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Trends and Challenges in Requirement Analysis for; Modern Web Applications, Web Services, and Web of Things

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Abstract: Requirements are the key to develop any software. Requirement engineering is a specific discipline of software engineering where one can gather, analyze and evaluate the requirements of particular software. Requirement analysis is the phase of requirement engineering, which refines the requirements according to the technicality of the software. When it comes to web engineering, the importance of requirement engineering specifically requirement analysis becomes more important because of the complexity of the web-based software projects. This paper identifies some invisible trends and challenges in the requirement analysis phase while developing any sort of web related products, services or web of things. Through a systematic literature review, it is well known fact that web applications and web services are fully handled with RE but WoT struggling in the field of requirement engineering. These challenges are then validated from different software houses. Researchers are trying to solve the associated challenges with WoT. 12 challenges and 25 new trends are identified for the requirement analysis in web engineering.

Keywords: Requirement analysis, web applications, web services, web of things (WoT);

I. INTRODUCTION

A web application requires a team of people to design and develop a web application by using certain tools and techniques leading to a common goal and strategy. The design and code generation of the web applications mostly depend on the requirements gathered during the requirement engineering. The gather requirements are then refined to get more concise set of requirements that need to be implemented for the design of the web application. This is the most important step in the developing of the web applications.

On the other hand, web services are related to the any piece of the software that is opened to internet by using standardize messaging system of XML. These are the web application components which mainly rely on internet. These can be publishing and able to be found and used through web. Web applications are used to communicate different platforms with each other by using web services.

Web of thing (WoT) is the new paradigm of internet of things (IoT). It allows the real time objects to be a part of three Ws. It provides the application layer to the Internet of Things in the same manners as Application layer provides an interface to the Network layer on internet communication system. Web of thing uses the predefined standards of web those are used in web programming, semantic web and the real time web.

There is a deep relationship between web applications, web services and web of things. Web applications are for the users and web services are for the web programs to communicate and exchange Meta data with each other. Both of these (application and services) are been used by the WoT to allow real time objects to be the part of World Wide Web.

Developing such systems requires great attention because your product is mainly depending on what you understood. This requires some new tools and techniques to deal with. Requirement analysis is the only phase of requirement engineering where one can address all such challenges, which are probably; occur during the developing of the system. Beside this, as the technological era is going forward, new concepts are rapidly taking maturity. Such new trends in requirement analysis are needed to be address in such a manner that requirement analysts minimize the efforts to search for such techniques. The objectives of this research are to address the new trends in the field of RE in web engineering.

Agenda of this paper is, section II will present literature review, section III will present Methodology while section IV will present some challenges in requirement analysis based on the previous literature,

section V will present trends in requirement analysis in the light of previous literature in web engineering. Section VI presents statistical evidences to validate the challenges and trends and section VII presents the conclusion.

II. LITERATURE REVIEW

Web engineering focusing on such techniques, tools and methodologies, which lays the foundation for the development of the web applications, web services, and enter the world to the new era of Web of Things. Web engineering is an engineering discipline becoming more and major competency because of more than 1.5 billion website and web-based products are live and operative [1]. In the modern era of technology, many businesses are dependent on web and even most of the businesses are because of the web. Over the past couple of years, different transitions happened in the web technology. That's why web becoming more and more complex and now a day a single website is the combination of different web languages. There is a huge relationship possible between the web engineering competency and web technology. There are three viewpoints regarding web engineering competency. These are industrial competency, national competency and pedagogic competency. The industrial competency is a web competency mainly relies on the vender needs i-e industry [2]. The pedagogic competency relies on the curricula [3]. Last but not the least the National competency view point could be different from country to country. All these web engineering competency viewpoints are distributed on web protocols, web user interface and display languages, web programming (client and server side), data access on the web, web services and emerging technology, and web deployment and maintenance [4]. Different frameworks have been designed to work with web engineering in the recent past such as agile web framework [5]. AWE is a light weight web development process which helps the teams to identify and manage the interactions between business, domain, software, and web related services in web engineering projects [6].

Targeting the web application has got particularly tremendous success in the recent past. The reason behind the scene is that the web applications connect everything to the web. Emotion prediction [7], automatic code generation from the flow charts [8], usage of web socket technology [9], introduction of liquid web applications [10], adaptive web applications for students [11], and web applications for social networking [12] are some of the examples. Such types of web applications boost up the process of web engineering.

