The Proposal of a Component Based Development Model to Develop Smart Home System

M. Rizwan Jameel Qureshi [1]

[1.] Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia
rmuhammd@kau.edu.sa

Abstract: The smart home technology controls the electronic devices in home environment using mobile phones. There are few solutions available in market to control home appliance electronic devices. One of the solutions is to control each device using a separate remote control. There are two problems associated with this solution. Firstly, it is difficult to manage separate controller for each device and secondly, the owner of devices has to be present in the vicinity to switch on/off. Another solution is to purchase off the shelf smart systems to control home appliances but the costs of smart home systems are very high. It is not affordable for majority of customers to purchase off the shelf smart home system. The objective of this research is to provide a novel economical solution to control the home appliances using mobile technology to on/off home appliances such as lights, air-conditioner, coffee maker and security cameras. A novel component based development (CBD) model is used to develop the proposed system. Survey is used as a research methodology to validate the proposed model. It is anticipated that proposed model will be cost effective and it will solve the problem in general.
[Qureshi MRJ. **The Proposal of a Component Based Development Model to Develop Smart Home System.** *Life Sci J* 2014;11(12):772-776]. (ISSN:1097-8135). http://www.lifesciencesite.com. 142

Keywords: Smart home, Mobile technology, component based development; Case Study; Household devices

1. Introduction

There is a significant advancement in the information and communications technology (ICT) during the last few years to introduce smart applications. Several companies are introducing smart systems for individual users like smart watch by Google Inc. and Microsoft Corporation. Smart home system is one of the solutions to facilitate people to control home appliances using mobile technology. The problem with the commercial smart home systems is that these solutions are very expensive and targeted to rich people like Apple Inc. products. The problem taken up in this research is to provide a cheap and novel solution to facilitate all categories of customers like the products of Samsung Electronics. This is achieved by developing a customized smart home system to control home appliances. A novel component based development (CBD) is proposed to develop smart home system.

Section 2 covers the related work. The problem selected in this paper is covered in section 3. Section 4 describes the details of customized component based development (CBD) model to develop smart home system. The validation of proposed model is illustrated in section 5.

2. Related Work

The literature review is composed of two parts. First part is used to identify the existing smart home systems to support this research. Existing CBD models are studied in the second part to identify the problems in the CBD domain to propose a customized CBD model for this research.

2.1 Existing Smart Home Systems

Rosslin and Tai-hoon (Rosslin and Tai-hoon, 2010) wrote papers on applications, systems and methods in Smart Home (SH) Technology. The objective of the research, by Rosslin and Tai-hoon, is to illustrate the current technologies and tools available to integrate or apply in SH systems. Emerging trends for Smart Home technology are also described. Ten guidelines are provided as well to use SH technology (Rosslin and Tai-hoon, 2010). A review on security in Smart Home development is provided by Rosslin and Tai-hoon (Rosslin and Tai-hoon, 2010). The main objective of the review is to focus on Smart Home and its security issues. Rosslin and Tai-hoon (Rosslin and Tai-hoon, 2010) also review the tools related to smart home security. The main problem of both papers is just providing the reviews about SH technology without identifying the problems and suggesting a solution related to SH (Rosslin and Tai-hoon, 2010).

Basil (Basil, 2010) describes the hardware implementation of multiplatform control system for home automation using LabVIEW dataflow visual programming language. The main objective is to design and implement a control and monitor system for SH (Basil, 2010). The main limitation of the LabVIEW system is that it does not have mobile interface. The LabVIEW system is a web based solution of the SH problem and it is not very flexible and mobile solution [3].

Caytiles and Park (Caytiles and Park, 2012) investigated Mobile IP (MIP)-based architecture for SH system. The main objective of research by

Caytiles and Park (Caytiles and Park, 2012) is to discuss current developments in SH applications and MIP integration to SHS. Architecture is proposed for SH systems using MIP to provide a seamless communication between the users and the home devices/equipment's as user is outside of his home. There is great control available to user over the proposed system (Caytiles and Park, 2012) like if he/she changes his/her location or network provider still the system is can work to communicate with the user.

