USER-CENTRIC REQUIREMENTS ELICITATION FRAMEWORK FOR GLOBAL SOFTWARE DEVELOPMENT TEAMS

BY

MUHAMMAD AQEEL IQBAL

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International Islamic University Malaysia

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ABSTRACT

The requirements elicitation is considered as the foremost important activity of software development process with ultimate goal of requirements finalization for anticipated project. It is well accepted in the software engineering domain that an effective requirements elicitation process vitally contributes in success of software development endeavors. It is evident from the available state-of-art literature and industry practices that requirements elicitation process is critically dependent on participant's personality traits due to its highly social and collaborative context. Furthermore, the role of user's personality traits becomes a core pivot for requirements elicitation process in traditional inhouse as-well-as modern global software development practices. In global software development context, the role of user's personality traits in requirements elicitation process is further raised due to high variations in user's geographical locations having different cultural norms. Moreover, the user's personality traits-based user-centricness in requirements elicitation process greatly improves the overall process of requirements elicitation. Accordingly, there was a serious need to formulate a novel user-centric requirements elicitation framework incorporated with user's personality traits for global software development teams. In order to inspect this imperative issue, the dependency of requirements elicitation process on user's personality traits is investigated to find the impact of user's personality traits on requirements elicitation process. Consequentially, a user-centric requirements elicitation framework has been devised for global software development teams. The applicability and validity of the proposed framework has been evaluated using experimental approach at academic level pilot-test as-well-as industry level real-test. The evaluation results highlighted an overall quality improvement of 11.3% in requirements elicitation process for global software development teams. The evaluation results also revealed a more specific improvement of 31.6% in quality factor of correctness, 31.1% in quality factor of completeness and 20.6% in quality factor of consistency. The obtained results have fully justified the applicability of the formulated framework in the domain of software engineering.
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خلاصة البحث

يعتبر تحديد المتطلبات واحتياجات البرامج أهم خطوة في عملية تطوير البرمجيات وذلك لوضع اللمسات الأخيرة والصيغة النهائية للاحتياجات المتعلقة بالمشروع المتوقع. ومن الطبيعي جيداً في مجال هندسة البرمجيات أن عملية تحديد المتطلبات فعالة تساهم بشكل حيوي في نجاح مساعي تطوير البرمجيات. ويتضمن ذلك من خلال أحدث الدراسات الاكاديمية الصناعية المتاحة أن عملية الاستنباط وتحديد المتطلبات تعتمد بشكل حاسم على سمات الشخصية المشارك نظرا لسياقها الاجتماعي والتعاون. علاوة على ذلك، يصبح دور للسمات الشخصية للمستخدم محورا لعملية تحديد هذه المتطلبات في ممارسة تطوير البرمجيات الداخلية التقليدية فضلا عن ممارسة تطوير البرمجيات العلمية الحدية. وفي السياق العالمي لاطوير البرمجيات، يتزايد دور السمات الشخصية للمستخدم في عملية تحديد المتطلبات بسبب الاختلافات الكبيرة في الموقيع الجغرافية ذات المعايير الثقافة المختلفة. أضف إلى ذلك، فإن تركيز المستخدم على سمات شخصية المستخدم في عملية تحديد المتطلبات يؤدي إلى تحسين كبير في العملية الشاملة لتحديد هذه المتطلبات. وبناء على ذلك، كانت هناك حاجة ماسة إلى صياغة إطار جديد لتحديد المتطلبات تركز على المستخدم وإدماجها مع سمات شخصية المستخدم بالنسبة لفرق تطوير البرمجيات العالمية.ومن أجل الكشف عن هذه المشكلة، تم التحقيق في اعتماد عملية تحديد المتطلبات على السمات الشخصية للمستخدم لمعرفة تأثيرها على عملية تحديد هذه المتطلبات حيث تم وضع إطار عمل لتحديد المتطلبات يركز على مستخدمي فرق تطوير البرمجبات العالمية. تم تقييم مدى قابلة تطبيق الإطار المقترح وصلاحيته باستخدام النهج التجريبي في الاختبار التجريبي على المستوى الأكاديمي وكذلك الاختبار الحقيقي على المستوى الصناعي. أبرزت نتائج التقييم تحسنا عاما في الجودة بنسبة 11.3٪ في عملية أستنباط وتحديد المتطلبات واحتياجات البرامج لفرق تطوير البرمجيات العالمية. كما كشف نتائج التقييم عن تحسن أكثر تحديدا بنسبة 31.6٪ في معامل الجودة للصحة ، و 31.1٪ في عامل الجودة للاكتمال و 20.6٪ في عامل الجودة التناسق. كما برزت النتائج التي تم الحصول عليها كامل قابلية تطبيق الإطار المصاغ في مجال هندسة البرمجيات.

