Implementation of a Handheld Compute Engine for Personal Health Devices

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Abstract

In this paper, we propose a handheld Compute Engine (CE) for personal health devices (PHDs). The CE is a device that receives measurements from more than one PHD, and collects, analyzes and displays the received measurements. It also transfers the collected measurements to a remote monitoring server for more informative analysis. We implement the CE on a handheld device (i.e., smartphone) to provide seamless health monitoring services for patients or users. On the basis of the proposed CE, we construct a u-healthcare system comprising two PHDs: a medication dispenser and a pulse oximeter. The PHDs transfer their measurements to the CE, and the CE displays the received measurements. The application results show that the proposed CE operates properly.

Keywords: *Personal Health Device, Compute Engine, ISO/IEEE 11073, Ubiquitous healthcare, Mobile healthcare*

1. Introduction

In recent years, many researchers are focusing on ubiquitous-healthcare (u-healthcare) services that provide patients with continuous health monitoring, real-time health coaching, and intervention. Such services are being developed continuously owing to the increasing severity of social issues. Owing to this trend, personal health devices (PHDs) such as activity monitors, medication dispensers, pulse oximeters, and blood glucose phones have emerged as key components of u-healthcare systems [1, 2].

A PHD is a device that measures patient health data and transfers it to a compute engine (CE), such as a smartphone or personal computer, for analysis and display. A CE collects, analyzes and displays patient health data from more than one PHD. It also transfers the collected data to monitoring server (MS) for more informative analysis.

In this paper, we implement the CE on a handheld device (i.e., smartphone) to provide seamless health monitoring services for patients or users. On the basis of the proposed CE, we construct a u-healthcare system comprising two PHDs: a medication dispenser and a pulse oximeter, developed in our previous studies [3, 4]. The medication dispenser delivers medication to chronic disease patients according to a predetermined schedule, and the pulse oximeter measures a user's SpO_2 and pulse rate non-invasively. These PHDs transfer their measurements to the CE using the ISO/IEEE 11073 protocol [5] which is the international standard for personal health devices. The CE analyzes and extracts measurements from the 11073-based messages, and displays the measurements to users. The application results show that the proposed CE operates properly.

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The remainder of this paper is organized as follows. Section 2 introduces the architecture of existing u-healthcare systems, and the proposed handheld CE. Section 3 presents the application results of the proposed CE, and Section 4 summarizes and concludes the paper.

2. Proposed Handheld Compute Engine

2.1. General Architecture of u-Healthcare Systems

u-Healthcare systems are being studied intensively owing to the increasing severity of social issues. Some studies have been conducted into the development of PHDs such as activity monitors [6, 7], medication dispensers [8, 9], and pulse oximeters [10, 11]. These PHDs measure and acquire different kinds of health data (e.g., medication status, caloric expenditure, pulse rate) at the patient’s home. In addition, standard protocols for plug-and-play interoperability have been actively investigated [12]-[15]. Figure 1 shows the general architecture of u-healthcare systems.

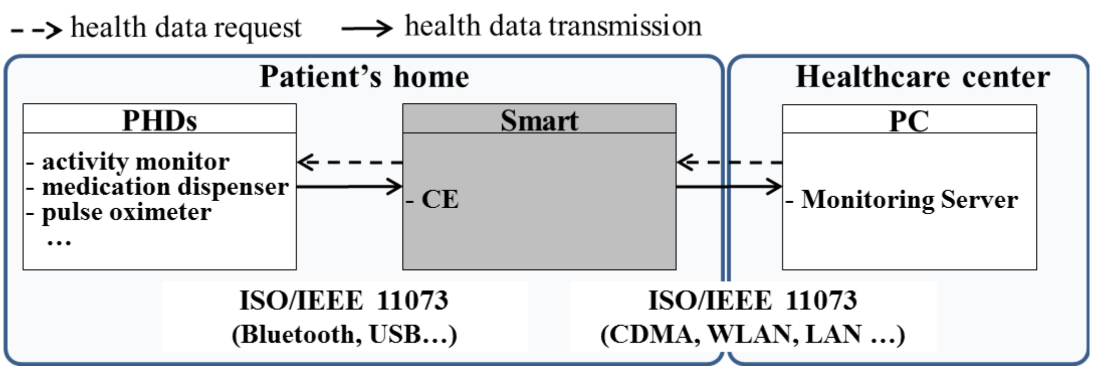

Figure 1. Architecture of the Proposed u-healthcare System

- *PHD*: A PHD is a device that measures patient health data. PHDs are usually installed at the patient’s home.
- *CE*: A CE is a device that collects patient health data from more than one PHD, and transfers the collected data to an external device for analysis and display. Smartphones and PCs are typically used as CEs.
- *MS*: A MS is a device that analyzes the health data received from CEs, and provides analysis results. It also provides patients with a web-based user-interface (UI) for analysis feedback.

In general, PHDs are small and light weight and therefore they have constraints such as low power, limited memory and low bandwidth. To address the constraints, PHDs should transfer their measurements to a device that has better performance (i.e., a CE). A CE plays two important roles in the u-healthcare systems: it collects, analyzes and displays patient health data from more than one PHD. And it also transfers the collected data to MS for more informative analysis.

2.2. Handheld CE

To provide seamless health monitoring services for users, we design and implement a CE on a handheld device (i.e., smartphone). The CE receives measurements from PHDs and conveys them to an external MS. Figure 2 shows the architecture of the CE.

