EDUCATUM JSMT Vol. 9 No.1 (2022)
ISSN 2289-7070 / e-ISSN 2462-2451 (92-98)
*https://*ejournal.upsi.edu.my/index.php/EJSMT/index

A Comparison Analysis Study to Analysis Requirements Elicitation for Arduino Development of IoT Application

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Published: 28 June 2022

To cite this article (APA): Yusop, N. (2022). A Comparison Analysis Study to Analysis Requirements Elicitation for Arduino Development of IoT Application. *EDUCATUM Journal of Science, Mathematics and Technology*, *9*(1), 92–98. https://doi.org/10.37134/ejsmt.vol9.1.9.2022

To link to this article: https://doi.org/10.37134/ejsmt.vol9.1.9.2022

Abstract

A rapid IoT application and its technology nowadays allowed the needs analyse of requirements elicitation to ensure the application product developed is consistent, correctness and complete. However, improper to elicit requirements is lead the failure of Arduino and IoT development. As requirements engineer, they must know how to elicit the requirements before proceeds to software development. Therefore, this paper provides a gap of study for existing work requirements elicitation that exist in market for commercial and for research purposes. We report our findings from review and analysis of different studies. The strengths and weaknesses of the features and utility are also presented to provide further understanding of the gaps and weaknesses of each research. We conclude that these researches are still immature and need further improvements.

Keywords Requirement elicitation, Arduino development, IoT application, Software engineering

INTRODUCTION

A rapid IoT application nowadays allowed the needs analyse of requirements elicitation to ensure it is consistent, correctness and complete. Requirement elicitation specifically is elicited by requirements engineer in software development life cycle (SDLC). However, the elicitation requirements elicited by requirements engineer are not similar with their client's intended requirements and will lead an error prone. There is limited tool support providing end-to-end support between the Requirements Engineers and their client for the validation and improvement of these requirements [1].

The IoT application works which uses integration of Arduino devices and application. The success of Arduino application specifically represents how the application of Arduino are designed and elicited. Therefore, it is important to elicit the requirements at early stage of requirements engineering phase. This is can be illustrated that to develop a high-quality ICT systems, the quality requirements must be consider [2]. Therefore, eliciting the requirement by Requirements Engineers is becoming an essential process in the development of Arduino application.

In this paper, a review on existing works and tool support to elicit the requirements of Arduino application are presented. The paper is organized as follows: Section 2 describes the background of study. This is followed by Section 3, survey literature. Then, Section 4 depicted to the discussion of the overall

finding that presents a description of selected tools for requirements elicitation on Arduino application available in the market together with its comparison analysis. Lastly, Section 5 is of this paper ends with a conclusion and future work.

RESEARCH BACKGROUND

Requirements engineering and 3C of Requirements

Requirements engineering use natural language to collect requirements from client-stakeholder. Requirements engineering can be classified with two main process which are requirements elicitation and requirements validation. Wrong elicitation may lead the application is failure. Requirements engineer difficult to understand the terms or component used in Arduino of IoT application due to the requirements involve an engineering work flow such as hardware and electronics requirements. Therefore, majority of requirements engineer were not prepared and trained. The elicitation requirements are referring to how requirements extracted from the client-stakeholder. A several requirements engineer have knowledge to identify, elicit, analyse in order to produce the quality of requirements. Producing a quality of requirements at early stages is cost-effective and reduce the testing efforts when the correctness and consistency of requirements is identified at beginning of software development.

Indeed, Zowghi [3] describes the causal relationship between Consistency, Completeness and Correctness (3Cs) of requirements as below.

A. Consistency
Consistency refers to situations where a specification contains no internal contradictions.

B. Completeness
Completeness refers to situations where a specification entails everything that is known to be "true" in a certain context.

C. Correctness
Correctness is often more pragmatically defined as satisfaction of certain business goal and it is usually combination of consistency and completeness.

Informal, semi-formal and formal requirements

Requirements can be divided in three types as described as below [4].

A. Informal
Informal is described in natural languages with represent with diagrams or pictures. They use natural language as their notation tool and does any require preparation. However, the informal may produce error prone that may vague expression, ambiguities and unmeasurable statements.

B. Semi-formal
Semi-formal is a combination between natural language and graphical notation that provide by captured the natural language in a form of diagram notation. Example of semi-formal model namely ERD, Use Case Diagram, etc.