APPROVAL PAGE

The thesis of Muhammad Aqeel Iqbal has been approved by the following:

_____
Asadullah Shah
Supervisor

_____
Norsaremah Salleh
Co-Supervisor

_____
Nor Azlin Nordin
Co-Supervisor

_____
Noor Azura Zakaria
Co-Supervisor

_____
Akram Zeki Khedher
Internal Examiner

_____
Paul Rodrigues
External Examiner

_____
Abd Samad bin Hasan Basari
External Examiner

_____
Mohamed Elwathig Saeed Mirghani
Chairman

DECLARATION

I hereby declare that this thesis is the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

Muhammad Aqeel Iqbal

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Firstly, it is my utmost pleasure to dedicate this work to my dear parents and my family, who granted me the gift of their unwavering belief in my ability to accomplish this goal: thank you for your support and patience.

I wish to express my appreciations and thanks to those who provided their time, effort and support for this research project. To the members of my thesis committee, thank you for sticking with me.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The software engineering domain emerged to overcome the software development complexities and difficulties by providing good practices for software developers (Akbar, et al., 2018). The software engineering practices enabled the software development industry to develop good quality software to meet the user expectations. The researchers from the domain of software engineering proposed a large number of good practices in form of software development processes in last few decades (Araújo, et al., 2020). The quality of the software has been assured by using good practices of software development with different software quality assurance mechanisms. The software engineering practices provide systematic ways to develop good quality software through a structured approach known as software development life cycle. The software development life cycle defines a philosophical model for developing good quality software using well-defined methodology. The requirements engineering is first stage of software development lifecycle with ultimate goal of requirements gathering and documentation for product.

1.1.1 Requirements Engineering

The *Requirements Engineering (RE)* is considered as the most important activity performed during software development life cycle as front-line process to gather requirements from stakeholders (Burnay, et al., 2020). The requirements engineering process is divided into two main phase including requirements development phase and requirements management phase. The requirements development phase is further

decomposed of four sub-stages including requirements elicitation stage, requirements analysis stage, requirements specifications stage and requirements validation stage. The requirements elicitation stage is concerned with eliciting requirements from different stakeholders of product using different requirements elicitation techniques (Cirqueira, et al., 2020). The requirements analysis stage is concerned with analyzing the elicited requirements to find out any ambiguities, redundancies, inconsistencies, incompleteness, verifiability, measurability, conciseness, understandability and traceability. The requirements specifications stage is concerned with documenting the agreed requirements in an approved template to formulate a formal deliverable of requirements engineering process. The requirements validation stage is concerned with reviewing the documented requirements and confirming them from product users for their final approval as requirements baseline document. The requirements management process is concerned with managing the changes in the requirements baseline document and proceed control mechanism to implement all desired changes through a systematic change control process (Alsanad & Chikh, 2017). Consider figure-1.1, which explains the different stages of requirements engineering process with their sub-stages and different activities carried out during each stage.