2.2 Existing CBD Models

Stojanovic et al. (Stojanovic et al., 2003) describe how component concept chains and increases potency of agile development principles and its practices. The objective of this paper is to eliminate limitations of agile models and reduce the gap between CBD and agile development by integrating their common characteristics.

A hybrid component-based development process model is proposed in (Teiniker, 2005). The proposed model contains positive features of model-driven and test-driven process models. A case study is conducted to validate the proposed model. The proposed model needs further validations using more case studies.

In (Cooper, 2006) author Rational Unified Process (RUP) based process is used to develop commercial off the shelf (COTS) based software. The intent of this paper is to up-front certain issues from requirement engineering point of view while bringing in agility into COTS development. The main issues are short development time, test-driven development environment and agile principles while preparing functional specification for COTS.

A software-cycle model is proposed for reuse and reengineering (John and Victor, 1991) suggests five stages to reuse a component.

- Analysis of existing programs to sort components to be reused.
- Reengineering to eliminate domain specific troubles.
- Saving reusable components in the repository.
- Construction of independent status components with a reuse approach to store in a repository.
- Reuse components to develop new programs.

The proposed model is not a complete process model for CBD but focus of this research is on reuse activities. Poorly gathered SW requirements could fail a SW project (Hemant et al., 2003). It is because of natural drawback in requirements determination methods. An approach is proposed to construct SW by categorizing components in a knowledge base. Existing components are recognized, chosen and integrated in a newly developed SW by using the knowledge base. Different classification schemes to reuse artifacts have been discussed as well. These are enumerated, keyword, faceted and hypertext. The objective of this paper is to ease requirements gathering using knowledge base but the paper lacks in suggesting a comprehensive process model for CBD.

An incremental method is presented for distributed CBD (de Almeida et al., 2004). It is based on two phases. The first phase composes of gathering requirements of the problem domain and construction of employable components in object-oriented (OO) language. These employable components are stored in a repository. SW Engineers look up MVCASE tool to select the necessary components to develop the SW system in the second phase. The proposed process model is not a transparent model and a use of a specific CASE tool is the requirement of this process model.

A software life cycle model is anticipated to support CBD using OO construction (Luiz et al., 2001). The main phases of model are Domain Engineering, System Analysis, Design and Implementation. The major problem of this model is the selection of reusable components during the design phase. The selection of reusable components should be during the analysis phase. Therefore analyst can estimate the cost, schedule and effort required to develop and integrate the components.

The four stage component-based development process model is very complex for implementation (Hutchinson et al., 2004). The core objective of this paper is to integrate off-the-shelf components with the newly developed components rather than in house development. Repository has not been used here.

CBD process model main phases are Component Analysis, Architectural Design, Component Brokerage, Component Production and Component Integration phases (Ning, 1996). The CBD model is a modification of Waterfall process model with the integration of these phases. Waterfall model is not suitable for commercial applications because of the verification of phase's repetition. It is time and cost consuming process model which is suitable only for research projects.

3. Problem Definition

The study area is focused on developing a novel smart home solution to facilitate all categories of customers. For this purpose, a customized CBD model is proposed. The research question, taken up in this paper, is as follows.

"*How to propose customized CBD model to develop a smart system controlling home appliances in house or out of house using mobile technology?*"

4. The Proposed Customized CBD model

The Component Based Development (CBD) approach is used to develop smart home system. The CBD approach is selected because architecture of smart home system is based on components. Figure 1 depicts the CBD architecture of smart home system. Figure 2 is the diagrammatic representation of the proposed customized CBD model. The detailed breakdown of the proposed model phases are shown in the figure 3.

The details are described as follows to implement the proposed model using CBD approach to customize existing components.

'Plan' Phase

Customer is communicated to gather initial requirements to develop project specification. Project specification or proposal document is composed of feasibility and risk assessments. Cost benefits analysis (CBA) sheet is prepared. CBA sheet helps the customer to decide whether the smart home system is feasible or not.

