Chapter 12
A Service-Oriented Privacy-Aware System for Medication Safety and Prescription Compliance in Smart Home Environments

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ABSTRACT
Medication management is becoming more complex, and the likelihood of unsafe prescriptions has increased because of the rapid pace of new medications introduced to the market, the trend of modern healthcare towards specialization, and the variety of medication interactions that complicate the prescribing process and patient management of medications. The severity of this problem is magnified when patients require multiple medications or have cognitive impairments. To counter this problem and improve the quality of patient healthcare, we designed and implemented a service-oriented system for medication management that collects and integrates information from patient smart homes, doctor offices and pharmacies to 1) detect adverse reactions among prescribed medications, existing health conditions, and foods, and 2) monitor and promote compliance with prescription instructions. The system is privacy-aware and designed to support information privacy regulations, such as the Health Information Portability and Accountability Act (HIPAA).

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INTRODUCTION

Smart homes use pervasive computing principles to connect and integrate different technologies to assist residents with activities of daily living (ADL) in their homes (Helal, 2005). Research on smart homes and pervasive computing systems, especially those with applications and services designed for the elderly and persons with special needs, has gained a lot of attention in recent years as the baby boomer generation has reached retirement age and many need assistance with ADL (Noury et al., 2003). A primary need that has yet to be adequately addressed by researchers in pervasive computing is patient medication management (Reyes Álamo, Babbitt, Wong, & Chang, 2008a; Nugent et al., 2005; Noury et al., 2003). Medication management can be challenging because of complicated and often confusing medication names, multiple medication providers, multiple prescriptions, and complicated medication schedules. The MedMarx report from the United States Pharmacopeia (Hicks, Becker, & Cousins, 2006) indicates that over three fourths of medication errors occur during prescription and administration of medications; the former because of omitted or incorrect dosage details or conflicting medications, and the latter for omitting a dose, taking the wrong dose amount, taking an extra dose, taking the wrong medication, or taking a dose at the wrong time. If a patient wishes to remain at home safely with a high quality of healthcare, two facets of medication management are of particular importance: 1) detecting medication conflicts among prescriptions and existing health conditions, and 2) maintaining compliance with timing, quantity, and other prescription instructions.

Using patient medical information also comes with significant implications for privacy. As such, information privacy standards and regulations, such as the Health Information Privacy and Accountability Act (HIPAA) and subsequent Privacy Rule (OCR, 2003), should be incorporated into the design and operation of a medication management system to protect medical information and safeguard patient privacy.

The Medicine Information Support System (MISS) (Reyes Álamo, et al., 2008a, Reyes Álamo, Yang, Babbitt, Wong, & Chang, 2010a) is a privacy-aware, smart home-based solution to integrate patient homes with doctor offices and pharmacies to assist patients with medication management by facilitating medication safety and prescription compliance. The MISS is designed to wrap transparently around existing computer systems in doctor offices, pharmacies and smart homes using service-oriented technologies, i.e. OSGi and Web Services, while supporting platform independence and interoperability. This paper introduces additional materials related to the requirements, implementation, and evaluation of MISS and clarifies the presentation of these previous papers. In particular, the service-oriented design principles behind MISS have been realized in terms of a larger automated service composition framework that checks for the liveness properties of the proposed composite services (Reyes Álamo, 2010).

The rest of the paper is organized as follows: we first present a survey of medication-related services and applications in smart home environments and existing medication information systems. This is followed by discussing the key requirements of MISS, obtained from use case analysis, and presenting the models used for medication safety and prescription compliance. Subsequently, the design and operation of MISS are presented, followed by an analysis of how this design conforms to HIPAA. The details on our prototype implementation, including the automated composition framework, and the directions of the current and future research are presented. Finally, the paper ends with a concluding review and a list of contributions to medication management systems.