When it comes to the web services, we got some more interesting web related products like semantic web services technology [13], mining underline semantic approaches toward web services [14], web services for 3D MHD equilibrium data [15], guest editorial [16], and different approaches of web services for the selection of multiple users [16]. Advance research in web services [15] summarizes the whole scenario. IEEE Transaction on web services (TWS) sponsored such researches in the field of web services.

The most emerging web technology is the web of things (WoT). With the advancement of technology, things are going towards more complication. As the web is growing up, drastic changes have been seen with the advent of Internet of Things (IoT). With the introduction of WoT in 2007 to the IoT bring the revolution in the field of web. There must be 12 elements [18] in the WoT. Concepts like smart city, intelligent Manufacturing, and E-health offer the use of WoT. Web of things just provide a single platform to the IoT devices like sensors, actuators, embedded devices, and RFID [19].

Developing of the web-based system, which provides a structure access to the large amount of data and information under some critical context through some views and through different context is a complex activity. In order to get high quality web applications, the developers need to be standardized in their approach towards the tools and techniques for developing the system.

It is a well-known fact that the product quality is directly been related to the needs of the users of any system. The key is to capture the user requirements correct and précis [20]. Requirements describe the services to be met from the system or define the property of the system. Requirement engineering starts with Requirement elicitation, followed by requirement analysis, requirement validation and verification, and requirement management.

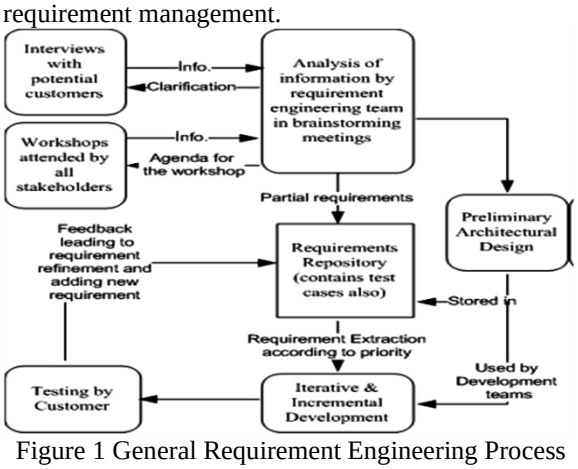


Figure 1 General Requirement Engineering Process [20]

In requirement analysis, particularly in web engineering, the developer analyzes the needs of the stakeholders. This analysis may be done in terms of content, structuring, access and layout. Domain-specific information, those are must be available to the web, are defined by the content analysis. To organize these contents, structural analysis may be conducted. This may include relationships and views. The content relationship represents the transition and semantic connection between the contents. For example, generalization, specialization, composition and domain dependent relations are included in the structural relationship analysis. In the view structural analysis, information's are able to be customized in different styles and relationships. Different views can be provided to the same content information. This may be carried out by providing different classes to the content user. For example, the abstract of the paper is visible to every user, that might be external or internal but the full document must be visible to the internal user only. The style of information access must be analyzed in the access requirement analysis. This includes the indexing, information presentation, and other facilities. The general appearance properties must be defined in the Layout requirements analysis [21].

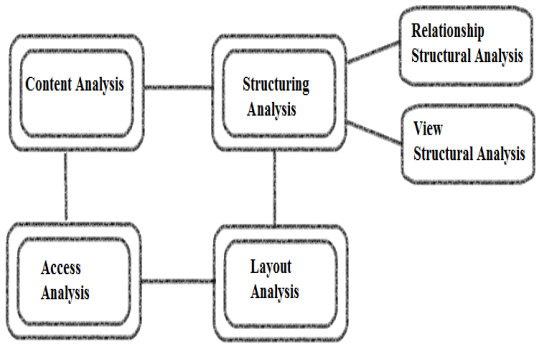


Figure 2: Requirement Analysis in Web Eng.

III. METHODOLOGY

This section introduces the methodology used for conducting this research. In this study we used systematic literature review. We designed a search string and collect more than 600 research papers. Inclusion and exclusion criteria have been defined. The study is designed to review this literature critically and then obtained results out of it. We have obtained some trends and challenges through the systematic literature. To validate these trends and challenges we conduct an empirical study. While conducting empirical study we prepare a questionnaire regarding these challenges. The questionnaire was then distributed among different software houses across the globe. We distributed the questionnaires through the google forms. We got more than 100 responses. Then statistical analysis has been made and the final conclusions are been presented.

