Chapter 8
Healthcare Oriented Smart House for Elderly and/or Disabled People: A Case Study

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ABSTRACT

Smart houses represent a modern technology which can secure and facilitate our life. The objective of this chapter is to adapt medical sensors to home automated systems, which collect medical data such as blood pressure, heart rate and electrical heart activity for elderly and/or disabled persons. Firstly, the collected data is transferred to a home server and to an external manager for further analysis. Subsequently, data is stored at a database where monitoring is available only for authorized users via a simple web interface. The IEEE 802.15.4 wireless standard has been chosen as the preferred solution for communication in the smart house. Finally, two implementation scenarios of the smart house for an elderly and/or disabled person are simulated using the Custodian software tool. This case study shows that simulating the automation system of a smart house before the implementation is advantageous.

INTRODUCTION AND LITERATURE REVIEW

Smart houses support services which ease and secure people's lives. The applications that a smart house can support are realised by wireless sensors and are divided into the following five categories (Stefanov, Bien, Bang, 2004), (Dewsbury, Taylor, Edge, 2002):

- *Energy management:* Applications which can control the heating and lighting system

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of the house in order to provide the desirable temperature and light.
- *Security and safety:* Applications which can provide security services.
- *Air control services:* Applications which can control the house air quality.
- *Healthcare and health monitoring applications:* Sensors attached on occupant's body collect data about certain biomedical signs. This data is stored, analyzed, evaluated and finally utilised to provide a global view of occupant's health condition.
- *Entertainment:* Applications which can provide entertainment services.

A smart house can help elderly and/or disabled people to have a good quality life and feel safe in their own house. Such a smart house should support healthcare oriented services like medical data collection, data transmission to an external medical manager and data evaluation. Collected medical data represent blood pressure, blood oxygen saturation, body weight, pulse rate and electrical heart activity. Subsequently, data is stored in medical databases, where it is analyzed by medical oriented software. Finally, the system informs a distant medical center in order to manage a possible medical emergency (Stefanov, Bien, Bang, 2004), (Dewsbury, Taylor, Edge, 2002).

The healthcare applications in a smart house are based on lightweight, intelligent medical sensors. These sensors can sense, collect, process and exchange medical data. The network should be wireless in order to give the opportunity to the occupant to move freely and with no restrictions. This type of network represents a Wireless Body Area Network (WBAN), because the sensors are spread over human's body. As it is explained in the following section, the most popular standard for low rate wireless sensor network (WSN) applications is the IEEE 802.15.4 (Gutierrez, 2004), (Gutierrez, Naeve, Callaway, Bourgeois, Mitter, Heile, 2001). The designed smart house system has to be a multi-tier system, divided into three tiers. The 1st tier is composed of sensors that are placed over human's body. The 2nd tier is a personal server that stores, process and manages the collected data. Additionally, a home server may be included in order to store all data. The home server can enable applications to manage any medical emergency situations. Finally, the task of communication with external managers is part of the 3rd tier (Milenkovic, Otto, Jovanov, 2006).

The external managers can be placed in a hospital or in a doctor's office and are responsible for the system and the healthcare management of the smart house occupant. The collected data can be further analyzed and the results can be stored to have a backup and a medical history of the smart house's occupant. The medical devices (sensors) are used to measure parameters such as body temperature, weight, blood pressure, while more complex devices such as electrocardiograms (ECG) are used to check occupant's heart condition. A well known experimental system is MITThril developed at MIT, which is composed of "wearable computing platforms" used for continuous medical data collection and monitoring. One of the most important sensors is ECG which monitors the electrical heart activity in a graphical way. Body temperature and blood pressure are measured by a lightweight sensor, which uses a three-axis movement positioning sensor (Milenkovic, Otto, Jovanov, 2006).

In (Liang, Huang, Jiang, Yao, 2008) a system of wireless smart home sensor network based on the IEEE 802.15.4 standard using Public Switched Telephone Network (PSTN) remote control and a 2.4 GHz radio frequency transceiver is proposed. This work describes the network configuration, the communication protocol and the software/hardware implementation process. In (Chen, Nugent, Mulvenna, Finlay, Hong, Poland, 2008) the challenge of assisting the inhabitants of a smart house in performing the correct actions at the correct time in the correct place is addressed. Particularly, this work introduces a novel logic-based approach to cognitive modelling based on a