A Design of U-system for Group Management Using Wireless Sensor Network and Android Device

SeungJoon Lee[1], Min Chul Kim[1], Yeo Sun Kyung[1], Kyung Kwon Jung[1], JooWoong Kim[1], Yong Gu Lee[2] and Ki Hwan Eom[1]

[1]*Department of Electronics and Electrical Engineering, Dongguk University,26, Pil-dong 3-ga, Jung-gu, Seoul, Korea*

[2]*Department of Medical Instrument and Information, Hallym College, Chuncheon City, Gangwond-do, Korea*

kiwhanum@dongguk.edu

Abstract

This paper presents a group management system using Wireless Sensor Network (WSN) and smart phone devices. The proposed system was comprised of personal device based on sensor node of WSN, smart phone device which is used by group manager and web server. The sensor node called as personal device which is held by group members sends adata packet every 2 seconds to the manager device. The manager can check their group member's distance from him within a 30-meter radius and battery residual quantity on the manager device. Manager device sends its latitude and longitude data from Global Positioning System(GPS) and information of personal devices to web server. Therefore, other person such as group member's parents can assure their children's safety and security through the web page. The (Received Signal Strength Indicator) RSSI value from sensor node was converted into distance data by computed log-normal path loss model.

Keywords: Group Management System, Wireless Sensor Network, Android Platform, Web Server, Log-Normal Path Loss Model

1. Introduction

Recently, the great needs ofRadio Frequency Identification (RFID) / Ubiquitous Sensor Network (USN) is being increasedin the field of service. Especially, Real Time Location System (RTLS) and Location Base Service (LBS) are in the limelight in the area of security and safety.

Children been kidnapped or been lured away by strangers is continually increased in the statistics of National Police Agency in Korea. For parents or guardians, it is hard work to take care their children when they went to field trip [1]. Also, the tour guide spent much time and paid excessively attention to safety of tourists. About 3,800 children under the age of eight go missing each year in Korea, from among 92% of them returned their home. However, 8% of them never met again their parents for at last. Therefore, a system which can secure them was required for parents and their guardians.

Some similar systems such as kids finder using Bluetooth technology and group tour guide system with RFIDs and Wireless Sensor Networks(WSNs) was realizedin several literatures [1-5]. And a group management application was also implemented on smart phone devices with Global Positioning System (GPS) data. However, to realize

these systems, many sensor nodes of WSN are required. And above system is not suitable for children or disabled people who cannot use smart phone or Personal Digital Assistants (PDA) devices well.

Therefore, in this paper, the group management system using WSNs and smart phone device is proposed for parents, guardian and tour guide to prevent missing their children and easily manage tourists. The personal device sends data packet including their Identification(ID), Received Signal Strength Indicator (RSSI), battery status and emergency information to manager device every 2 seconds. The manager device receives the data packet, displays condition of each person who has personal device and notifies when the person is far from manager, or in the emergency situation. The manager device transmits above information containing GPS data to the web server. Parents can check location of their children and guardian. In order to assure flexible activities of children and tourists, the network of the system was configured with multi-hop network. Low-power algorithm was implemented in the personal device to extend their battery life time.

The rest of this paper is organized as follows. In Section 2, architecture and design of the group management system is represented in details. Section 3 describes experimental results in field test with several personal devices.Some concluding remarks are given in Section 4.
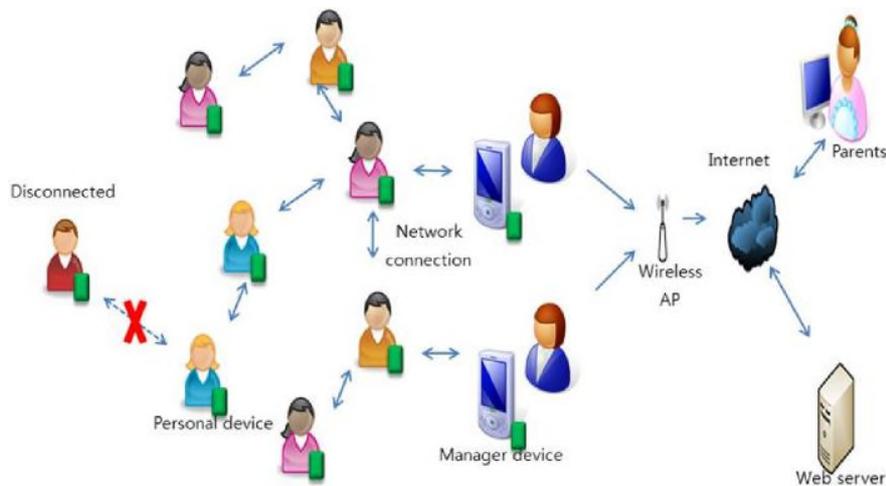
2. System Architecture