IV. CHALLENGES IN REQUIREMENT ANALYSIS

Understanding the needs of the customer is a very challenging task. Especially in web engineering this task becomes more complicated due to covering different aspects of a single piece of web engineered software. Requirement analysis phase defines the requirements of the system. Requirement analysis doesn't deal with the system construction. It deals only with what to be constructed. At this level the requirement analyst must be focused on the system "what", not "how". A fully refined requirement document has been generated from this phase of the system construction. This requirement document will become the foundation of the system and these requirements will be easier to be translated to system algorithms and different data structures. The analysis of the web system must consist of the following three basic steps. The figure shows these steps as simple as it is.

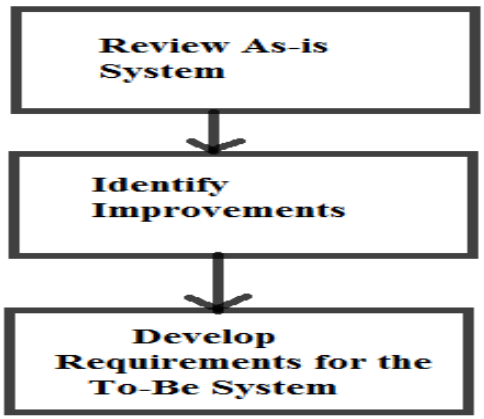


Figure 3: Requirement Analysis Basic Steps

There are six basic activities, which must be performed to analyze any web engineer system in order to avoid major challenges those are going to be discussed in a while.

Gather detail information
Define functional requirements
Define non-functional requirements
Develop user interface dialogs
Prioritize requirements
Evaluate requirements with User

Requirement analysts face many challenges in following these activities. The most common challenges that requirement analyst is facing now a days are discussed below.

C1: Customer understandability: The customer actually doesn't know what he wants to develop. This is a common problem and exists with every software project. But when it comes to web engineering, the problem becomes more complicated. All you have to do is that the system analyst needs to be very specific, precise and stick to what he wants to ask.

C2: Changing requirements: This is a common trend now a day. Technologies are changing, so business requirements are also changing with the same speed. In web applications when the project is progressing, the things become clearer to the customer and they change their demands with the progress rate of the system. To avoid such challenges, we can use light weight methodologies like Agile Methods. It is recommended to use agile in web.

C3: Customer time line: Obviously the user of the system is customer and he must define the business goals. It is very much often that most of the customers have had limited time for the project and he wants it in emergency. To agree with the customer time line is a challenge. In web engineering specifically, one can't say that the project will be completed in the time that customer want. System analyst need to look around his resources, conversation with customer, and generate a project plan.

C4: Communication gaps between customers, engineers and project managers: Things become more complicated with there is no communication. Lack of communication leads the system to failure. Problems solve with discussion. The customers come from the environment where there is no technicality. In web applications and web services all the system stakeholders need to communicate regularly. The system analyst needs to guarantee from the customer to conduct meetings twice a week. Agile methods are more focused to avoid such gaps. There are three types of communication barriers associated with the users.

Problems within users

Problems between users

Problems among users

C5: Development team doesn't understand politics of the customer organization: The customer organization has a great value and effect on the project success. To get more accurate requirements, the system analyst needs to adopt the culture of the customer organization. In web engineering such politics plays an important role.

C6: Stakeholders implication: Sometime the stakeholders take a position for a particular technical solution. That may be possible but will cost more and time consuming. Instead of that the same functionality may be performed by another module but due to the lack of customer technical mind, the system analyst faces the problem to either include it or not. Leave it for the technical team.

C7: Conflicting priorities: Different people are working in the same culture but all of them have different approaches towards the system. All these have different priorities. To avoid such conflicts, need to discuss with the key stakeholder or with the spoke person of the organization.

C8: Success criteria are not well defined: The customer doesn't know what his /her needs are. He/she doesn't know what his /her expectations were and what the system the system is giving. The analyst needs to break the projects in chunks and make sure that the customer is well enough understood the system.

C9: Handling short development cycle: It is proved empirically that the development cycle for the web applications mostly short i-e from 5 to 6 months.