'Model' phase

Model phase is used to analyze and design the system. The detailed analysis of the proposed system is started only if customer approves the proposal. Functional specification is end product of analysis. The main contents of functional specification are detailed description of system's requirements and modeling. The requirements are finalized after taking the consent of customer through extensive prototyping. A domain analysis is performed to find a suitable architecture for the application to be developed (Luiz et al., 2001). An architectural model of the application is developed that enables a software engineer to evaluate efficiency of design, judge options of design and minimize potential threats coupled with software development (Pressman, 2010). Project manager conducts a meeting with all team members. Meeting is named as impact analysis. Main objectives of the impact analysis meeting are to:

- identify the components which are reusable.
- measure the impact for the changes to customize the reusable components for a client.

Prototyping technique is used to approve the interface and functions. Review of technical specification is also performed based on the feedback of customer.

'Code, Test & Maintain' Phase

Reusable components need qualification, adaptation and composition. Component qualification makes sure that the selected component will execute the desired functionality; integrate easily into the structural design of new application; demonstrate the quality attributes (e.g., reliability, performance, usability) required.

The relationships among the components are identified. The properties and behaviors of the components are identified as well. Constraints are always there even after components qualify for reuse into new application, such as technical and integration constraints. Components are wrapped to manage constraints during adaptation.

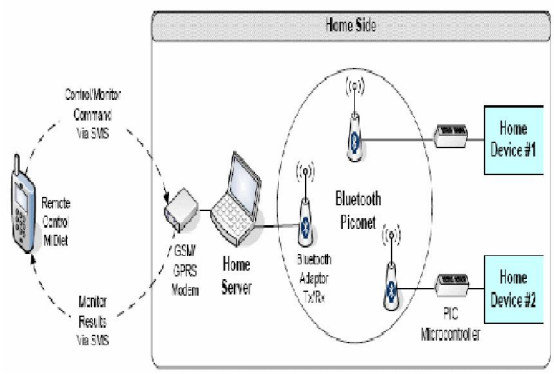

Figure 1. Architecture of Smart Home System (dc262.4shared.com, 2014)

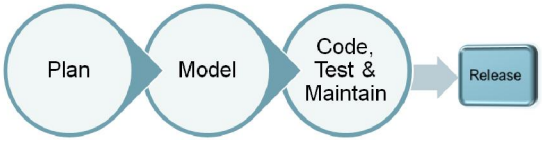

Figure 2. The Proposed Customized CBD Model

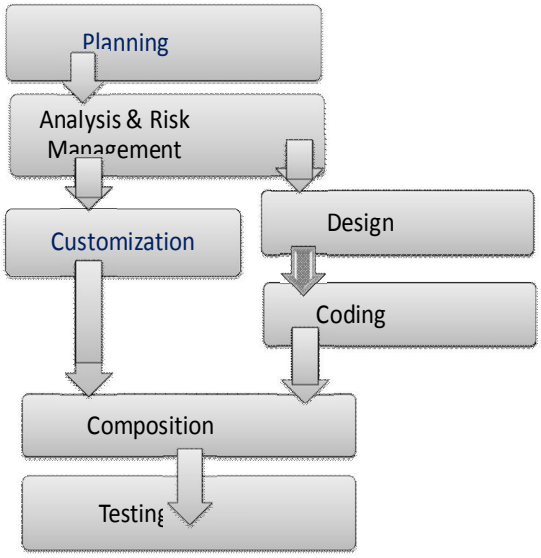

Figure 3. The Detailed View of the Proposed CBD Process Model

Composition involves integration of components into the architecture of new application. An infrastructure is required to achieve composition. Infrastructure will connect components, provide interoperability and execute operations. Infrastructure constitutes a collection of four architectural elements to attain component composition.

Data Exchange Model- Procedures to access and communicate data be written for reusable components e.g., API based data exchange.

Automation- Kinds of SW tools, subroutines and scripts can be applied to achieve interoperability between components such as remote automation by Microsoft.

Structured Storage- Technology holds varied data as a single component document to index, search and access components e.g., ActiveX and DOM.

Architectural Models are used for intercommunication between or among components such as CORBA and RMI. The customized components are tested using test-driven development approach. The test cases are prepared first before customizing a component. The software is deployed if client approves it.