C. Formal
Formal specification requirements are a predefined the rules for determining the meaning of specification or requirements. This formal specification founded in mathematical principles with use syntax and semantic

with large technique skill to produce less ambiguity. The examples, Algebraic specification Technique, rewriting system and all of these is supported by the tools.

Internet of things, Internet of things application and Arduino development

A. Internet of things

Internet of things is a network physical objects that can everyday object that are readable, locatable, addressable, through information sensing devices communication. The internet of things classified by three categories, 1) People to people, 2) People to things, 3) Things to Thing through internet [5].The physical objects not specific for computer but to the devices such as vehicles, medical instruments, camera, people building and etc [6] [7]. The object connected within network have data collected, analysed, and used for initializing for specific action, management and decision making [8].

B. Internet of things Application

IoT Application can be defined as IoT application related to the production of goods and services, including in manufacturing and utilities [9]. IoT applications refers to IoT applications are adopted by the market, they have already proved to be serviceable, supported by a strong technology alliance [6][7].

C. Arduino development

Arduino is open-source electronic prototyping that involve the use of software and hardware. The development of Arduino using Integrated Development Environment (IDE) such as Arduino IDE that free in market. Many hands-on applications developments has been developed by [10] that focusing from the simple to extraordinary as guidance for new product engineer or software engineer or student to developed Arduino of IoT application.

In addition, most of studied approach such as the EUC (Essential Use Case) was developed by Constantine and Lockwood [11] to support better communication between developers and stakeholders through a technology-free model and to assist better requirements elicitation. Yet, the requirements related involve in software system application requirements, for example the user needs to login the username and password to enter to the system. There are project stakeholders does not have technical understanding of Information System and project engineering requirements. In order to overcome the problems defined above, many approaches, methods, model, framework and tool have been developed to ease requirement engineer to including formal, semi-formal and informal. However, according to existing study, there is a necessity for enhancements on the tools that help eliciting requirements for Arduino development of IoT application.

RELATED WORK

There have been several works on requirements elicitation challenge in Arduino application. In this section, we present the existing approach for requirements elicitation of IoT application.

Ibrahim and Kamalrudin [12] developed a model to elicit security requirements of IoT application. The semi-formalised EUC model of security IoT application developed to improve the process of capturing the security requirements for IoT applications. Based on findings, they found that EUCs to enhance the process of eliciting security requirements to produce accurate and complete security requirements for IoT applications. However, the study focusing on the security requirements of IoT application not to Arduino development.

Albuquerque et al.[13] developed the RPT, a rapid prototyping tool approaches for smart toys called IoT4Fun toolkit that applied mixing the embedded, modular, and plug and-play approaches. This tool used motion tracking data, wireless communication, and contactless identification. In this smart toy, they elicited five requirements to developed RPT smart toys namely, 1) adaptability by design, 2)

distributed data collection, 3) multimodal user feedback, 4) different play features and 5) limit personal data collection. However, the RPT approaches focus on the prototype not to the model of requirements specifically on development of Arduino and IoT application.

Canedo et al. [14] developed a design thinking for eliciting requirements of mobile applications. The design thinking developed to get closed between stakeholder and software project in order to produce a quality product. The elicitation developed using design thinking is evaluated in a Brazilian Public Agency. Based on the findings, they found that traditional methodology adopted by the Agency is bureaucratic and hinders the creation process. However, the elicitation requirements using design thinking developed is not for Arduino and IoT application and only focusing on Mobile application elicitation.

Sakamoo and Miranda [15] developed a method called M4REMAIP for requirements elicitation for mobile application. To do this, they considered HCI perspectives, design and interaction issues. Throughout of their work, most application developed of mobile application specifically for home control. They found that developed method is usefulness for requirements elicitation for interaction purpose. However, the method proposed limited to home control application requirements and none of work of Arduino application requirements.

Nakajima and Komiyama [2] proposed SQuaRE framework use quality requirements framework of the ISO/IEC 25030. This framework is adapted to IoT can be applied to an Internet of things application. In this framework, there are five main divisions and one extension division were constructed. The outcome of the constructed framework focus on the usefulness of the framework. However, they need more application of framework from various system to evaluate and Arduino application also exclusive of their work evaluation.

Pramudianto et al. [16] proposed the position domain modelling and object virtualization. They developed a tool of this work to allowed domain model integrated to the IoT. They found the application developers able work in virtual to implement IoT. However, the model developed limited to IoT application developer for the modelling and there is none work discuss for specific in Arduino application development of IoT application.

