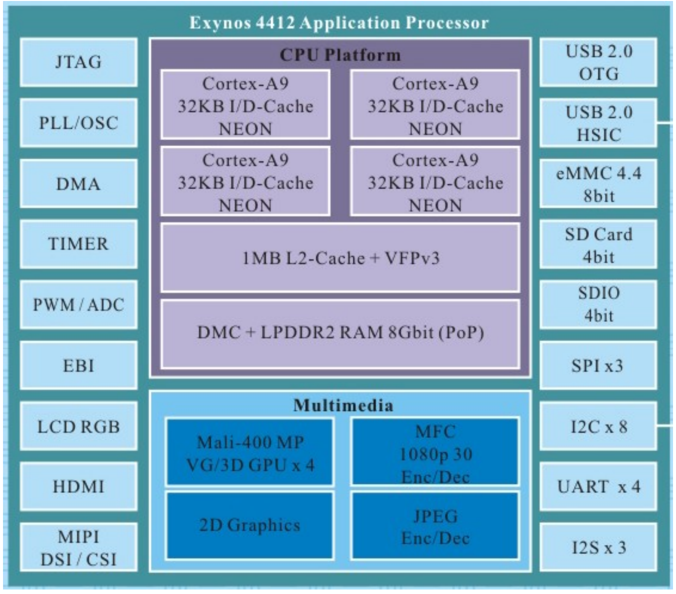

Fig. 2. Exynos 4412 application processor architecture.

A. Embedded Processor

In order to port Android platform, Samsung Exynos 4 Quad core (4412) which is an ARM Cortex-A9 based application processor has been used. Exynos is a series of ARM-based System-on-Chips (SoCs) by Samsung Electronics, and is a continuation of Samsung's earlier S3C, S5L and S5P line of SoCs [2].

This branch CPU has been used widely in electronics products, such as Samsung Galaxy S II, Samsung Galaxy Tab 7.0 Plus, Samsung Galaxy Note, Samsung Galaxy Tab 7.0 and many more. Figure 1 shows the architecture of Exynos 4412 application processor.

Since Exynos 4412 chip includes interfaces for camera, audio codec, LAN, HDMI, and micro SD-card, it is easy to equip a module with various devices.

B. Android Open Source Project

Linux, Windows-CE, and Android are the most used embedded OS (eOS). Amongst them, Android open-source platform stands out as the most widely utilized. It is developed by the Open Handset Alliance, a group of 71 technology and mobile companies, whose objective is to create a free, mobile software platform. In our system, Kitkat version of Android Platform was adopted.

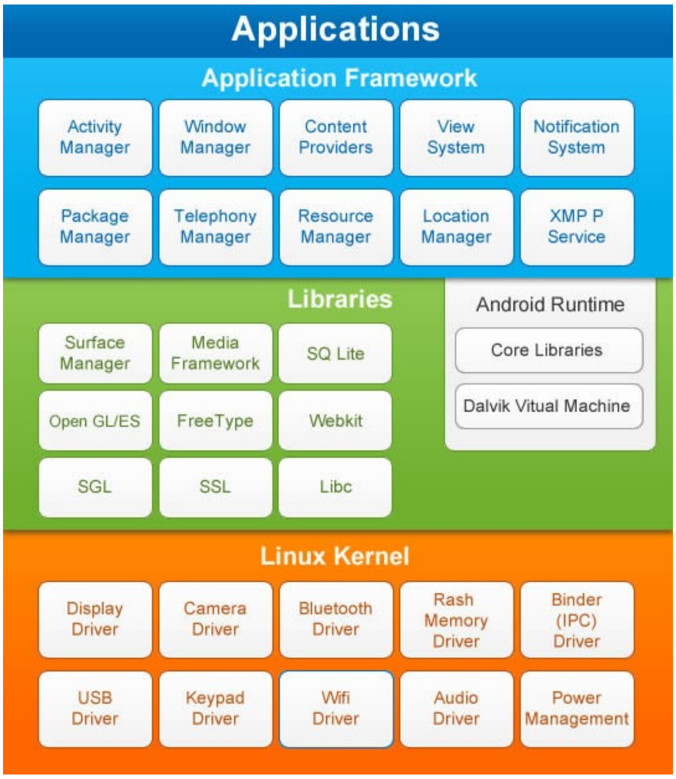

Fig. 3. Android architecture.