C10: Parallel Development Process: Due to short span of time, it is necessary to run most of the development phase's parallel. This is the most important step to be analyzed that what sort of activities will be run parallel.

C11: RE Facing Challenges with WoT: WoT is a quite new technology and RE is suite poorly to the WoT. There is much need to work for the RE in WoT. The challenge that WoT facing, is because of the immaturity of the technology.

C12: Scope barriers: There are some abstract level problems and some problems are associated with the requirement sources. Scope issues originate from the boundaries of the targeted application if the scope is not well defined.

V. TRENDS IN REQUIREMENT ANALYSIS

Requirement analysis is not that much easy that we are expecting. It becomes the backbone of RE when it comes to web application or web services or web of things. Modern technological era demands for the modern tools and techniques. There are some modern age trends for the requirement analysis in web engineering. These are:

T1: User requirements and user interview: User is the main stakeholder of the system. So, the application that needs to be build must meet his/her needs. Interview him throughout the analysis and if possible, ask him to conduct one or two meetings in a week. This will help him to open his mind and he will be able to speak about the system requirements more clearly. Through this way the analyst will better understand the user psychology and they will have a clearer understanding of the user requirements.

T2: Making the use of prototype: This is a better way to extract requirement from the user. The prototype will help the user to imagine the application that he/she wants to build. This is a kind of experimentation. The

customer will give a feedback the analyst will use those different feedbacks as an input to the requirement document.

T3: Wireframes: This is a better idea to draw the web application through lines. The idea is to represent the application in the simple way to demonstrate the position of different components. Once wireframes are constructed, it will be easy to modify later on if the customer is disagreeing at some stage. It will help the customer to preview the application layout and assess what he/she demands.

T4: UI Design: Build the user interface first. This will help the user to interact with the system. Allow the user to communicate with system through different ways. Take a video of the screen while user using the system which will help the analyst to discover what the user is trying to do in this particular situation.

T5: Scenario based method: Scenario differences depend upon the context of the system. The scenario defines the interaction of the system agents with its components or with external components or users. The purpose of the scenario-based approach is to provide early analysis of the system to avoid any inconvenience or conflict later on.

T6: Viewpoint based approach: Multiple stakeholders interact with the system. Everyone has their own viewpoint to the system. All the requirements of the system can be interpreted by getting different views from different stakeholders. This will help the analyst to finalize complete requirements of the system.

T7: Goal oriented RE Method: Use goals to retrieve the requirements. The goals may be specific or highly abstracted or may be functional or non-functional. Highly abstracted goals will help the customer to extract the requirements at a very high level. Conflict resolution method may be followed to remove any sort of conflicts at the early stages.

T8: Software Architecture oriented: It focuses on the process aspects of the RE. The focus is to introduce the software architecture to the requirement analysis. This is useful but the only issue is if the requirements are not changing.

T9: Formal method: The formal method techniques are usable to identify and analyze any inconsistency in the requirements. Formal methods are quite useful in web of things because it solves real time problems in easy way.

T10: Software cost reduction method: This method can also be applied to the web. It is a tabular method used to ensure that system satisfies the critical requirement or not.

T11: Behavior Trees: It determines the impacts of changing of the functional requirements and then looks after these changes.

T12: Use Case Maps Method: This is a scenario-based method, can be used to describe high level of the system and the links the organizational structure to the behavior of the system. It also validates the scenarios and use as a medium between the key stakeholders of the system.

T13: Logic and logic programming-based technique: This is an event-based technique, used to specify the requirements in terms of the reaction of the system to the events.

T14: Problem frames method: It follows the basic concept of "divide and rule". Decompose the problem, open it to the user and solve the problem by documenting the sub-problem.

T15: Classical logic mathematics: It is an open area to partial specification and find out inconsistencies between the requirements.

T16: Blackboard method: Use of share blackboard space to coordinate the knowledge of distributed stakeholders.

T17: Deficiency-Driven requirement analysis: If the design is failing to satisfy the requirements, this method is used to analyze such perspectives of the system. This method will be applied till the system satisfies the requirements.

T18: Coordination contracts: These are the rules and constraints used for the interaction between any two objects. It also shows the behavior while interacting between objects. It confirms the contracts between the objects. It is only related with contracts, not the objects.

T19: Real-time component factory: It is used for developing components that are able to be customizing later on. It will help to analyze tasks priority and exception handling policies. It also provides a specific interface for customizing these services.

