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Conceptual Persuasive Mobile Healthcare Architecture for Monitoring Children's Obesity Status among Parents

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Over the recent years, several persuasive strategies are integrated into the design of software in the healthcare domain. However, most of the current systems are implementing persuasive strategies without describing how it should be integrated. Therefore, the practitioners face difficulties in implementing strategies due to the vague picture of this area. This paper proposes a generalizable software architecture in mobile healthcare to be used independently of the problem domain. One of these domains is the obesity problem among Malaysian children, which it is highest in Southeast Asia countries. In addition, most of the current mobile healthcare architectures lack the persuasive features to persuade parents to monitor their children's obesity status. This study attempts to design a conceptual persuasive mobile healthcare architecture for parents to monitor their children's obesity status.

Keywords: Software architecture, Persuasive strategies, Persuasive components; Mobile healthcare.

1. INTRODUCTION

The proliferation of technologies in the health field offers an opportunity to achieve interactive communications that can persuade individuals to adopt some useful behaviors. The past years have witnessed a progressive shift in mobile healthcare (m-Healthcare) to be the promising tools for supporting people in adhering to their health goals[1]. Global Observatory for eHealth (GOe) of the World Health Organization (WHO) defines mobile health as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices"[2]. Healthcare assessed through the m-healthcare system is regarded as a solution to address the high cost of healthcare besides maintaining the status of the treatment overtime[3].

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Recently, m-healthcare has been used by many individuals who wish to attain health benefits[4]. Example of m-healthcare applications include interventions that help people to (a) quit smoking[5], (b)monitor obesity status[6], self-manage diabetes through a mobile-based solution[7], apply behavioral monitoring such as monitoring of children status by school nurses before collecting and storing the data locally, as practiced in the United States. (The traditional way involves sending it at a later time to a central database)[8]. Mobile applications solutions are becoming increasingly popular because they can be used by a great number of people and that they target different health issues or groups of patients[9]. While the applications are beneficial, they pose many domains that have yet to be attended to make the utilization successful[10].

One of these domains is the adoption of mobile application in healthcare for monitoring children obesity status among parents. Recently, obesity among Malaysian children is the highest in Southeast Asia and ranked sixth in Asia countries[11]. The World Health Organization (WHO) estimates that 2.8 million people die each year due to being overweight or obese [12].

In addressing this problem, parents should be responsible for their children's well-being and the effort has to start early when the children are still young[13-14]. More than 60% of parents fail to recognize that their child is overweight [15]. Whilst 79% of parents did not perceive their child's weight to be a health risk[16]. Therefore, a mobile application can serve as a good tool for parents to monitor their child's obesity. Nowadays, many persuasive strategies are gradually integrated into the design process of obesity systems. Persuasive features were implemented in building web-based application[17]. A framework was proposed to intervene childhood obesity by using a persuasive web-mobile technology[18].

However, studies on how persuasive strategies should be implemented are limited[19], particularly those on mobile architecture and mobile healthcare in particular young[19]. Most of the current mobile healthcare architectures lack persuasive features that can persuade parents to monitor their children's obesity status young[19-20]. Hence this paper attempts to develop generalizable software architecture in mobile healthcare for parents to use independently of the problem domain. This paper describes a conceptual persuasive mobile healthcare architecture for parents to monitor their children's obesity status.

2. SOFTWARE ARCHITECTURE DESIGN.

The software architecture (SA) community has developed several methods to support the architecture design process. Each of the architecture-centric design methods has its strengths and weaknesses. One way of leveraging their strengths and overcoming weak points is to select different approaches and techniques from different methods and apply them based on contextual requirements. The most critical part in developing a software architecture is to choose the right methodology. Following a particular methodology in developing a software architecture renders high positive consequences. Based on the never-ending arguments and supported by practitioners' experience, which fewer defects were obtained when a methodology is used in a software architecture development. Thus, the methodology is providing a clear cut idea to develop software architecture and deliver it in a short time with excellent value. Adopting a better methodology poses high challenges hence the method needs to be selected wisely in order to provide effective disciplines. Such measure would deliver high quality outcomes for business success, and it can also avoid the wasted steps, squandered productivity, discouraged developers, and non-active administrators. This is to assert that the designed architecture meets both functional (behavioral) and nonfunctional (non-behavioral) requirements.

The literature documents multiple views of the proposed Software Architecture Design Methods (SADMs). Software Engineering Institute (SEI) is one of the precursors in the engineering research software architecture (AS). One of the principal producers of this kind of methods is SEI. SEI has created many design and analysis methods: Software Architecture Analysis Method (SAAM) from[21], Architecture Tradeoff Analysis Method (ATAM) from[22], Cost Benefit Analysis Method (CBAM), Quality Attribute Workshops (QAWs), Quality Assessment of System Architectures (QUASAR), and Attribute-Driven Design (ADD) from [23]. Documentation for all of them can be found in the SEI's website.