Figure1. System Architecture

The proposed group management system architecture is shown in Figure 1. The system fundamentally comprised of manager device based on WSN, personal device on the android platform and web server using Personal Hypertext Preprocessor (PHP) and the Apache. The group leader carried the manager device, and the personal device which was held by children or tourists broadcasts data signals with multi-hop network at set times. The web page on the web server described location of group leader and how children far from the manager. Our main aim with the system is to offer following services: (i) notifying manager when each member leaves the group, (ii) informing manager that member has an emergency to prevent accidents on field trip, (iii) showing

status of children to their parents in the web page, (iv) employing less sensor nodes to realize the group management system.

2.1. Personal Device

The personal devices are implemented by K-mote as shown in Figure 2. The K-mote is a sensor node of WSN based on Telos revision B platform and supports TinyOS 1.0 and 2.0. It operates in the 2.4GHz frequency band and is realized by MSP430F1611 micro-processor of Texas Instrument(TI) which operates with 8MHz clock frequency, IEEE 802.15.4 wireless radio chip CC2420 which provide 2.4GHz band for wireless communication, and ceramic antenna to provide good data transmission in indoor environments.The epic core was implemented with the MSP430 and CC2420 for the personal device. The PCB artwork for the device was described in Figure 3.
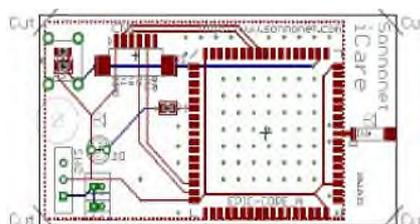

Figure2. Personal Device

Figure3. PCB Artwork for Personal Device

The multi-hop network between each sensor node was realized by Minimum Cost Forwarding Algorithm. The algorithm is a method of a node based on the most optimized link through exchanging Beacon Message with surrounding nodes including Link Quality Indicator (LQI) information to find parents node.

Each node has different node ID and base node is considered as node 0 as shown in Figure 4. The nodes in Figure 4 start initializing with transmitting advertisement (ADV) signal to surrounding nodes. We make assumption that among two nodes which are located in long distance to transmit with one-hop send ADV signal through multi-hop network. The ADV message sent to surrounding nodes from each node contains RSSI and LQI information. The base node basically has the lowest cost ˝0˝. Each sensor node chooses the lowest sum of the link cost and sets up communication channel by
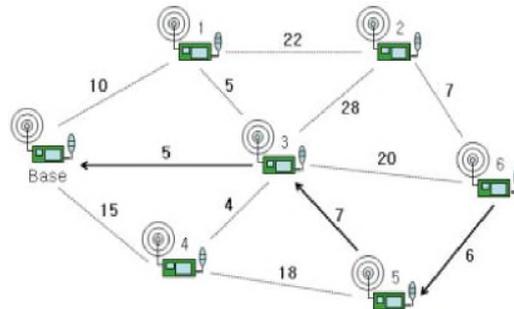
(1)

Figure4. Transmitting Data Using Minimum Cost Algorithm

Also, for long lifetime of the personal device,low-power consumption algorithm was applied to the designed personal device. The power consumption of certain operation of CC2420 which has a function of Radio Frequency (RF) communication is represented in Table 1. As shown in Table 1, when the system operated in Receiver X-tal (RX) or Transmitter X-tal (TX) mode, the largest power was consumed by the CC2420. Thus, to reduce power consumption of the device, low-power algorithm was realized by toggling the RF module.