The software requirements are described at different levels of abstractions depending upon the type of requirements, source of requirements and context of elicitation scenario (Groen, et al., 2017). The software requirements are usually described at three different levels of abstractions including business level requirements, user level requirements and product level requirements. The hierarchy of requirements comprised of these three abstraction levels is shown in the figure-1.2. The business level requirements define the

business objectives of the client organization that can be achieved by using the desired software product (Wagner, Fernández, Kalinowski, & Felderer, 2018).

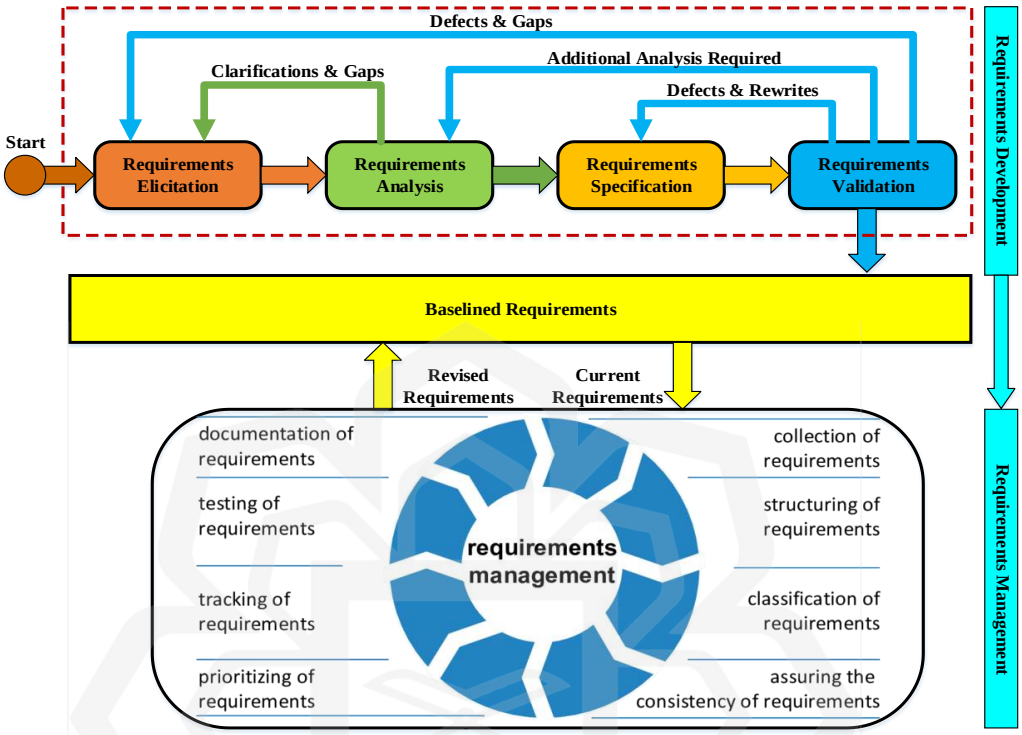

Figure-1.1: Requirements Engineering Process (Dermeval, et al., 2015)

The business level requirements generally give the broad spectrum about features and functionalities of the product. The user requirements further add details to business level requirements by providing descriptions of the features from the user perspectives (Thew & Sutcliffe, 2017). The user level requirements describe the tasks that can be accomplished by system users to meet the high-level business requirements. The product level requirements are documented in form of software requirements specifications, which comprised of functional requirements, non-functional requirements, external interface requirements, data requirements and system constrains (Dar, et al., 2020).