More interestingly, five different methods were compared by[24] that include Attribute-Driven Design (ADD) Method[25], Business Architecture Process and Organization (BAPO), Architectural Separation of Concerns (ASC)[26], Siemens' 4 Views (S4V) method[27], and the Rational Unified Process 4 + 1 views (RUP 4 + 1)[28-29]. All these methods were developed by different authors and organizations, and they were developed at SEI, Nokia Research, Siemens Corporate Research, Rational Software (i.e. now IBM), and Philips Research respectively. Commonalities were extracted based on this comparison to construct a general software architecture design approach.

The general software architecture involves three activities that comprise of architectural analysis, synthesis, evaluation, and evolution[24]. Architectural analysis is a process of studying and understanding software requirements whereas synthesis is a process of architectural construction. In addition, evaluation activities aim to verify the quality of the designed architecture in relation to the original requirements as shows in Figure 1. Finally, evolution activities involve the continuous process of maintaining, adapting, and improving the existing architecture in order to improve its efficiency and reduce its complexity[24]

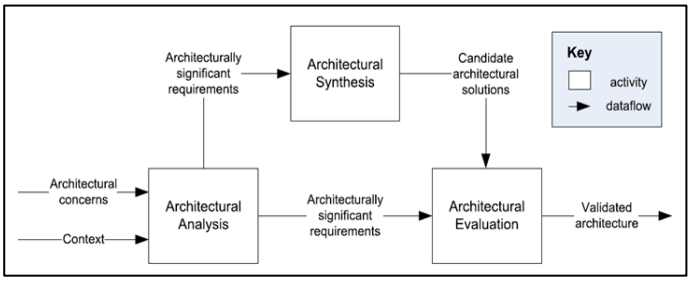

Fig.1. Architectural Design Activities[24].

The design science cycle includes three phases of problem investigation, and it is very similar to the software architecture design process. In the same way, software architecture design includes the activities to understand the problem, find a solution for the problem, and evaluate the solution[30]. The same activities were referred as architectural analysis, architectural synthesis, and architectural evaluation[24]. Nevertheless, there is a growing need to systematically gather empirical evidence

about the advantages or otherwise of tools and methods rather than just rely on promotional anecdotes or rhetoric[30]. Therefore, systematically accumulating provides scientifically valid approaches to gather the evidence in software architecture research.

3. THE PROPOSED CONCEPTUAL PERSUASIVE MOBILE HEALTHCARE ARCHITECTURE

This section describes the analysis and design of a software architecture based on an android platform and how the persuasive components are integrated into the software architecture.

3.1 ARCHITECTURAL ANALYSIS (UNDERSTAND THE PROBLEM)

This phase involves identifying the problem and extracting the most critical needs from ambiguous problem that is the incorporation of persuasive strategies in mobile healthcare being too general. Most of the trials in the literatures adapt the concepts from[31] without showing how the adaptation and the implementation of the strategies were made. Studies on persuasive mobile architecture have been scarce[19], and most of the current mobile healthcare architectures lack the persuasive features that can persuade parents to monitor their children's obesity status[19-20]. This necessitates a set of guidelines for adopting and implementing persuasive strategies in order to match with the target behavior in mobile healthcare. Consequently, it can take advantage of concepts, models, and processes that put forward[31-34] on how to create products to persuade, as well as some principles of[35]. Hence, this phase of analysis is for proof-of-these concepts, models, and processes, and for converting it to actual software development guidelines to be integrated into mobile architecture through the architectural synthesis phase.

3.2 ARCHITECTURAL SYNTHESIS (FIND A SOLUTION FOR THE PROBLEM)

There are several methods to support architects in identifying candidate solutions during architectural synthesis such as architectural patterns[36], styles[25], and reference architectures[37]. The candidate solution of this study focuses on the use of architecture patterns in the architectural synthesis phase. Through past decade, architectural patterns are becoming increasingly an integral part of the practices program of architecture design[36]. The architectural patterns often determine solutions to design problems by describing basic components, their responsibilities, and relationships[38]. This phase must specify the type of architectural pattern that will be used in this study because different architectural patterns imply different consequences even if they are very similar in addressing problems[36]. Examples of architectural patterns are the Presentation Abstraction-Control pattern (PAC), the Model-View-Controller pattern (MVC), pipe and filter, blackboard, and layer patterns[39-40]. The MVC design pattern is the methodology used widely to distribute the program functions into separate interactive application components: models, views, and controllers[41]. In fact, most of the recent studies have focused on design patterns[42] for mobile applications, based mostly on the MVC patterns. One of these new and exciting applications that have spread in recent years is the android application[43]. Android is an operating system (OS) open-source based on Linux kernel for mobile devices such as smartphones, tablets, e-reader devices, etc. and is currently being developed by Google[44]. According to[45-46], the MVC design pattern is implicitly an integral in the android software development kit (SDK) as shows in Figure 2. Consequently, this study proposes an MVC pattern and adapts it to design an android software architecture.

