

**A REUSABLE APPLICATION FRAMEWORK
FOR CONTEXT-AWARE MOBILE PATIENT
MONITORING SYSTEMS**

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**DOCTOR OF PHILOSOPHY
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Abstrak

Pembangunan Sistem Pemantauan Konteks Sedar Pesakit Mudah Alih (CaMPaMS) menggunakan sensor tanpa wayar adalah sangat kompleks. Untuk mengatasi masalah ini, Rangka Kerja Pemantauan Konteks Sedar Pesakit Mudah Alih (CaMPaMF) telah diperkenalkan sebagai satu teknik yang sesuai untuk meningkatkan kualiti keseluruhan pembangunan dan mengatasi kerumitan pembangunan CaMPaMS. Walaupun terdapat beberapa kajian yang mereka bentuk CaMPaMF yang boleh digunakan semula, masih belum ada lagi kajian yang memfokus kepada bagaimana mereka bentuk dan menilai rangka kerja aplikasi berdasarkan aspek kebolehgunaan semula berganda dan menggunakan pendekatan penilaian kebolehgunaan semula berganda. Tambahan pula, tiada kajian yang mengintegrasikan kesemua keperluan domain CaMPaMS. Oleh itu, tujuan kajian ini adalah untuk mereka bentuk CaMPaMF yang boleh digunakan semula untuk CaMPaMS. Untuk mencapai matlamat ini, dua belas kaedah telah digunakan: kajian literatur, analisis kandungan, matriks konsep, pemodelan ciri, penggunaan pelbagai kes, kajian pakar domain, model yang berasaskan pendekatan senibina, analisis kod statik, pendekatan model kebolehgunaan semula dan prototaip, pengiraan jumlah nilai penggunaan semula, dan kajian pakar perisian. Hasil utama kajian ini adalah CaMPaMF boleh digunakan semula yang direka bentuk dan dinilai agar ia mengandungi pelbagai aspek kebolehgunaan semula. CaMPaMF terdiri daripada model domain yang disahkan oleh doktor pakar runding sebagai pakar domain, model seni bina, model platform bebas, model platform khusus yang disahkan oleh pakar perisian, dan tiga prototaip CaMPaMS untuk memantau pesakit tekanan darah tinggi, sawan, atau penyakit kencing manis, dan pelbagai pendekatan penilaian kebolehgunaan semula. Kajian ini menyumbang kepada badan pengetahuan kejuruteraan perisian, terutamanya dalam bidang mereka bentuk dan menilai rangka kerja aplikasi yang boleh digunakan semula. Penyelidik boleh menggunakan model domain untuk meningkatkan kefahaman tentang kehendak domain CaMPaMS, sekali gus diperluaskan dengan keperluan baharu. Pembangun juga boleh menggunakan semula dan memperluaskan CaMPaMF untuk membangunkan pelbagai CaMPaMS untuk pesakit yang berbeza. Industri perisian juga boleh menggunakan semula CaMPaMF untuk mengurangkan keperluan untuk berunding dengan pakar domain dan mengurangkan masa pembangunan CaMPaMS.

Kata kunci: Rangka kerja aplikasi guna semula, Penilaian kerangka kerja aplikasi kebolehgunaan semula berganda, Aspek kebolehgunaan semula berganda, Sistem pemantauan pesakit mudah alih

Abstract

The development of Context-aware Mobile Patient Monitoring Systems (CaMPaMS) using wireless sensors is very complex. To overcome this problem, the Context-aware Mobile Patient Monitoring Framework (CaMPaMF) was introduced as an ideal reuse technique to enhance the overall development quality and overcome the development complexity of CaMPaMS. While a few studies have designed reusable CaMPaMFs, there has not been enough study looking at how to design and evaluate application frameworks based on multiple reusability aspects and multiple reusability evaluation approaches. Furthermore, there also has not been enough study that integrates the identified domain requirements of CaMPaMS. Therefore, the aim of this research is to design a reusable CaMPaMF for CaMPaMS. To achieve this aim, twelve methods were used: literature search, content analysis, concept matrix, feature modelling, use case assortment, domain expert review, model-driven architecture approach, static code analysis, reusability model approach, prototyping, amount of reuse calculation, and software expert review. The primary outcome of this research is a reusable CaMPaMF designed and evaluated to capture reusability from different aspects. CaMPaMF includes a domain model validated by consultant physicians as domain experts, an architectural model, a platform-independent model, a platform-specific model validated by software expert review, and three CaMPaMS prototypes for monitoring patients with hypertension, epilepsy, or diabetes, and multiple reusability evaluation approaches. This research contributes to the body of software engineering knowledge, particularly in the area of design and evaluation of reusable application frameworks. Researchers can use the domain model to enhance the understanding of CaMPaMS domain requirements, thus extend it with new requirements. Developers can also reuse and extend CaMPaMF to develop various CaMPaMS for different diseases. Software industries can also reuse CaMPaMF to reduce the need to consult domain experts and the time required to build CaMPaMS from scratch, thus reducing the development cost and time.

Keywords: Reusable application framework, Multiple reusability evaluation approaches, Multiple reusability aspects, Mobile patient monitoring systems

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Mahmood Ghaleb Al-Bashayreh

August 2013

Dedication

To my mother Sabah and my father Gheleb

To my dear wife Ola

To my dear son AbdulRahman

To my brothers, Malek & Fares and my sisters Ala' and Eman

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List of Abbreviations

| | |
|---------|---|
| BP | Blood Pressure |
| BT | Body Temperature |
| CaMPaMF | Context-aware Mobile Patient Monitoring Framework |
| CCL | Context Characterization Layer |
| CIM | Computation Independent Model |
| CML | Context Monitoring Layer |
| CaMPaMS | Context-aware Mobile Patient Monitoring Systems |
| DIP | Dependency Inversion Principle |
| DRM | Design Research Methodology |
| ECG | Electrocardiogram |
| FODA | Feature-Oriented Domain Analysis |
| HR | Heart Rate |
| ISP | Interface-Segregation Principle |
| JMA | Jordan Medical Association |
| LSP | Liskov Substitution Principle |
| MDA | Model Driven Architecture |
| MDD | Model Driven Development |
| MDRE | Model Driven Requirement Engineering |
| MPMS | Mobile Patient Monitoring Systems |
| OCP | Open-Closed Principle |
| PIM | Platform Independent Model |
| PMS | Patient Monitoring Systems |
| PSM | Platform Specific Model |
| RR | Respiration Rate |
| SRP | Single Responsibility Principle |
| UML | Unified Modelling Language |
| WBS | Wireless Body Sensors |
| WHO | World Health Organisation |

CHAPTER ONE

INTRODUCTION

1.1. Overview

This chapter introduces the research that is presented in this thesis. The research background and motivation is described, followed by a presentation of the research problem, the research questions, and the objectives, scope and framework of the research, along with its significance. Finally, this chapter presents an outline of the whole thesis.

1.2. Research Background and Motivation

Reuse-based software engineering is a development approach that increases the reuse of existing software [1]. Software reuse is one of the fundamental software engineering concepts [2] and one of the most commonly used principles to simplify application development and overcome development complexities. Reusing software reduces the number of software assets that need to be developed and reuses well-tested assets that have been used in many systems with minimal errors. Moreover, software reuse encapsulates the knowledge of specialists [3-5].

According to [6], identifying the aspects that affect software reusability can enhance the knowledge required to build a reusable software components and identify the potential of reusing existing software modules in new a software development. Therefore, it is important to identify the aspects that can affect software reusability.

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