Elderly Assistive Living based on IoT System

W. Suntiamorntut, S. Charoenpanyasak, J.Nopparat, S. Julrat, M.Manopirol
Centre of Excellence in Wireless Sensor Networks,
Department of Computer Engineering, Faculty of Engineering,
Prince of Songkla University, Hatyai Songkhla Thailand, 90112

{wannarat@coe.psu.ac.th}

Abstract—This paper proposes the emerging technologies for the elderly assistive system. By combining Internet, embedded systems, and wireless connectivity, the system can offer a great potential to assist the elderly people to live safely in their homes. The low cost emergency button is also proposed in this paper. The final contribution of this work is to demonstrate our IoT technology that applied in the elderly assistive living. This leads to give the promise of improving the healthcare in the developing countries.

Keywords; *IoT, elderly assistive system, smart home*

I. Introduction

Internet of Things (IoTs) use many small devices, called nodes, to connect each other wirelessly. The transmission by small devices needs to focus on saving energy. The device consists of several modules such as Digital I/O Analog I/O and communicate module. The device transmits data with the radio frequency ISM 2.4 GHz based on IEEE 802.15.4 and Zigbee standard. IoTs is very famous and being a emerge technology. It is widely used in many popular applications such as smart home and health care monitoring.

In Thailand, we are facing the large increase in the elderly people, as a result of the increased life expectancy. Thai Health Promotion Foundation reported that we will have the elderly people about 20% of the overall Thai population in 2025 (more than 8 million). The modern Thai society has been changing making the aging people lived independently at home. Therefore, there is a high risk of fall or another injury. This critical problem is not just in Thailand, fall induced injuries is a major health issue concerns worldwide.

The IoTs research work for healthcare system is the patient monitoring in several different purposes for instances, a vital sign monitoring in the surgery patient and a living assistive system. These applications are mainly involved to the mobility of the patient equipped devices which is different from the traditional static wireless sensor networks. Moreover, the data from sensor is not simple as same as environment sensing. The continuous signal is needed to be transmitted through the networks. The complex data processing has to perform on the tiny battery-powered embedded device called *node* with limited computation and radio communication.

The key advantage of using wireless sensor networks is a node. Soon, MEMS [1] and nanotechnology will yield tiny, low cost and low power node. This so tiny devices help make the wearable sensor research possible.

The well-known health care applications using wireless sensor network is *CodeBlue* [2] project developed by Harvard University. This application covers pre-hospital and in-hospital emergency care and patient rehabilitation. Many wireless vital signs such as pulse oximeter, blood pressure and two-lead Electromyogram (EKG) were developed to successfully use in their projects.

Another well-known project is *AlarmNet* [3] developed by University of Virginia. The architecture was implemented for smart healthcare, real-time monitoring and independent-living resident based on sensor node technology. By using this technology, a continuous medical history can be followed whilst preserving resident comfort and privacy. The daily activity patterns can be a significant cause of the resident health problems.

Another example is the research of Wearable Wireless Body/Personal Area Network (WWBAN) [4] that integrated a number of physiological sensors such as Electrocardiogram (ECG) to monitor heart activity, Electromyogram (EKG) to monitor muscle activity and Electroencephalogram (EEG) to monitor brain electrical activity, blood pressure and tilt sensor to monitor trunk position, breath sensor and motion sensor. Apart of those wearable sensors, they can also track the location [5] of the residents.

The last example is the fall detection and alerting system on a mobile and pervasive environment [6] developed by University of Beira Interior. Sensor fall based on accelerometer has been implemented to detect and report the accelerometer caused by a fall. Their system was also able to

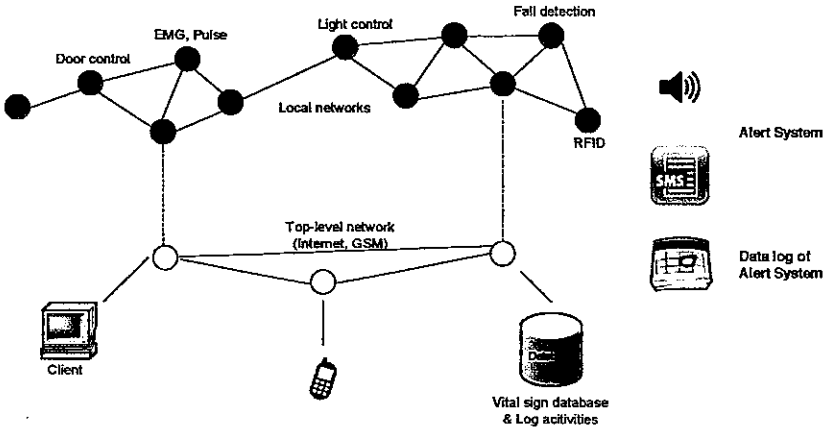

Figure 1. Elderly assisted living wireless networks architecture

and alert message via mobile phone (SMS) and located the elderly people using GPS.

In this paper, we propose the elderly assistive living system which could be deployed in a private house with a low-cost system. Our ubiquitous networked system is the combination of Internet of Things (IoT), Wireless LAN (WLAN) and BLE applied in smart home for elderly people. An Emergency button is also introduced in this paper. Many electrical equipment in smart home has been integrated to help the elderly for more comfortable. The proposed system can be expanded to use as a behavior learning system in the future because all activities are kept in cloud based system. In an emergency situation, the alarm system will directly report to the hospital or every authorized people.

The remainder of this paper is organized as follows. The architecture of the proposed elderly assisted living system and the routing protocol are explained in Section II. Section III of the paper describes the deployment. Section IV is a discussion. Finally, our work has been concluded in Section V.