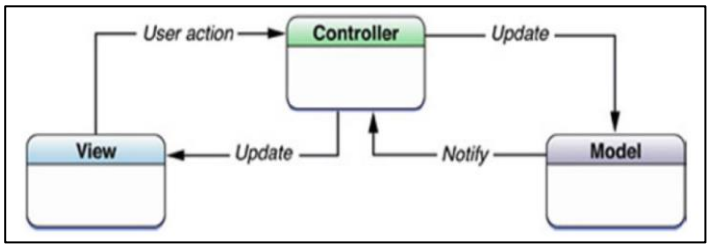

Fig.2. The MVC design pattern[45].

Only a few studies have attempted to study the android application architecture, whereas the android society has determined architecture as an important part of the successful system design[47]. Android requires no particular architecture[48]. Developers may choose a suitable architecture for their applications that are especially difficult for less experienced developers. Finally, after identifying the MVC pattern as a candidate solution for the architecture design, the persuasive strategies to monitor children obesity status are classified based on the Fogg's behavior model[33] and are integrated into the MVC pattern. Thereupon, the efficiency of the proposed architecture will be tested by implementing it in a real application. Finally, the main components of the android application architecture will be clarified, which is the MVC as embedded of them. These elements have been used in order to create the appropriate persuasive components for mobile healthcare. The proposed solution will be through the development of the practical categorization of these persuasive components. This means determining each persuasive element in order to classify it based on activity class, services class, broadcast receivers class, and content providers class. In addition, the classification of android components depends on the MVC pattern and it involves simplifying the work for novices or experiences, and enables the creation of less complex applications. Consequently, the proposed

architecture will be used as a reference for the practitioners to develop mobile healthcare application that can change behavior among parents. Hence, the practitioners will not encounter any difficulties or ambiguities in implementing the persuasive strategies as shown in Figure 3.

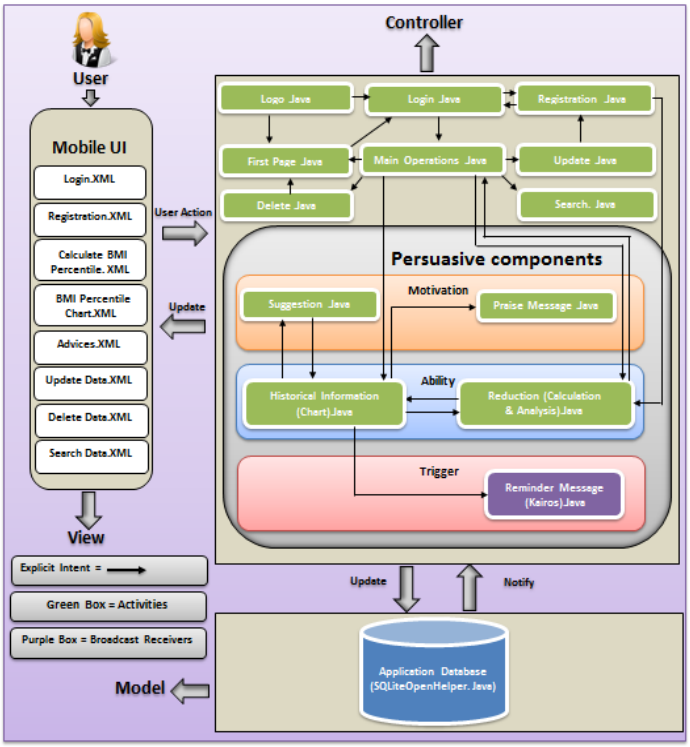

Fig.3. Conceptual Persuasive Architecture of the Mobile Healthcare Application for Monitoring Children's Obesity.

In Figure 3 the persuasive components that are integrated into mobile healthcare architecture include suggestion, Praise, reduction, historical information and reminder message. The first important component is the reduction, this can be convinced the parents by reducing the complexity and simplifying the required process through easy and simple steps. As a good example, the parents can monitor their children's obesity status by monitoring their children's BMI Percentile from time to time. The second element is the suggestion that will enable parents to retrieve advices on recommended food intake based on their children's BMI status at the right time, as well as provides the advice on exercises that are suitable for their children. The third element is the historical information that allows the parents to store the BMI Percentile status for their children over time in the database and display it on a chart to them on-demand. The praise is the fourth component that incorporated, this through the expression of praise, with words, figurative, signs, or loud, expressive, this element works only when the parents are completed the monitoring their child's obesity status. The last component is reminder message, this refers to intervening at the right time, which means introducing message at the opportune moment or at the right time when the parents are forgotten monitoring their children's BMI Percentile.