T20: Connector based adaptation process: This defines the connectors of the system. The cooperative actions describe the inter-communication between the classes and adaptation level of the connectors.

T21: Iterative evolutionary process: It is used for the successive evolution of specification in the requirement analysis. Such informal requirements will be iterated and evaluated till the completion of the requirements.

T22: Code based techniques: It is used to locate the program control points which will help the analyst to find out the specific behavior of the system and if there is any kind of change request, the analyst will be able to know where these changes will be accommodated.

T23: Genetic algorithm: This is a stage of the evaluation of individual components. This will help to analyze the process of recombination and mutation. Environment suitable components will be selected here at this level.

T24: Weaves: This consists of small chunks of the software. These chunks are allowed to communicate each other through web services. If there is any kind of miscommunication, the weaves enable the runtime reconfiguration without disturbing the flow of the objects.

T25: Fuzzy logics: This algorithm is used with the proposed architecture on behalf of the user requirements. It is used to analyze the adaptive changes. The theme is to choose between available responses in the uncertain and imprecise conditions when requirements are changing.

VI. STATISTICAL EVIDENCES

In this section we present some evidences from different industries across the globe. These evidences are presented in order to validate the challenges. We asked question about each challenge and the responses are discussed below.

C1: Customer understandability: In this regard we asked from our respondents that "are you agree that the customers are not understood what they want to build?". The responses were:

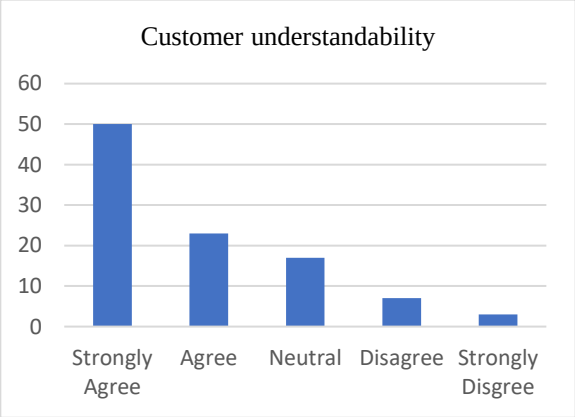


Figure 4. Customer Understandability

C2: Changing requirements: In this regard we asked that "Is change in requirements cause problems in the requirement analysis?". The responses are:

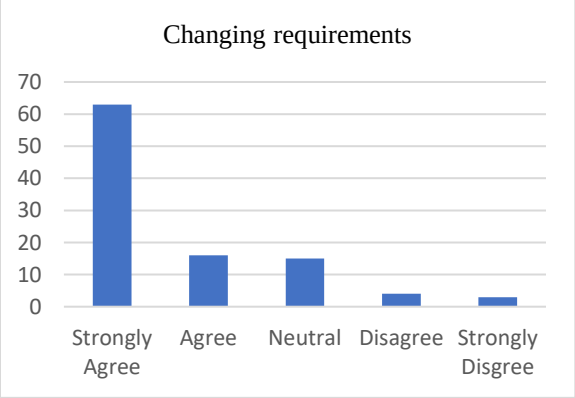


Figure 5. Change in Requirements

C3: Customer time line: In this regard we asked that "Is the customer time line affect the requirement analysis with respect to web applications?". The responses are:

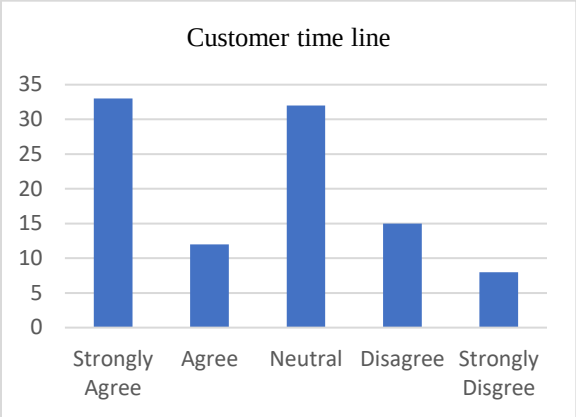


Figure 6. Customer Time Line

C4: Communication gaps between customers, engineers and project managers: To find out that the communication gap affects the requirement analysis, we asked "is there any communication gap exists between the customers and project managers regarding web application?". The responses are:

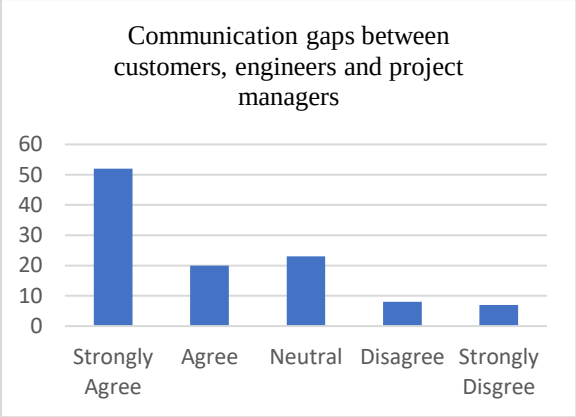


Figure 7. Communication gaps between customers, engineers and project managers

C5: Development team doesn't understand politics of the customer organization: To know whether the development team is known to the customer organization or not, we asked "Is the development team understand the politics of the customer organization or not?". The responses are:

Figure 8. Is the Development team understand politics of the customer organization or not?

C6: Stakeholders implication: To find that the customer demands for a particular module affects the requirement analysis, we asked "Is the stakeholder implication affects the requirement analysis?".

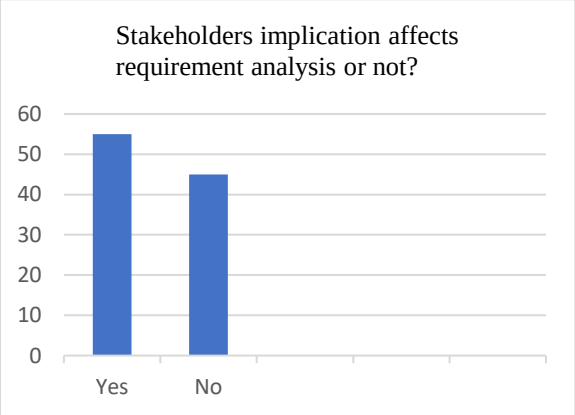


Figure 9. Stakeholders implication affects requirement analysis.

C7: Conflicting priorities: "Conflicting requirements can affect the process of requirement analysis in web engineering?". The responses are:

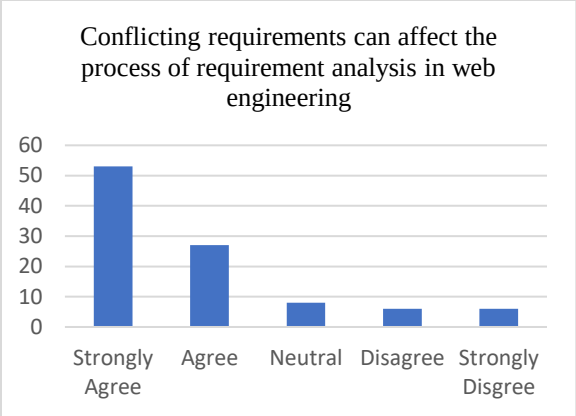


Figure 10. Conflicting requirements can affect the process of requirement analysis

C8: Success criteria are not well defined: To know the boundary of the requirement analysis, we asked "There is no success criteria to stop the requirement analysis in web engineering?". The responses are:

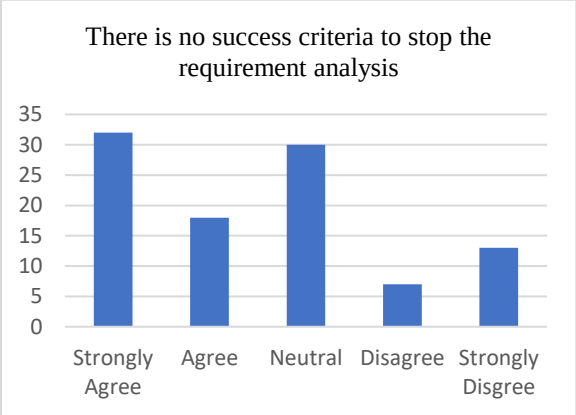


Figure 11. There is no success criteria to stop the requirement analysis?