Table 1. Power Consumption of CC240

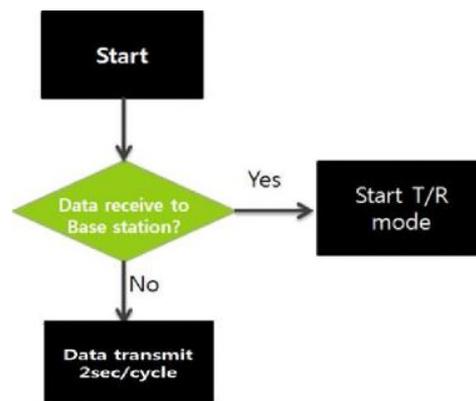| Operation	Power consumption (mW)
Active power (MCU active)	3
Sleep power (MCU sleep)	0.015
RX power (MCU-RF module active)	38
TX power (MCU-RF module active)	35

Figure5. A Fow Chart of Personal Device

The personal device sends data packet to manager device in every 2seconds when it does not receive data from the base station. If the base station connecting with manager device

sends some data, the personal device operates in RX or TX mode for low-power consumption. Figure 5 describes a flow chart of personal device.

2.2. Manager Device

Since wireless communication was required for the manager device and the smart phone users are increasing at an enormous rate, smart phone based on android platform was employed for the group manager in the system. Android platform is completely open source and free mobile platform. Therefore the application developers and smart phone manufacturers don't have to pay for license.
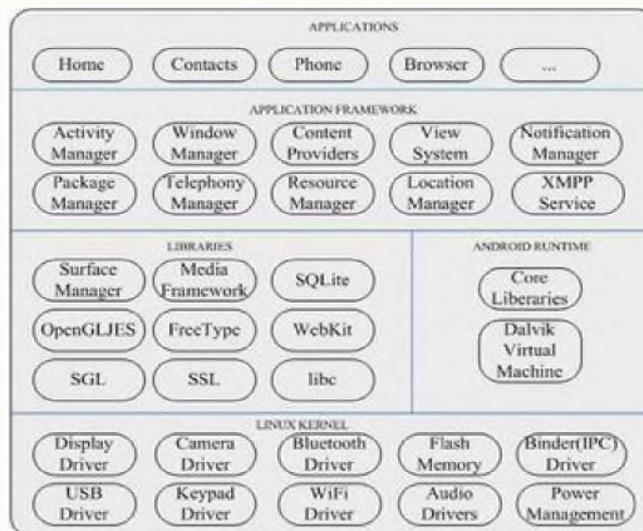

Figure 6. Android System Structure

The software structure of android can be split into four levels: the Application, the Application Framework, library and the android operation environment(Run Time), and operating system as shown in Figure 6 [7]. The android application program is a set of task. The task conducted by the application isknown as activity. Comprising an activity and switching to other activities is possible in each screen. Through intent object, changing activity and transmitting specific value to next screen is available [8].

The base node receives status of each sensor node with particular packet as shown in Table 2. The ID of sensor node, the number of packet from another sensor node, emergency situation and battery status in Table 2 is indicated by Node ID, Sequence_Counter, Operation and Battery respectively.

Table 2. Data Format

Payload	Size (Byte)
Node ID	2
Sequence Counter	2
Operation	2
Battery	2
RSSI	2

Basically, we can use serial port to communicate with the base node and a android device using Java Native Interface (JNI). However, in this method, the transmission speed between the base node and android device is too slow. Thus, in order to connect with the manager device, embodied module with base node and Bluetooth was used as shown in Figure 7. The data packet from sensor node to base node is transmitted through Bluetooth communication to the device of group leader.
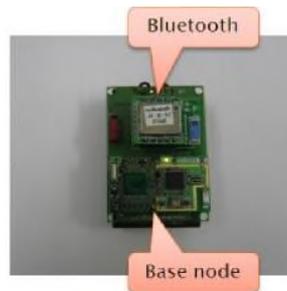

Figure 7. Designed Module of Base Node and myBlutooth-EX

2.3. Web Server

Most of information of students is managed by web server to show their parents. The web server based on PHP and apache receives the information from android device and store to database. The informationstored at database is listed at web page as depicted in Figure 8.
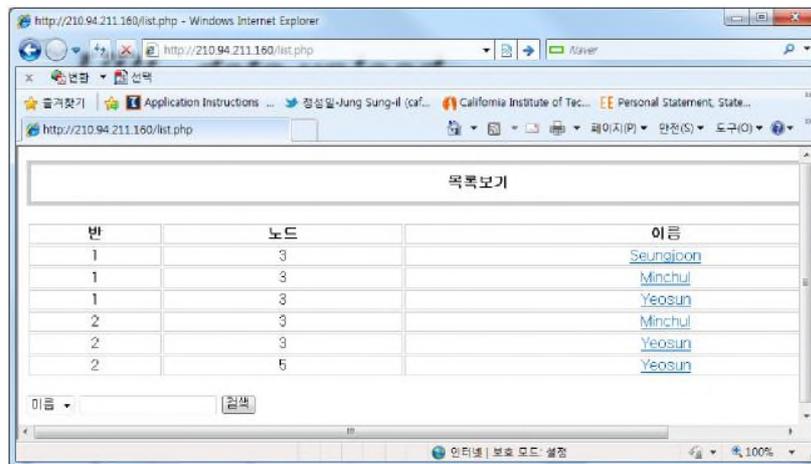