5. Validation of the Customized CBD Model

A survey involving sixteen software development organizations was conducted to evaluate the proposed CBD model. The people who filled the forms had more than six years' experience in software development. The objective of the questionnaire is as follows.

Effect on reusability with respect to interoperability, complexity, efficiency, reliability, upgradeability, time saving, cost and quality for the proposed CBD Process.

The frequency distribution of the support for '*Plan*' phase is shown in Table 1.

Table 1-Frequency Distribution for 'Plan' Phase

Likert Scale		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	10	26.3	26.3	26.3
	4	21	55.3	55.3	81.6
	5	7	18.4	18.4	100.0
	Total	38	100.0	100.0	

It is displayed in Table 1 that 55.3% of the participants are highly supporting the suitability of 'Plan' phase for the proposed CBD model. Among respondents, 18.4% of the participants are very highly encouraging the suitability of this phase for the proposed CBD model and 26.3% of the respondents are reporting the nominal suitability of this phase for the proposed model.

The frequency distribution of the support for '*Model*' phase is shown in Table 2.

Table 2- Frequency Distribution for 'Model' Phase

Likert Scale		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3	5	13.2	13.2	13.2
	4	24	63.2	63.2	76.3
	5	9	23.7	23.7	100.0
	Total	38	100.0	100.0	

Table 2 shows that 63.2% of the respondents are highly favoring the suitability of 'Model' phase for the proposed CBD model. It is also reflected in Table 2 that 23.7% of the participants are recommending the suitability of this phase very highly and only 13.2% of the participants are reporting the nominal effect of this phase on the proposed model.

The frequency distribution of the support for 'Code, Test & Maintain' phase is shown in Table 3.

Table 3- Frequency Distribution for 'Code, Test & Maintain' Phase

Likert Scale		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2	1	2.6	2.6	2.6
	3	6	15.8	15.8	18.4
	4	13	34.2	34.2	52.6
	5	18	47.4	47.4	100.0
	Total	38	100.0	100.0	

Table 3 shows that 47.4% of the respondents are of the view that 'Code, Test & Maintain' phase is highly suitable for the proposed CBD model. It is also observed in Table 3 that 34.2% of the participants are supporting the suitability of this phase very highly while 15.8% of the software professionals report the nominal effect of this phase on the proposed model. Among respondents, there are only 2.6% who report the low effect of this phase on the proposed model.

Univariate analysis is performed to conclude the results (McClave et al., 2010). It can be concluded from equation that respondents highly supported improvement in reusability because of interoperability, complexity, efficiency, reliability, upgradeability, cost saving and quality for CBD projects. R square value shows that variation in quality is 0.869 because of defined variables. It is expected that variables have strong contribution if value of R square > 0.7 and weak if value of R square < 0.3 (McClave et al., 2010). The variables in this model have very significant contribution because value of R square is 0.869 for the defined model. Therefore it can be concluded that the model is highly reliable.

Reusability = - 0.163 + 0.176 interoperability + 0.472 complexity + 0.003354 efficiency - .00868 reliability + 0.111 upgradeability + 0.359 time saving – 0.190 cost + 0.172 quality

The equation indicates effect of independent variables (Interoperability, complexity, efficiency, reliability, upgradeability, time saving, cost and quality) on the dependent variable (reusability). The adjustment factor in equation is – 0.163 which calculates the effect of quality parameters on reusability by SPSS statistical software package itself (McClave et al., 2010).

The defined model suggests that if a unit:

- increases interoperability it increases 0.176 units in reusability;
- increases complexity it increases 0.472 units in reusability;
- increases efficiency it increases 0.003354 units in reusability;
- increases reliability it decreases 0.00868 units in reusability;
- increases time saving it increases 0.359 units in reusability;
- increases cost it decreases 0.190 units in reusability;

The above results show quality metrics (interoperability, complexity, efficiency, reliability, upgradeability, time saving, cost saving and quality) have very significant effect on reusability. This shows that the proposed model is reasonably useful for software companies using CBD.