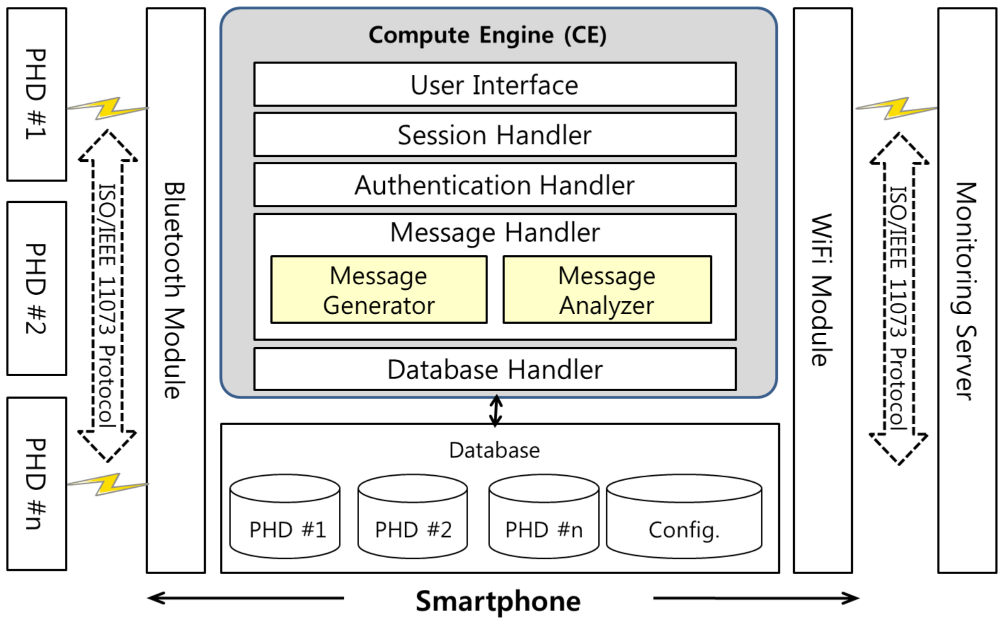

Figure 2. Architecture of an Integrated Gateway

- *User Interface*: displays the measurements in graphical forms.
- *Session Handler:* manages a communication session with a PHD. It maintains a connection with the PHD until a session is complete.
- *Authentication Manager*: authenticates the credential information.
- *Message Analyzer:* extracts measurements from the received 11073 message.
- *Message Generator:* generates measurement request messages for PHDs.
- *Database Handler:* extracts/stores the configuration and measurements of each PHD.

3. Application and Experimental Results

In this section, we present the results of applying the proposed CE to a u-healthcare system. We use a medication dispenser, and a pulse oximeter, developed in our previous studies [3, 4], as PHDs of the u-healthcare system. The medication dispenser delivers medication to chronic disease patients according to a predetermined schedule, and the pulse oximeter measures a user's SpO2 and pulse rate non-invasively. The 11073-10472 [16] and 11073-10404 [17] are applied to the medication dispenser, and pulse oximeter, respectively. Figure 3 shows the PHDs used in our u-healthcare system.

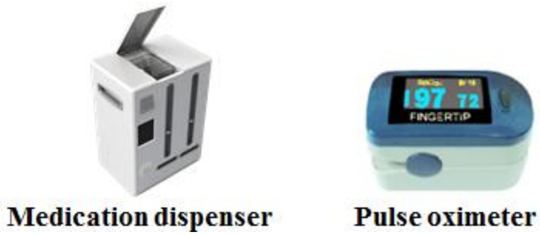

Figure 3. Applied PHDs

The CE is implemented on a smartphone (LG-LU2300). It operates on a 1-GHz T1 OMAP 3630 processor, and runs on Android 2.2. In addition, an embedded SQL database, SQLite [18], is used for the database. The CE and PHDs are connected via Bluetooth, and the CE and MS are connected via WiFi. Figure 4 shows the CE's main menu, profile menu (which represents the user information), and display menu (which represents health data in graphical form).

Figure 4. User Menus of the Integrated Gateway

The MS was implemented in C# on a desktop computer with an Intel Core 2 Dual processor (2.66 GHz) and 1024 MB of RAM. In addition, MSSQL was used for the database. It analyzes an integration message received from a CE, and provides analysis results. Figure 5 shows the implemented MS. Based on Figure 5, the MS receives an integration message from CE and displays measurements of each PHD properly.

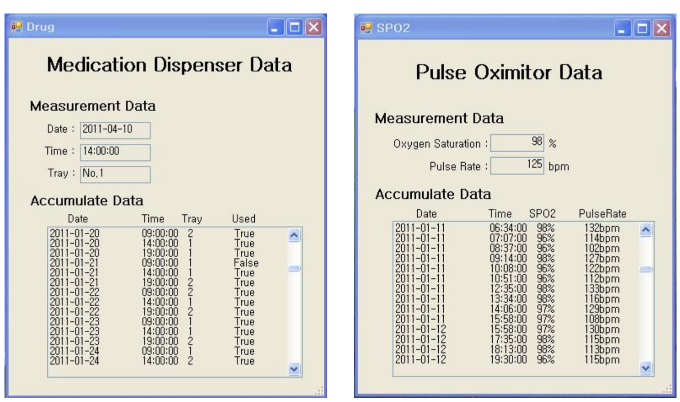

Figure 5. Graphical UI of MS

4. Conclusion

In this paper, we proposed a handheld CE for PHDs. The CE receives measurements from PHDs, and collects, analyzes and displays the received measurements. It also transfers the collected measurements to a remote MS for more informative analysis. We implemented the CE on a smartphone to provide seamless health monitoring services for patients or users. On the basis of the proposed CE, we constructed a u-healthcare system. The application results showed that the proposed CE operates properly. In the future, we plan to consider transmission efficiency issues which may arise during transferring measurements to the MS.

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