The Android platform includes an operating system, middleware and applications. As for the features, Android incorporates the common features found nowadays in any mobile device platform, such as application framework reusing, integrated browser, optimized graphics, media support, and network technologies, etc. The Android architecture, depicted in Figure 3, is composed of five layers: Applications, Application Framework, Libraries, Android Runtime and finally the Linux kernel. The Linux kernel, version 3.0, is the bottommost layer and is also a hardware abstraction layer (HAL) that enables the interaction of the upper layers with the hardware layer via device drivers. Furthermore, it also provides the most fundamental system services such as security, memory management, process management and network stack.

In order to port android on our hardware, we have configured android open source platform, HAL and implemented several device driver code in kernel such as Omnivision cameras (OV3640 and OV5640), LCD, Touchscreen, Battery charger, Power regulator etc.,

C. *Zigbee network*

Zigbee is a protocol that had been developed based on Open System Interconnection (OSI) layer model. It builds on IEEE standard 802.15.4 which defines the physical and Medium Access Control (MAC) layers. Zigbee supports three types of communication topologies; star topology, tree topology and mesh topology. Zigbee wireless device operates with very-low power consumption which makes it the most attractive wireless device to use in Wireless Sensor Network (WSN). Zigbee has multi-hop communication capability, hence providing an unlimited range of communication.

D. *Patient registration and management system*

There are some number of hospitals that are using MIS in their patients' data management processes. These are limited to expensive and immobile systems. On the other hand, the need in Mongolia is to have inexpensive and mobile system that is capable of managing patient's data. Herein, we implemented such an information system that meets the above requirements. It is designed for managing a database of patients who are being treated for hepatitis as it is one of the critical situations that Mongolian medical professionals are faced with.

III. SYSTEM IMPLEMENTATION

A. *Hardware design and implementation*

The Altium designer tool was used to design and develop the hardware. In this tablet, we have used Exynos4412 CPU module which has simplified the PCB designing process. Therefore, the base Printed Circuit Board (PCB) of the tablet was designed with 0.8mm thickness, 2 layers and several high speed components or interfaces such as LVDS, USB, HDMI. One attractive advantage of Altium Designer is the possibility of setting special rules on partial connection objects. For example, in tablet's USB data connection, minus and plus data lines must be routed with 95 Ohm differential impedance and their lengths must be matched. Thus, the proposed tablet incorporates several high speed digital interfaces and components that follow standard or predetermined special rules for some parts of PCB.

B. *Android porting*

The advent of Android has generated tremendous interest in the developer community to customize the same for their products running on other embedded platforms. The android porting implementation is shown in Figure 4. In order to port Android on our tablet, following steps are implemented:

1. Preparing the build environment

Ubuntu 14.04 version is recommended for build environment. On Ubuntu, use OpenJDK and arm-linux-gcc for building Android. The latest version of Android requires Java 7. After installing Java, required packages also must be installed.

2. Porting the bootloader

The Linux kernel makes some fundamental assumptions when it gets control from a bootloader. The bootloader must have initialized the DRAM controller. Linux assumes that the system RAM is present and fully functional. Therefore, the boot loader should also initialize the system memory map. This is usually done via a set of processor registers.

3. Porting the Linux kernel

Kernel is loaded in RAM and run by bootloader. To customize Linux kernel into Android, Androidisms must be done on it such as wakelocks, lowmem handler, binder, RAM console, logger etc .,

4. Developing device drivers

Everything in Unix is a file, including devices. For developing device drivers, use standard Linux model API, try avoiding wakelocks in drivers and use modules for development.

5. Implementing Android hardware libs (HAL)

Hardware abstraction layer (HAL), layer between the kernel and the application framework, is very important for porting Android to a custom board. Especially, when integrating new devices to a custom board such as input sensors.