4. RESEARCH METHOD

The research combines qualitative and quantitative methods to achieve all aspects of the problem and solve it, as adapted from[49]. The methodology is divided into three phases: (i) problem identification, (ii) solution design, and (iii) evaluation. Each phase is divided into steps as illustrated below.

In the first phase, the researchers gather all possible related information to enhance their understanding on every aspect of the problem, including its causes. Hence this phase will be carried out as a theoretical study to gather information related to the theories and strategies of persuasion, or persuasive models to understand the domain of the study. A critical analysis will be conducted on the existing works, which will lead to identifying the gap in the implementation of the persuasive strategies in software healthcare domain.

The second phase is the software architecture design that is adapted from[24-30]. Generally, this study takes two main activities: (1) architectural analysis, and (2) architectural synthesis. All phases interact with each other along the period of this study, where the detailed descriptions of each activity will be discussed in the following sections.

The activity of architectural analysis has a great impact on software development process, thus in this activity the m-healthcare requirements will be formulated on architectural decisions firstly. This process will focus on the input or functional requirements of persuasive m-health care. In addition, relevant components of the m-healthcare architecture and its relationships will be identified and documented. What will be captured is a set of requirements imposed on the persuasive m-healthcare architecture for stakeholders' needs.

The ensuing architectural synthesis activity is the main activity in an architectural design that consists of decision-making in order to identify candidate solutions[24-30]. This phase aims to find available alternatives for the problems by choosing the most appropriate architectural design to fulfill the stakeholders' needs. Tang et al. suggest that creative design requires architects to refine and formulate the problem and solution at the same time[50], implying that the architectural analysis and architectural synthesis phases are closely linked. However, the architecture solutions and options are based on unproven assumptions[51], thus, the architects prefer solutions that are familiar rather than alternatives that are unfamiliar[51].

The last phase of the research method is the architecture evaluation, the main goal being to evaluate the ability of the selected architecture in delivering a system that is able to fulfill the quality requirement, improve the quality of the software systems, and to find

out any possible risks[40-52]. Also the purpose of the architectural evaluation phase is to validate the design solutions in order to ensure that the architecture design decisions are in the right way. This phase involves comparing the candidate architectural solution which is taken during the architectural synthesis with the architecturally significant requirements. In general, the persuasive m-healthcare architecture will be evaluated using two techniques as described below.

1) Technical Aspect: This section involves a qualitative study that utilizes experts' review (expert opinion). This section will be divided in two parts: First, seven experts who have a PhD in Information Systems (IS) or Computer Science (CS) or Software Engineering (SE) or Human Computer Interaction (HCI) or Children Obesity (CO) or Persuasive Technology (PT) will be gathered. They have at least five years' experience or teaching background in IS or CS or SE. They have specific related knowledge and expertise on the issues of architecture design and evaluation and readiness to provide effective analysis and interpretations. Also, they have enthusiasm to act as an unbiased evaluator.

In this part, semi-structured interviews based on open-ended question with experts will be conducted[53] to determine which quality attributes that are related to validate the model-view-controller architecture. Whereas, there are multiple sets of quality attributes which are used for software architecture evaluation, which is highly related to software pattern evaluation. The ISO: 9126 standard provides a starting point, which has been tested in academic and industrial situations[54]. However, ISO: 9126 is a standard for software quality and not specific to software pattern evaluation. Therefore the standard might have to be adapted to only include attributes that the MVC patterns can influence.

The second part involves validating the findings of the first part. This will be carried out by implementing an architectural prototype approach among same experts to experiment whether the persuasive m-healthcare architecture provides the required quality attributes. In sum, it is a helpful, necessary, and executable program that can reflect critical architectural components and quality attributes of the proposed system for experimental purposes.

2) Conceptual Aspect: This section will be conducted quantitatively to test the architectural prototype approach. The test will be conducted on thirty of parents to check their perceptions about the persuasiveness components in the mobile healthcare application. This point can also check the extent to which the parents are persuaded to use this application to monitor their children obesity. If they are persuaded, healthier lifestyle can be achieved and it can help Malaysian parents to manage their children obesity and reduce health care cost.

5. CONCLUSION

In conclusion, this paper focuses on integrating persuasive components into a software architecture based on the android platform to be used for developing behavior-change support systems. Persuasion strategies are applied by persuading parents to monitor their children obesity. These strategies are incorporated based on Fogg's behavior model to encompass motivation, ability, and trigger, paving the way for developing more robust persuasive systems and for providing a linkage between users' interaction with these systems. The ultimate aim of the persuasive software architecture is to give an opportunity for practitioners to design more persuasive systems that are more visible and less complicated. Future work will include experts review and actual users' evaluation of the proposed software architecture to further improve the system.

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