II. Elderly Assisted Living Architecture

The proposed elderly assisted living system consists of the local wireless networks and the top-level networks as shown in Figure 1. The local wireless networks compose of fall detection and other vital sign sensors based on wireless sensor networks and RFID whilst the top-level networks are Internet and GSM.

The fall detection sensor and the other vital sign sensors are attached on the patient or the resident. Meanwhile, the RFID reader has been embedded on the node and used for personal identification. The data from the RFID reader can be sent wirelessly to the base station. This can reduce the cost of wiring in the original RFID system and also increase the flexibility of the installation. Both wireless sensors and RFID are connected to the wireless router (base station). The administrator or caregiver can access directly to fall detection or RFID devices on wireless sensor networks via Internet or GSM.

Even wireless sensor network provides a suitable interface and cost for physical control and information monitoring. its limitations can cause many problems for realistic applications. The resource constraints such as energy, computational power, storage available and bandwidth are the major limitation in wireless sensor networks which becomes the elderly assisted living system requirements. The necessary sensors have connected via Zigbee protocol. The backbone network architecture of the elderly assisted living system is shown in Figure 2. The networked system which composed of node devices, smart gateway, applications, user and third party service will be presented in this section. In our system, we can divide into smart home cloud, devices, third party services and applications.

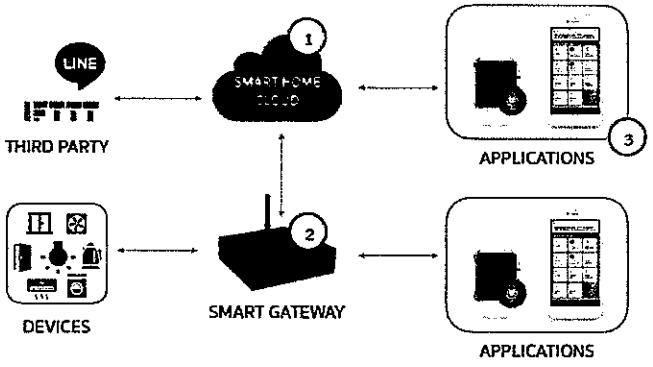

Figure 2. Smart home architecture based on IoT

A. Smart home cloud

It has been used to store the home records. Smart home cloud is the bridge between applications and smart gateway and also between applications and third party such as Line IFTT.

B. Third Party Services

Our assistive living system is able to report the emergency events via Line IFTT, SMS and E-mail. All events and activities will be recorded on Google calendar for a future analysis.

C. *Smart Gateway*

This device uses to communicate with electronic devices, sensors and wearable devices. Smart gateway will wait for the command from smart home cloud in order to control all devices in the house.

D. *Applications*

We choose to develop the applications based on HomeKit from iOS because of easy of usage, security and Siri option. Moreover, we can use the applications from Apple watch as well.

III. Deployment

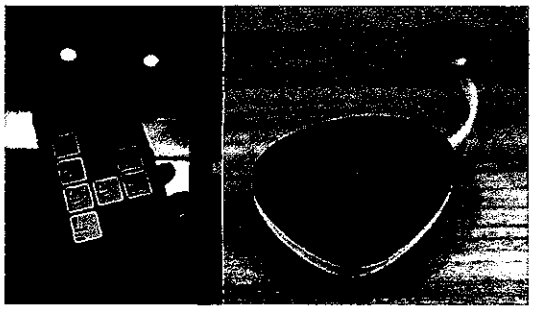

Figure 3. HomeKit and Emergency button

The electronic devices such as lamp, sensors and door lock are deployed in two elderly people home for getting the use case experiences. The mobile application based on iOS has been used to control and monitor lighting and electronic door lock. Elderly people can use their voice to control on-off equipment easily. The small wireless device has been used for emergency call as shown in Figure3. After we leave the system running for around 6 months, elderly people and their family can work out quite well with our solution. In addition, elderly people and their family also request for more system such as medicine remainder device as shown in Figure4.

Figure 4. Medicine reminder Device

IV. Conclusion

Our system, smart home for elderly people can work very well. The family member and elderly people themselves are able to use the technology properly. They do not refuse to trail the new equipment. This shows a good sign for offering a digital IoT solution for ageing people in Thailand.

Acknowledgment

The author would like to thank to BTFP, Office of The National Broadcasting and Telecommunications Commission (NBTC) for research grant supportive.

References

[1] Chang Liu. Fundations of MEMS. *Pearson Prentice Hall*, 2006.

[2] Welsh M. et al., CodeBlue: Wireless Sensor Networks for Medical are. From: http://www.eecs.harvard.edu/~mdw/proj/codeblue/, 2005.

[3] Wood A. et al., ALARM-NET: Wireless Sensor Networks for Assisted-Living and Residential Monitoring. *Technical Report CS-2006-11, Department of Computer Science, University of Virginia.*, 2006.

[4] E. Jovanov, A. Milenkovic, C. Otto and P. C. de Groen. A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation. *In Journal of Neuro Engineering and Rehabilitation*, vol.2, pp.6-15, 2005.

[5] Gao Tia et al., Vital Signs Monitoring and Patient Tracking Over a Wireless Network. *In Journal of Johns Hopkins APLTechnical Digest*, vol. 27, pp.48-60, 2006.

[6] Ivo C. Lopes, Binod Vaidya and Joel J.P.C. Rodrigues. Towards an autonomous fall detection and alerting system on a mobile and pervasive environment. *In Journal of Telecommunication Systems*, vol.48, pp.1-12, 2011.