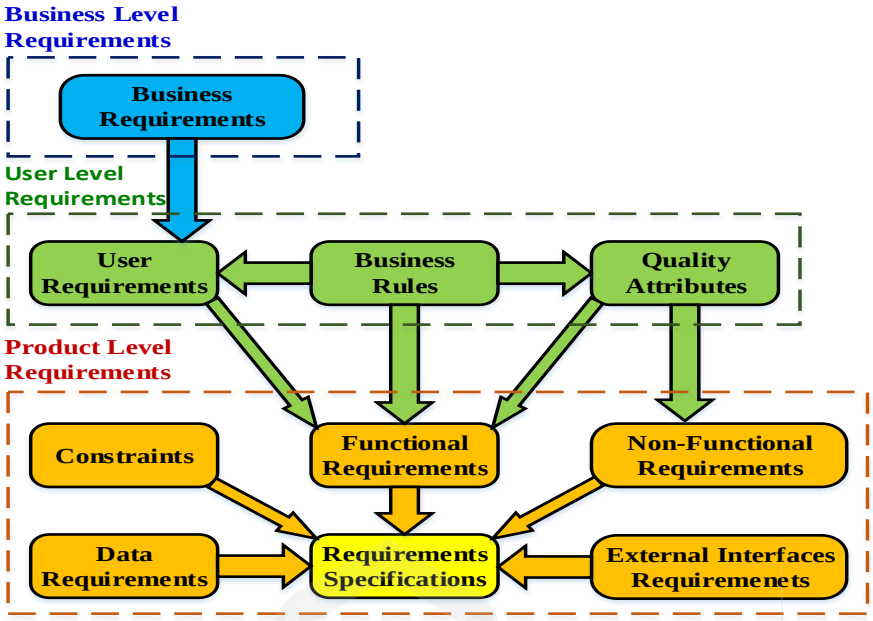

Figure-1.2: Levels of Software Requirements (Horkoff, et al., 2017)

1.1.2 Requirements Elicitation Process

The requirements engineering process is essentially an iterative process accomplished as a spiral model which consists of four stages including requirements elicitation stage, requirements analysis stage, requirements specifications stage and requirements validation stage. The requirements elicitation stage is considered as the foremost important stage of requirements engineering process, which is performed as a frontline activity to capture requirements from product users (Debnath, et al., 2020). The requirements elicitation team is internally comprised of two sub-teams/sub-groups including requirements analyst's team/group and product user's team/group.

In requirements elicitation, the requirements analyst's team and product user's team interact with each other using different requirements elicitation techniques to conceptualize anticipated product, (Díaz, et al., 2021). Traditionally, the requirements elicitation process is decomposed into four stages including objective establishment

stage, background understanding stage, knowledge organization stage and requirements gathering stage (Lane, O'Raghallaigh, & Sammon, 2016). Consider the figure-1.3, which shows four stages of requirements elicitation process along with details of internal activities or tasks performed during each stage.

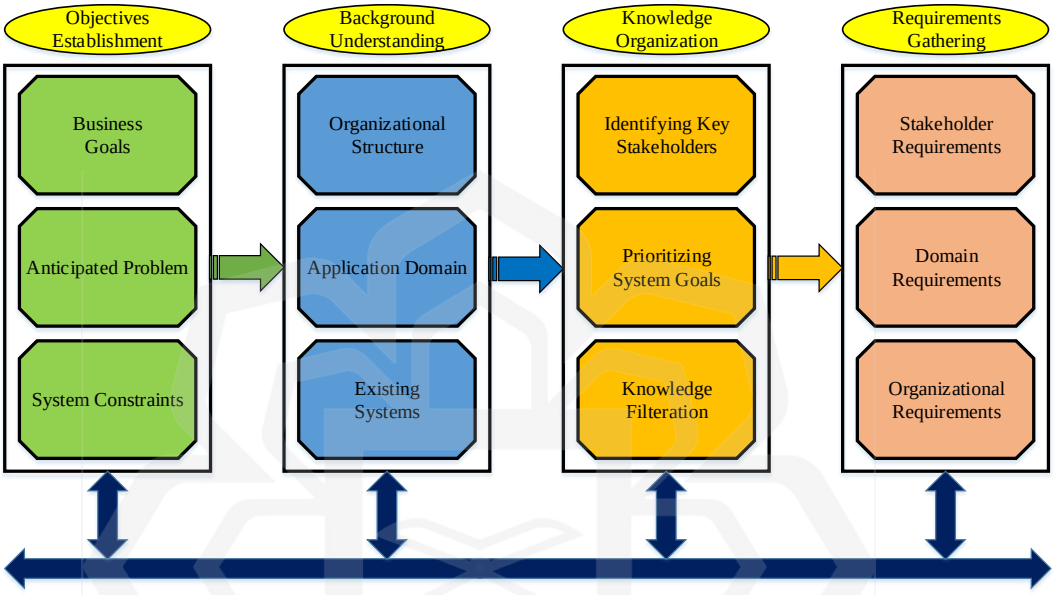

Figure-1.3: Requirements Elicitation Process (Lane et al., 2016)