Laplante [17] described the process of eliciting requirements for an IoT system to support emergency room activities. The author used screen shott and component description to assist in the process of architectural design once the requirements specification is complete. generalized to identify stakeholders and boundaries for a broader IoT application covering the entire hospital. However, the eliciting requirements covered.

Kamuller et al. [18] developed a combination framework for supporting the ethic. They proposed another framework used Isabelle framework as high level logical model. This framework that has ethical requirement elicitation eFRIEND with automated reasoning. Then, they allowed these combination frameworks between eFriend and Isabelle were used for two purposes namely i) elicitation of ethically motivated requirements ii) formal machine that supported analysis of attacks at early development. The case study of this to diagnose Alzheimer. This study is dedicated end-to-end cryptographic protocol but requirements of elicitation of client-stakeholder is not cover.

Yusop et al. [19] studied the elicitation requirements for mobile application development. The study focused in extracting security attributes for mobile application requirements faced by novice requirements engineers. From their findings, provide a tool able to elicit security requirements among novice requirements engineers. However, the study limited to eliciting security requirements from mobile application not in Arduino Application.

Based on these analyses, they demonstrate the limitations of current IoT device design methodologies when studied different of elicitation of IoT devices and application. However, the method and tool for eliciting requirements from clients stakeholder for Arduino application by requirements engineer is very limited.

RESULT AND DISCUSSION

We compare the nine existing works related to eliciting requirements of IoT application. The comparison features based on methodology/approach/technique, IoT domain-based applications, requirement representation, Technology and process in requirements as shown in Table 1.

Table 1 Comparison of IoT application

Year	Author	Name	Require-ments Represen-tation			Method/ Approach/ Framework/ Tool					Technolo-gy			Process in Requirements Engineering			
			Formal	Semi-Formal	Informal	Model	Method	Approach	Framework	Tool	Arduino	Iot	Mobile App	Elicitation	Analysis	Validation	Verification
2019	[12]	EUC				✓				✓		✓		✓			
2020	[13]	IoT4Fun	✓							✓		✓					
2020	[14]	Design Thinking								✓			✓	✓			
2014	[15]	M4REMAIP					✓						✓	✓			
2019	[2]	SQuaRE			✓				✓			✓		✓	✓		
2013	[16]			✓							✓	✓					
2018	[17]	Rich Pictures and Use Case		✓		✓						✓		✓			
2021	[18]	eFRIEND and automated reasoning	✓	✓					✓					✓			
2018	[19]	EUC				✓							✓	✓		✓	
Total			2	3	1	3	1	0	2	3	1	5	3	7	1	1	0

To developed an application, requirements must be collected from the client stakeholder at early. Proper eliciting requirements from client-stakeholder encourages the positive effectiveness and success of development. However, current works and tools do not provide a proper eliciting requirement such as there is none tool developed at early elicitation requirements for Arduino and IoT application. Thus, it is necessary to have a tool for eliciting a requirements of Arduino application as well as IoT application that support the Arduino development. We have conducted a review on the nine studies on EUC, IoT4Fun, Design Thinking. A few studies were found work on the framework such as SQUARE, eFRIEND and automated reasoning.

Based on our review as shown on Table 1, we found that there are various approaches or methodologies used by IoT application that supporting the Arduino application. We also found that IoT application based on the specificity and purpose of the respective tools. In terms of requirements representation, the semi-formal is most used to elicit requirements. Based on the analysis, the analysis support elicitation and analysis are required process to developing IoT application. Further, most of tools IoT application but do not support IoT application with Arduino development.

CONCLUSION

Eliciting requirements of IoT application by requirements engineer during early phase of software development life-cycle is important. Most of requirements engineer do not properly trained to elicit requirements of IoT application and Arduino development as well. This is to ensure the eliciting requirements from stake-holder is consistent, correctness and complete. Therefore, this paper is providing a gap of study for existing work on eliciting requirements that exist in market for commercial and for research purposes. We report the findings and analysis different of studies on eliciting requirements of Arduino application. The strength and weakness provide the understanding the limitations of the existing tool. We can conclude that the current existing still immature and need further enhancements.

In future works, we plan to developed an approach and automated tool to elicit requirements of IoT application and Arduino development from client-stakeholder by requirements engineer. This tool will assist the requirements engineering for eliciting requirements at early stage of development IoT application and Arduino development.

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