Chapter 30
Services and Monitors for Dependability Assessment of Mobile Health Monitoring Systems

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ABSTRACT

The problem of failure detection in mHealth monitoring systems is becoming more critical, and the use of wireless technologies and commodity hardware/software platforms pose new challenges to their correct functioning. Remote and continuous monitoring of patients' vital signs aims to improve the quality of life of patients. Such applications, however, are particularly critical from the point of view of dependability. Wireless channels can be affected by packet loss, and cheap and wireless-enabled medical devices can exhibit wrong readings, inducing the medical staff to make wrong decisions. In this chapter, the authors present the results of a Failure Modes and Effects Analysis (FMEA) conducted to identify the dependability threats of health monitoring systems and a set of services and monitors for the assurance of high degrees of dependability to mobile health monitoring systems. Moreover, the authors describe a case study realized to detect failures at runtime.

1. INTRODUCTION

Health monitoring systems have been shown to be effective in helping to manage chronic disease, post-acute care, and monitoring the safety of the older adult population. They can help older adults slow progression of chronic disease and ensure continued recovery after being discharged from an acute care setting. The implementation of such systems is gaining an increasing attention

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in the academia and the industry, also due to the increasing healthcare costs and the aging of the world population (Hao et al., 2008).

To this purpose, cabled measurement equipment is already used to guarantee reliable and robust control of vital signs. However such systems complicate patient autonomy and mobility. Hence, wireless technologies and mobile devices are starting to be applied to build more comfortable and patient-friendly health monitoring systems (Paksuniemi et al., 2006).

Nevertheless, the use of wireless technologies and the adoption of commodity hardware/software platforms, such as smartphones, pose new challenges on the correct functioning of health monitoring systems. Wireless channels can be affected by packet loss, due to shadowing and absence of signal coverage. Smartphones can be subjected to unpredictable failures, which could affect the correct functioning of the system. Finally, cheap and wireless-enabled medical devices can exhibit wrong readings and temporary disconnections from the so-called Body Area Network (BAN (O'Donovan et al., 2009)). These issues may induce the medical staff to take wrong decisions, e.g., to administer wrong dosages of medicine, which can happen to be fatal for the patient.

For these reasons, the problem of failure detection and management in health monitoring systems is starting to be addressed in the literature, especially for mobile systems. However, several studies are based on simplistic failure assumptions or on basic fault-tolerance schemes (such as, sensor redundancy), which are not assured to cover all possible failure scenarios. For instance, sensor replication is ineffective against smartphone failures.

To overcome the limitations of current solutions, in this paper we propose the design of reliable mobile health monitoring system, based on the configurable and the automatic deployment of system monitors, enriching the task of vital sign collection with the ability of detecting failures at runtime, hence enabling the realization of dependable health monitoring services. Differently from the previous attempts in the literature, we base our design on the results of a detailed Failure Mode and Effect Analysis of a typical mobile health monitoring system (Cinque et al., 2011) (Cinque et. al., 2012).

The FMEA allowed us to identify the failure modes of the main components composing such systems, by taking advantage of our past experience and detailed field studies on the dependability of mobile devices, wireless communication technologies, such as Bluetooth, and wireless sensor networks (WSNs). The characterization of the failure modes of the system components allowed us to identify the main responsibility of system monitors, along with their placement in a typical mobile health monitoring architecture. The driving idea behind our design is to keep monitors transparent to application developers, allowing them to implement dependable health monitoring applications only by using high-level collection and delivery services. Such services are in turn conceived to exploit the underlying system monitors to detect the failures and potentially react to them. In order to let the solution be adaptable to different application needs, monitors are conceived to be activated and configured automatically, based on a high-level and system-agnostic specification of the desired dependability level.

The rest of the paper is structured as follows: The related work is presented in Section 2; Section 3 describes the typical architecture of a mobile health monitoring system, while in Section 4 we discuss about the results on the realized FMEA. The proposed monitor-based dependable architecture is presented in Section 5. Section 6 presents a use example of a monitor. Finally, Section 7 reports our concluding remarks.