1.1.3 Requirements Elicitation in Global Software Development

The *Global Software Development (GSD)* is also known as *Distributed Software Development (DSD)* where the software development teams are located in different parts of world and interact with each other using different communication technologies (Carrillo De Gea, Nicolás, Fernández-Alemán, & Toval, 2017). The global software development is motivated by the opportunities of reaching flexibility in resources, attaining extra knowledge, speeding-up time-to-market and growing operational efficiency (Saleem, 2019). The global software development has become a common practice in software industry where software development projects are geographically

distributed across the different parts of world as is shown in figure-1.4. The software development teams working on GSD projects (commonly known as offshore projects) are distributed virtual teams as contrasted with traditional software development based on collocated physical teams working in the same locality (Ali & Lai, 2016). The global software development practice enables the software development companies to elevate their development quality (e.g. standards) as well as quantity (e.g. productivity) by collaborating their development efforts with other international companies (Khan, et al., 2021).

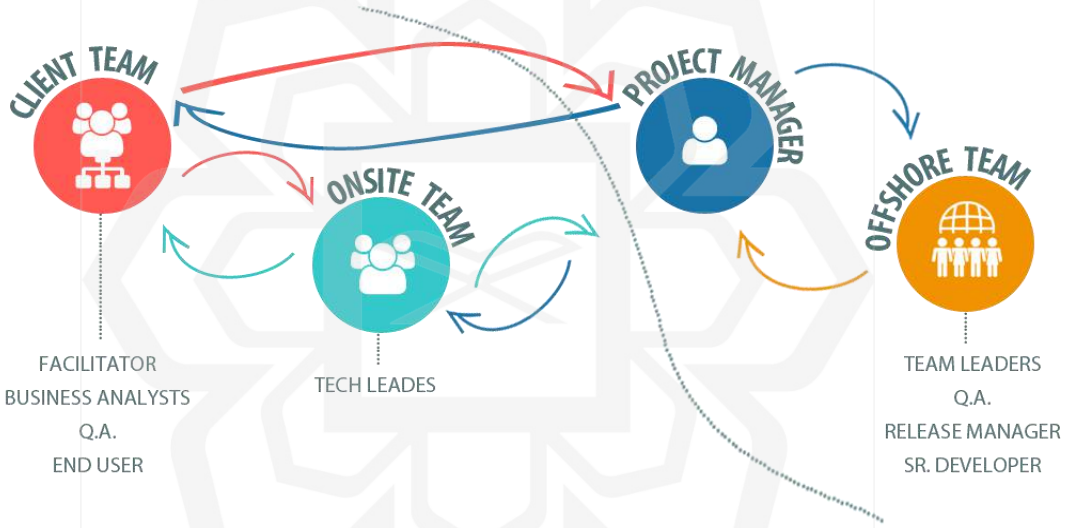

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Figure-1.4: Global Software Development (Khan, et al., 2021)

The different software development task performed during subsequent stages of software development rationally become challenging in global software development projects due to their remote localization of team members (Khan, Malik, Chofreh, & Goni, 2017). The requirements elicitation task is considered as one of the most challenging task of software development in global software development environments due to its highly social and collaborative nature (Yaseen, Baseer, & Sherin, 2015). The

requirements elicitation process in global software development contexts brings additional challenges for developers as compared to traditional software development contexts. The new challenges faced by requirements elicitation teams in GSD projects include the challenges occurred due to geographical distribution, temporal dispersion and cultural diversity of team members (Khan, Malik, Chofreh, & Goni, 2017), (Lim, et al., 2021).

