

IoT-based Monitoring System using Tri-level Context Making Model for Smart Home Services

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Abstract-- In future smart home based on Internet of Things (IoT), data acquisition and information analysis through various sensors will play a crucial role, and it will be a core technology to develop IoT-based smart home services. This paper proposes an IoT-based monitoring system using a tri-level context making model for context-aware services in smart homes.

I. INTRODUCTION

As advanced wired and wireless network technologies have developed, internet-connected mobile devices such as smart phones and tablets are now in general use. As a result, a new concept, Internet of Things (IoT), was introduced and it has received attention over the past few years. In general, IoT is an information sharing environment where objects in every-day life are connected to wired and wireless networks. Recently, it is used not only in the field of consumer electronics and appliances but also in other various fields such as a healthcare, smart home, smart car, energy system, and industrial security.

The IoT used to be compared to machine to machine (M2M) technology. According to the IoT global standard initiative (IoT-GSL), in the International Telecommunications Union (ITU-T), the IoT is not limited to physical objects but includes virtual objects such as contents. This characteristic of IoT is a typical difference when compared with M2M. In short, the M2M revolves around a machine which is the main object, but the IoT is introduced around an environment that has things or object surrounding people. According to [1], IoT means that each object or thing is connected and communicates through the Internet without human intervention, and the ultimate goal of IoT is to enhance the quality of human life. In human life, fields that are applied with the IoT technology are homes and buildings, which are defined as smart homes.

In past home automations, a network topology consisted of sensor nodes for data collection and transmission and servers or gateways for information collection and analysis [2], and the relationship between a sensor and an actuator was clearly defined [3]. On the other hand, in the IoT environment, a sensor and an actuator are not as clearly separated but rather defined as an individual object or thing. Thus, each object or thing is a sensor but also plays the role of the actuator, which should collect information while at the same time providing

information to objects such as user devices, cloud servers, and other IoT. Such difference is one of the most definitive features that distinguish the IoT-based smart homes and the past home automations. Therefore, in the future smart homes, a new type of IoT is needed to provide various services and to improve human life, without user intervention. This paper proposes an IoT-based monitoring system using tri-level context making model for smart home services. It also demonstrates a context-based smart home service using an actual prototype and service scenario for future IoT environments. The main purpose of this paper is to demonstrate future IoT technologies and propose direction of smart home services..

II. IOT-BASED MONITORING SYSTEM

From such perspective of the introduction, the IMS was designed to collect and analyze data, share information and create context in an IoT environment. Fig. 1 shows the hardware and software architecture of IMS and the difference between the home automation and the IoT-based smart home network topology. The IMS consists of the sensor part that measures environmental information, the communication part for connectivity, and the main process part that processes data and context. The sensor part is equipped with five sensors measuring temperature, humidity, gas, luminance, and movement. The communication part supports Wi-Fi and Bluetooth to interact with mobile devices, cloud servers, and other objects. Moreover, the IMS can provide collected and analyzed information via a webpage because it can be operated as a web server. The main processor part, equipped with the tri-level context making model, analyzes the collected

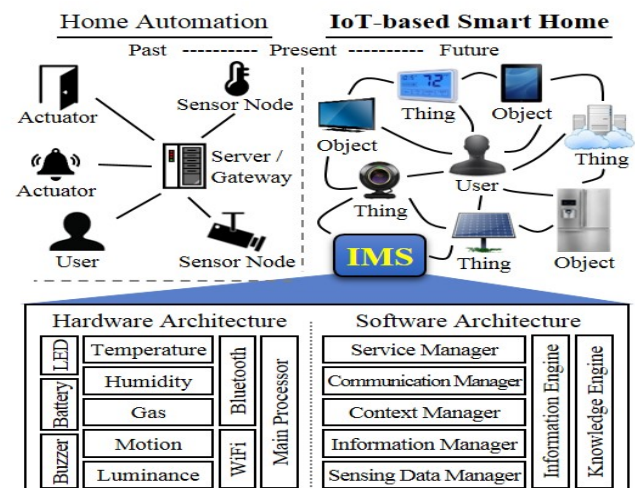


Fig. 1. Architecture of IMS and the difference between home automation and IoT-based smart home network topology.