Figure8. Web page of the list of Class, Node ID, Student name

When certain name of list page is clicked by parents or teachers, the student's information is displayedas shown in Figure 9. Their parents and teachers can check their children situation and location through the web page. The location of children and their guardian was presented by clicking the blue button on the web page in Figure 9. Figure 10 shows the location of the leader with the Google map Application Program Interface (API).

The web server provides Node ID and student name to the manager device which was inputted by group leader on web page to display the student list on the mobile equipment. The information of Node ID and student name was formedof the Extensible Mark-up Language (XML) type.
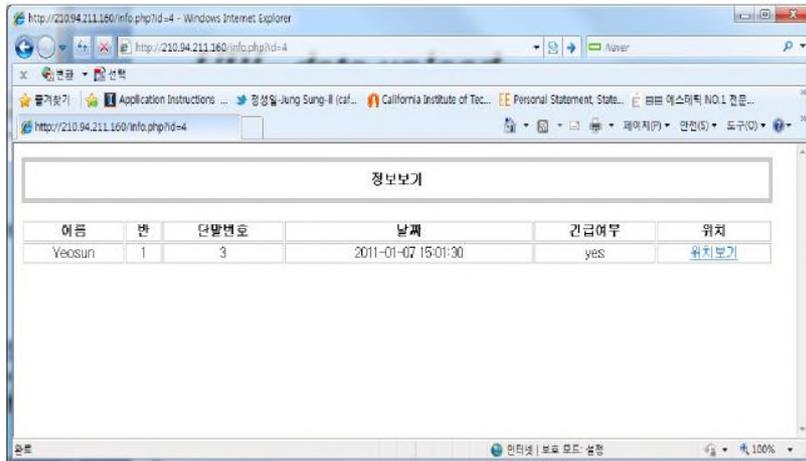

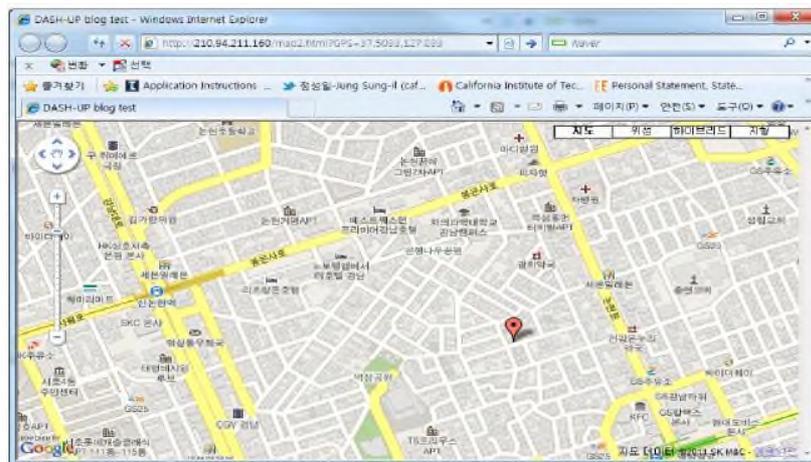**Figure9.** Information Page of student on Web Server

Figure10. Location of the Leader with Google Map API

3. Experimental Results

3.1. System Implementation

To evaluate performance of proposed system, we used four personal devices. The sensor node of certain student sends some information including RSSI. The RSSI value was converted to distance value by log-normal path loss shadowing model. The manager device displays the data from designed module with base node and the Bluetooth. The group management application software was tested on both two smart phones based on window mobile and android platform as shown in Figure 11. And

Figure 12 and Figure 13 showthe operation screen of android platform and window mobile device, respectively.