6. Conclusion

A novel process model has been presented for the component-based development. A survey involving sixteen software development organizations has also been carried out to evaluate the proposed model. An equation is developed from the data to estimate the effect of quality parameters on reusability. The results of the equation show that the proposed model is highly reliable and quality factors have significant effect on reusability. The proposed process provides strong support for reusability, interoperability, upgradeability, less complexity, time saving, cost saving, reliability and also improved quality. The validation of the proposed process for CBD provides an indication for its usability for the proposed system. Further validation of the proposed CBD model to develop the smart home system is a subject matter of future.

Acknowledgements:

This work was funded by the Deanship of Scientific Research (DSR), King Abdulaziz University, Jeddah, under grant No. (611-62-D1435). The author, therefore, acknowledges with thanks DSR technical and financial support.

Corresponding Author:
Dr. M. Rizwan Jameel Qureshi
Department of Information Technology
Faculty of Computing & Information Technology, King Abdulaziz University
80221 Jeddah 21589, Saudi Arabia
E-mail: rmuhammd@kau.edu.sa

References

1. J. R. Rosslin and K. Tai-hoon, “Applications, Systems and Methods in Smart Home Technology: A Review,” International Journal of Advanced Science and Technology, vol. 15, pp. 37-48, Feb. 2010.
2. J. R. Rosslin and K. Tai-hoon, “A Review on Security in Smart Home Development,” International Journal of Advanced Science and Technology, vol. 15, pp. 13-22, Feb. 2010.
3. H. Basil, “Design & Implementation of Smart House Control Using LabVIEW,” International Journal of Soft Computing and Engineering, vol. 1, pp. 98-106, Jan. 2012.
4. R. D. Caytiles and B. Park, “Mobile IP-Based Architecture for Smart Homes” International Journal of Smart Home, vol. 6, pp. 29-36, Jan. 2012.
5. Zoran Stojanovic, A. N. W. Dahanayake, Henk G. Sol, “Component-Oriented Agile Software Development,” Lecture Notes on Computer Science, Springer Press, pp. 315-318, 2003.
6. Teiniker, E., Schmoelzer, G., Faschingbauer, J., Kreiner, C., Weiss, R., "A hybrid component-based system development process," in Proc. 31st EUROMICRO Int. Conf. on Software Engineering and Advanced Applications, Porto, Portugal, 2005, pp. 152- 159.
7. Kendra M. L. Cooper, "Can Agility be Introduced into Requirements Engineering for COTS Component Based Development?," in Proc. Int. Workshop on Software Product Management (IWSPM'06 - RE'06 Workshop), Minneapolis, Minnesota, USA, 2006, pp. 35-37.
8. John WB, Victor RB. The Software-Cycle Model for Reengineering and Reuse. Proc. Of today's accomplishments; tomorrow's expectations USA 1991:267-81.
9. Hemant J, Padmal V, Fatemah MZ. An Assessment Model for Requirements Identification in Component-Based Software Development. The DATA BASE for Advances in Information Systems 2003;34(4):48-63.
10. de Almeida ES, Alvaro A, Lucredio D, do Prado AF, Trevelin LC. Distributed Component-Based Software Development: An Incremental Approach. Proc. of 28th Annual International Conference on Computer Software and Applications (COMPSAC) 2004, Hong Kong, China:4-9.
11. Luiz F. C., Miriam A. M. C., Dahai L. Component-Based Software Process. Proc. 7th Int. Conf. Object-Oriented Information Systems, Calgary, Canada 2001:523-529.
12. Hutchinson J, Kotonya G, Sommerville I, Hall S. A Service Model for Component-Based Development. Proc. 30th EUROMICRO Conf., Rennes- France 2004:162-169.
13. Ning J. Q. A Component-Based Software Development Model. Proc. 20th Conf. Computer Software and Applications, Seoul, Korea 1996: 389-394.
14. http://dc262.4shared.com/doc/YRqMoszr/preview_html_14db2b96.gif, 2014.
15. Pressman RS. Software Engineering. McGraw Hill Press, USA, 2010.
16. McClave T., George Benson P., Sincich Terry. Statistics for Business and Economics, Prentice-Hall, USA, 2010.

12/5/2014