C9: Handling short development cycle: "Is it true that short development life cycles affect the requirement analysis?". The responses are:

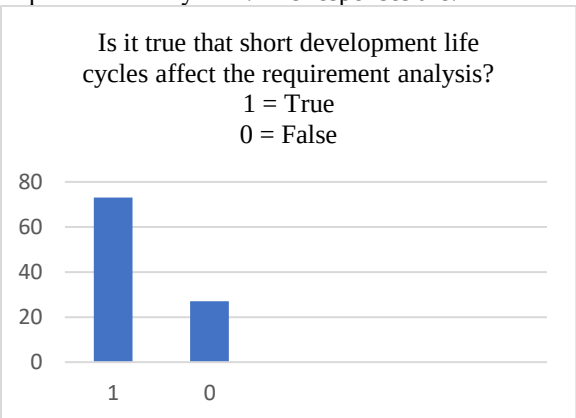


Figure 12. Handling short development cycle

C10: Parallel Development Process: To know about parallel process, we asked "Parallel development process can affect the requirement analysis". The responses are:

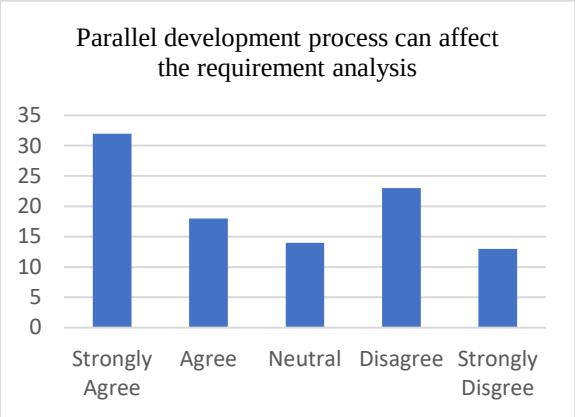


Figure 13. Parallel development process can affect the requirement analysis

C11: RE Facing Challenges with WoT: To understand whether RE is fully equipped to analyze requirements of WoT or not, we asked "Is it true that requirement analysis is not fully equipped with tools to analyze requirements?". The responses are:

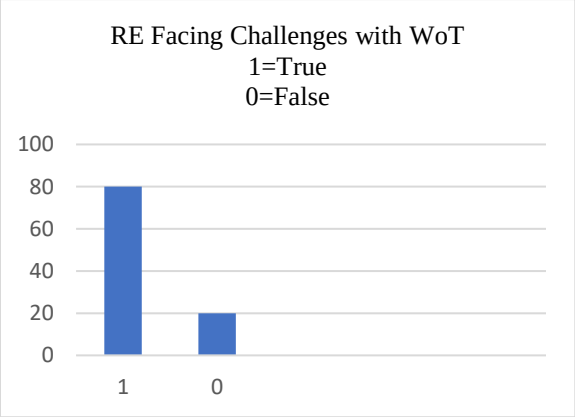
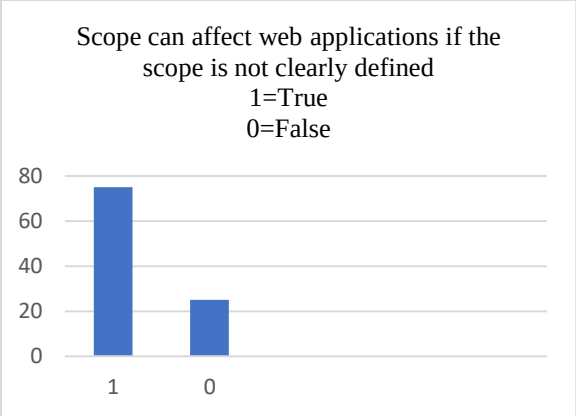


Figure 14. RE Facing Challenges with WoT

C12: Scope barriers: "Scope can affect web applications if the scope is not clearly defined?". The responses are:



VII. Conclusion

The requirement analysis is directed to deal with the current and future requirements of the system. It is a quite useful stage in the development of the any kind of system. But when it comes to web applications and web services, where the requirement becomes more critical, the importance of requirement analysis cannot be neglected. Requirement analysts are dealing with different kinds of scenarios in the web. The current researches show that web applications and web services are fully adopted in the RE processes but Web of things is a new area to the requirements engineering and it faces some difficult challenges. Researchers are underway to find the solutions to such challenges. In the future separate case studies can be designed to investigate each challenge and trend in the field of web engineering regarding requirement analysis.

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