6. Customizing the user space

Fig. 4. Android porting implementation.

User-space is customized by changing boot screen, status bar, preloaded applications, themes, adding new applications and adding new hardware type.

IV. EXPERIMENT

The proposed tablet was implemented in real mode. The experimental tablet is shown in Figure 5. It has built-in medical purpose android application, which is for patient registration, monitoring, and management. Also this system works with web server based data base, which stores all patient's data.

Fig. 5. Implemented Medical Android Tablet featuring Zigbee technology.

The Zigbee network has been tested by communicating tablet as the coordinator. Also, other end-node sensors and routers are used for experiment. The experimental network design of Zigbee featured sensor network and Medical Android Tablet is shown in Figure 6.

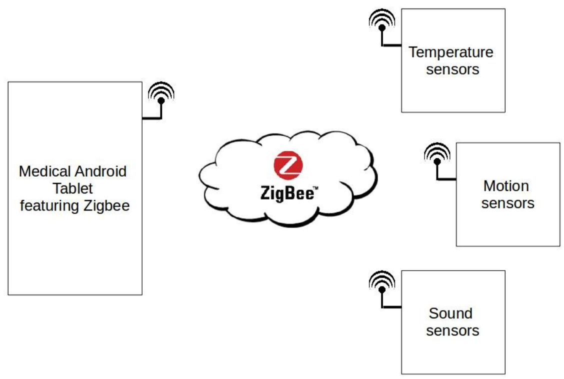

Fig. 6. Experimental network design of Zigbee featured sensor network and Medical Android Tablet.

In this work, the experiment was implemented through a mesh network between coordinator Tablet, up to 20 sensor nodes and routers. We used Zigbee based room temperature sensors, motion sensors, and sound detection sensor for network experimental purpose. The outdoor application range was up to 200 meters depending on environment characteristics and the indoor application range was up to 30 meters depending on the room numbers and environment. After implementing routers, the communication range was extended nearly twice larger.

V. Conclusion and Future Work

The developed tablet was successfully executed with the help of correlating Zigbee module, Android OS and Exynos 4412 based processor system. The implemented Zigbee module's communication range was within 20 meters indoor and up to 200 meters outdoor. Also, it is possible to extend communication range using routers. In this research work, we used temperature sensors, motion sensors and sound sensors for testing Zigbee network. For future development, we are planning to design and integrate Zigbee based personal healthcare equipments to the system. It will enable nurses to monitor multiple patients in the hospital area and increase medical quality.

Acknowledgment

The research was supported by Ametros Solutions LLC and ONOM foundation grant.

References

[1] Chien Yu Peng, Wei Shin Kao, You Zhao Liang and Wen Ko Chiou, "The Practices of Scenario Observation Approach in Defining Medical Tablet PC Applications," J. Jacko (Ed.): Human-Computer Interaction, Part IV, HCII 2007, LNCS 4553, pp. 518-524, 2007, Springer-Verlag Berlin Heidelberg 2007

[2] http://en.wikipedia.org/wiki/Exynos

[3] Cláudio Maia, Luis Miguel Nogueira, Luis Miguel Pinho, "Evaluating Android OS for Embedded Real-Time Systems", HURRAY-TR-100604, 06-29-2010

[4] Sung Wook Moon, Young Jin Kim, Ho Jun Myeong, Chang Soo Kim, Nam Ju Cha, and Dong Hwan Kim, "Implementation of Smartphone Environment Remote Control and Monitoring System for Android Operating System-based Robot Platform", 2011 8th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI), Nov. 23-26, 2011 in Songdo ConventiA, Incheon, Korea

[5] Kalpik M. Patel, Chirag K. Patel, "Porting Android on Arm Based Platform", International Journal of Innovative Research in Computer and Communication Engineering Vol.1, Issue 3, may 2013

[6] Karim Yaghmour, "Embedded Android" book

[7] Alessandro Rubini, "Linux Device Drivers" book

[8] http://free-electrons.com/docs/

[9] www.opersys.com