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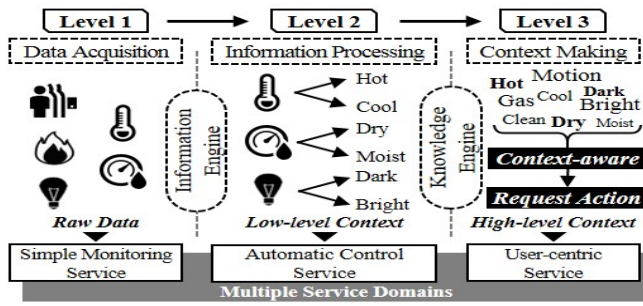


Fig. 2. Concept of the Tri-level Context Making Model

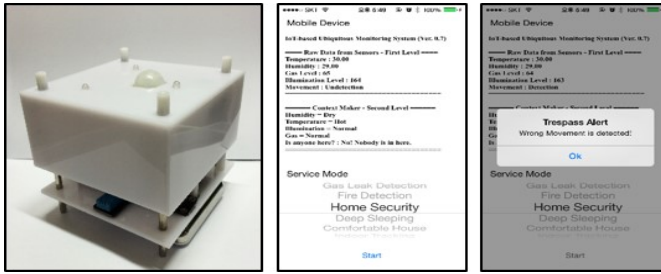


Fig. 3. Prototype of IoT-based monitoring system

data, creates context, and informs users by making a beeping sound and with an LED light according to context-aware results.

III. TRI-LEVEL CONTEXT MAKING MODEL

The tri-level context making model plays a role of generating context from collected data depending on the type and purpose of service domains. For guaranteeing quality of service (QoS) in various service domains, the proposed context making model is service oriented and divided into three levels. Each level of the proposed context making model has different service types, which are a simple monitoring service, an automatic control service, and a user-centric service. Fig. 2 shows the concept of the proposed context making model. The first step is the data acquisition in which data measured from the sensor is collected and calibrated. The second step is the information processing. In this step, the information engine provides appropriate threshold values according to sensor characteristics, and the collected data is processed into information which is low-level context. The last step is the context making. The aim of this step is to generate the situation-aware or context-aware information based on the knowledge engine. This engine transforms the information into high-level contexts depending on the service type. And in this step, the IMS requires an appropriate user action according to each generated context.

As an example of the context making process, if a gas data and a temperature data are collected in the first step, the proposed context model determines whether the air quality is fresh, moderate or poor according to the threshold value in the second step. The low-level context related to the temperature is also determined to be high, low, or normal. In the last step, the high-level context is generated based on the knowledge engine to see whether it is a fire situation where gas is detected and temperature is rising, or a ventilation-requiring

situation due to polluted air. The knowledge engine decides the most appropriate situation based on context-aware information that is initially learned and differs depending on characteristics of the service domains.

IV. IMPLEMENTATION

The proposed IMS using the tri-level context making model was designed with open source hardware and software in order to expand into future IoT. Two different scenarios were tested as IMS-based smart home services. The first was a disaster management service. In this scenario, if specific situations such as fires, gas leakage, and break-ins occurred, users can be aware of them through the alarming of LED lights, beep buzzers, and remote notification. The second scenario was a smart home health care service such as deep sleep management and comfortable house management. This service analyzes information necessary for the maintenance of pleasant living environments and health promotions, and then provides services that require certain actions such as ventilation, temperature control, and indoor exercise in the same way as the alarming service of the first scenario. Fig. 3 presents the prototype of IMS and the graphical user interface of a mobile application. Through the mobile application, users can realize what type of actions are required to achieve the purpose of a service.

V. CONCLUSION

In order to enrich daily lives with the IoT, a necessary technology is one that collects and analyzes much different information around us through various sensors. Moreover, creating and managing context, which is information with significance, will be the core technology to develop future IoT-based smart home services. In this paper, the IMS using a tri-level context making model for future smart home services was proposed. In the future IoT environment, collecting data and generating information from sensors are important because new services and various business models will appear. In order for the IoT to be fused into life and move forward, new IoT service designs and context analysis are also important. Therefore, the next step for this study will be reinforcing the knowledge engine, processing data from additional sensors, and visualizing data and information.

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