(a) Window Mobile Device   **(b)** Android Platform

Figure11. Manager Device
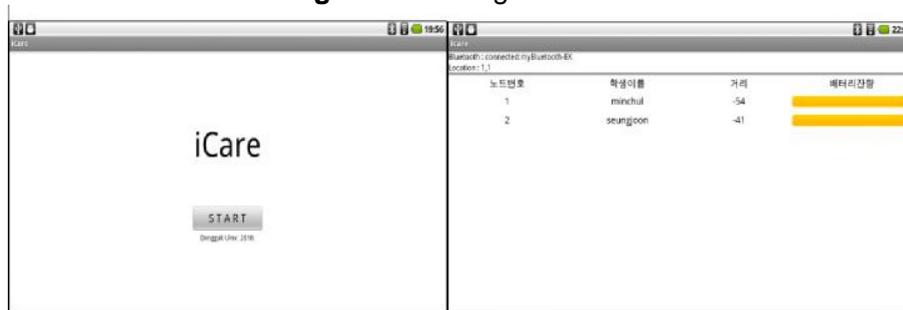
(a) Start Activity   **(b)** Main Activity

Figure12. Operating Screen of Android Platform

(a) List Screen   **(b)** Network Screen

Figure13. Operating Screen of Window Mobile Device

The group manager input their group member"s name and Node ID which will be held by group member on the web server. This information converted XML form to transmit to manager device. Manager device compares the Node ID from web server and base node, represents status of their students and informs when certain students has disconnected device with the manager.

3.2. Experimental Results on Personal Device

The base node can measure RSSI value of each sensor node. Therefore, we can verify distance between the sensor node and base with log-normal path loss model. As the distance grow farther and farther, the signal strength is decreased with log scale.

According to increasing distance between transmitter and receiver, path loss is increased as the following:

$$PL(d) \propto \left(\frac{d}{d_0}\right)^n \tag{2}$$

, where PL is path loss, d is distance between transmitter and receiver, n is path loss exponent which indicates how rapidly the path loss is increasing from growing distance. The d_0 is the reference distance. The log-normal path model can be written as

$$PL(d)[dB] = PL(d_0) + 10n\log 10 \left(\frac{d}{d_0}\right) + X_\sigma \tag{3}$$

, where $PL(d_0)$ is path loss in 1 meter which is reference distance, X_σ is random variable which has σ as its standard deviation.

The transmission power was measured in changing distance between sensor node and base node. The transmission power of sensor node was sat 0dBm(1mW) which is maximum value. Computed log-normal path loss model from measured RSSI data is shown in Figure 14. Table 3 shows model parameters of pathloss model.