Geographical Distribution factor of requirements elicitation in GSD introduces a big problem of lack of informal communication mechanisms due to the unavailability of face-to-face meetings. The informal communications are considered as the most important source of better understandability and information sharing in traditional requirements elicitation contexts (Nascimento, et al., 2020). The geographical distribution introduces anther big problem of lack of control and coordination during the requirements elicitation process. It becomes more difficult to manage globally distributed requirements elicitation teams as compared to collocated teams capable of freely interacting with each other at their times of interests and locations of comforts (Manjavacas, et al., 2020). The lack of control and coordination directly affects the quality of the elicitation process and subsequent outcomes in form of system requirements (Palomares, et al., 2021). The geographical distribution also introduces problem of work delays due to the poor communications, difficult coordination and lack of team mutual trust among team members.

Temporal Dispersion factor of requirements elicitation in GSD introduces additional challenges by limiting the time for interactions and communications among requirements elicitation team members. The asynchronous communication mostly

becomes the option for interactions with team members due to the lack of time overlaps. The synchronous communication is always considered as the most feasible way of communication and information sharing as compared to asynchronous communication among team members (Palomares, et al., 2020). The requirements understandability also becomes very difficult in asynchronous communications that totally rely on the textual information shared between team members. The asynchronous communication totally relies on the sharing of information in textual form, which makes it very difficult for team members to share all information or ideas with complete details (Poth, et al., 2020).

Cultural Diversity factor of requirements elicitation in GSD introduces problems caused by cultural variations of distributed team members. The cultural variations of distributed teams create diversity in native languages, working attitudes, ethical norms, social norms, religious thoughts, personalities and governing scenarios. The cultural diversity becomes the main reason for the lack of trust among the distributed team members. Hence, the cultural diversity becomes major cause for the poor understandability of system information and user requirements due to the variations in native languages (hence poor understandability of common language) and working behaviors of participants (Rueda, et al., 2020), (Saeeda, et al., 2020).

1.1.4 User-Centricness in Requirements Elicitation

The user-centricness generally refers to the user-centered or user-oriented nature of a process where different tasks of the process are customized to facilitate the users of process (Peischl, Ferk, & Holzinger, 2014). Accordingly, the user-centricness in requirements elicitation process refers to the customization of whole elicitation process

by using external parameters to facilitate the participating product users (user's team) during the elicitation sessions. The user-centricness can be achieved by using participant's hard-skills or soft-skills as external parameters to customize the whole requirements elicitation process (Brhel, Meth, Maedche, & Werder, 2015), (Ferrari, et al., 2020). The soft-skills based customizations may incorporate different human-factors like communication skills, inter-personal skills, work attitudes, work preferences and personality traits of participants (Giannakopoulou, et al., 2020), (Shojaifar, et al., 2020). The role of personality traits in the process of requirements elicitation becomes imperative due to the social and collaborative nature of this process where different people interact with each other to share system information (Costa, Reis, & Loureiro, 2015). Accordingly, the proposed framework has been incorporated with personality traits-based customizations of different internal activities and tasks in requirements elicitation process to achieve user-centricness.

The human factor plays a critical role in requirements elicitation process due to its collaborative and interactive nature to conceptualize the intimated product (Henriksson, et al., 2020), (Zalewski, et al., 2020). The requirements elicitation process is full of cross-sectional conversations among requirements analyst's team and other stakeholders of the product for conceptualization of intended product using different formal and informal communication mechanisms (Shafiq, et al., 2018). The requirements elicitation process is essentially a human-centered activity whose success is characteristically dependent on the working aptitude, work preferences, collaborative environment and behavioral capabilities of its involved participants. Therefore, the requirements elicitation process is essentially affected by the social, cultural and interpersonal aspects of its participants (Ambreen, Ikram, Usman, & Niazi, 2016).