Table 3. Log-normal Path Loss Model Parameter

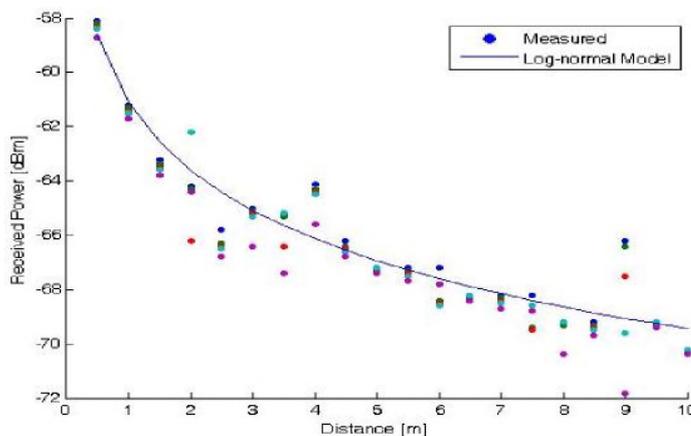| PL(d_0)	n	Xσ	
-61.903	0.8329	0.7924	

Figure14. Log-normal Path Loss Model

The experiment for low-power consumption was also carried out using designed algorithm applied on personal device. When 3V of input voltage was applied to the device and its power output is 0 dBm, the current consumption is lowest of 0.4mA, and highest of 21.96mA as shown in Figure 15. With the current consumption, the expected lifespan of personal device is more than 4 months.
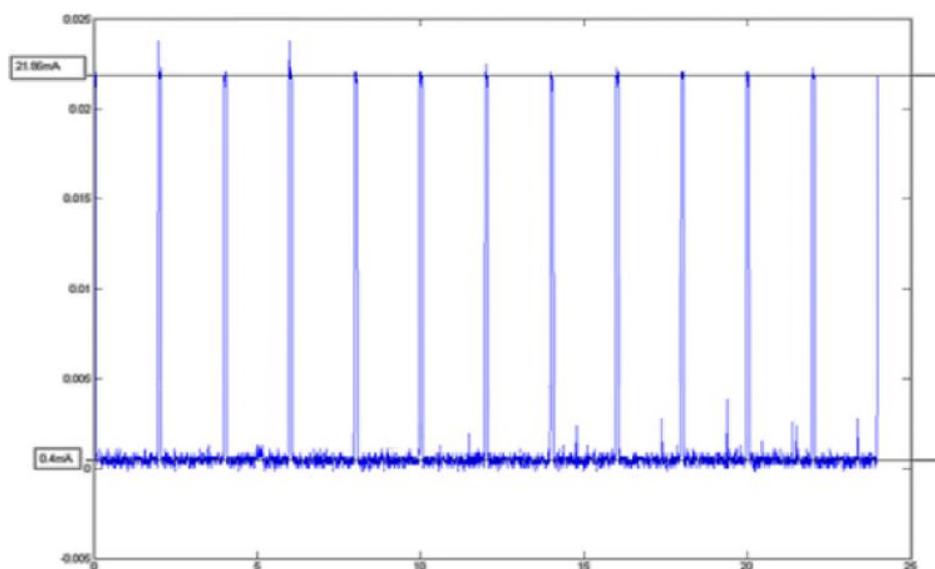
Figure15. Current Consumption of Personal Device

4. Conclusion

In this paper, the group management system with WSNs and application on android platform is proposed. The proposed system was comprised of manager device based on smart phone device, personal device which is sensor node for children and group members and web server. The base node and Bluetooth module was combined to specific module to communicate with the manager device. The personal device sends information including its Node ID, RSSI value, battery residual quantity and emergency situation to the manager device. The group leader can assure their student's distance from him with the data packet from personal device. The web server stored this information to display status of children and manager with map and show to other person such as group member's parents. The computed log-normal path loss model was used to convert RSSI data to distance value.

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Authors

Seung Joon Lee received the B.S. degree in Department of Electronic Engineering from Dongguk University, Seoul, Korea, in 2010, where he is currently pursuing the M.S. degree. His research interests are power line communication and artificial intelligence.

Min Chul Kim received the B.S degree in electronic engineering from Dongguk University, Seoul - Korea in 2010. He is currently getting a master's course in electronic engineering at Dongguk University. His research interests include sensor network and embedded system.

Yeo Sun Kyung received the B.S. degree in electronic engineering from Dongguk University, Seoul, Korea in 2010.She is working on a master"s degree in electronic engineering at Dongguk University, Seoul, Korea. Her research interests are manufacturing system, hydroelectric power generation and stochastic control.

Kyung Kwon Jung was born in Korea. He received the B.S., M.S., and Ph.D. degrees in Electronic Engineering from Dongguk University, Seoul, Korea in 1998, 2000 and 2003, respectively. He is currently working as research engineer in Electronic Engineering at Dongguk University and U-embedded Convergence Research Center at Korea Electronics Technology Institute. His research interests are in intelligent systems, digital signal processing and sensor network applications.

JooWoong Kim was born in Korea. He received the B.S. and M.S. and Ph.D. degree in Electronic Engineering from Dongguk University, Seoul, Korea. He is giving a lecture on department of Electrical and Electronic Engineering at Yuhan University. He is head of a research and developments in New Power Electronics Inc. His research interests are communication electronic control, sensor network and SMPS.

Yong Gu Lee was born in Korea. He received the B.S. and M.S. degrees in Electric Engineering and Ph.D. degree in Electronic Engineering from Dongguk University, Seoul, Korea in 1987, 1993 and 1997, respectively. He is currently working as a full professor in Radiological Technology at Hallym College. His research interests are in digital image processing and neural network applications.

KiHwan Eom received the B.S. and Ph.D. degree in Department of Electronic Engineering from Dongguk University, Korea in 1972, and 1986, respectively. He was a visiting professor from 1989 to 1990 at Toho University and from 2000 to 2001 at University of Canterbury. Since 1994, he has been with Dongguk University, where he is currently a professor in the Department of Electronic and Electrical Engineering. His research interests are in electronic application and convergence system.