

# Bridging Information and Knowledge using Codification Technology in Requirements Elicitation Process

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## ABSTRACT

Indeed, knowledge is very important for the organization. Tacit knowledge is the main source for explicit knowledge. Therefore, the tacit knowledge in organizational resources should effectively recognize and consequently explicitly represented. In the context of software requirements elicitation, organizations need to identify and allocate the knowledge during communicating for software requirements. Two categories of knowledge that involved are knowledge about the requirements and knowledge about the domain for which software being developed. Knowledge codification is proposed as a routine for seeking knowledge inputs that embodies in software requirements elicitation process and converting them on document context. As a result, the knowledge codification routine allows the building of the knowledge repository for use and reused in support of sustain software development. This paper offer a knowledge codification routine that categorized organizational resources into human, software, infrastructure and techniques as an input into explicit knowledge during requirements elicitation process.

**Keywords:** tacit knowledge, knowledge codification, software requirements elicitation.

## I INTRODUCTION

Knowledge codification is a process of discovering, interpreting, adapting, and learning. It acts as a bridge for representing information and tacit knowledge of organizational routines explicitly. Knowledge codification becomes a significant activity in an organization. As for example in knowledge economy, knowledge becomes as a source for competitive advantages and economic returns. Thus, it is important for organizations to offer mechanisms that can encourage their human resources to share their knowledge.

In software development, knowledge codification includes ability to understand the problem domain and technological used for the development.

Knowledge codification becomes crucial (Pratim, et. al., 2010; Marzanah, et. al., 2010) particularly in software requirements elicitation (Noraini & Abdullah, 2011) because it can reduce difficulties in conducting the activity. Organization may run into difficulties due to new stakeholders may emerge and the business environment may change. However, this would not be a major concern anymore when they codify their tacit knowledge to explicit knowledge to become organizational routines.

This paper potentially serves as a roadmap to assist researchers and practitioners to better understanding of information and knowledge in requirements elicitation process. The human, software, infrastructure and techniques in requirements elicitation process are the resources that were considered for codifying the knowledge (Pilat, & Kaindl, 2011; Noraini & Abdullah, 2011). The rest of the paper is organized as follows. Second, we introduce the studied background of knowledge codification and software requirements elicitation process. We then discuss the study on roles of human, software, infrastructure and techniques in requirements elicitation process. In the following section, we introduce codifying knowledge for requirements elicitation process. Then, we conclude the paper by summing up in the conclusion.

## II THEORITICAL BACKGROUND

Knowledge codification draws on involvement of information transformation. In the context of software requirements elicitation, organizations need to identify and allocate the knowledge components that perform during communicating for software requirements in the process. In this section, we provide brief theoretical background for knowledge codification and software requirements elicitation process before we move forward to the proposition.

### A. Knowledge Codification

Tacit knowledge is cognitive and experiential, whereas explicit knowledge is objective and

rational (Polanyi, 1958; Nonaka& Takeuchi, 1995). Tacit knowledge is difficult to transfer and share because it is embedded in personal cognition and practices. Besides, explicit knowledge is much simpler to trace, transfer, and share. The codification allows the building of the knowledge repository of organizational routines for use and reused. Previous study by Brian, et. al., 2009 revealed that codification technique is necessary to archive desired impacts of knowledge sharing for government and public especially in health-care industries. In addition, Pratin& William, 2010 provides agents in knowledge codification who create, transform, apply and diffuse knowledge. Thus, it is essential for organizations to create an environment in order to encourage knowledge workers sharing their knowledge in their daily activities.

#### **B. Software Requirement Elicitation Process**

Requirements elicitation is an important task in software development. Lack of requirements elicitation process will cause failure of the whole project (Hickey & Davis 2002). There are some major concerns in conducting this process such as sources of requirements, elicitation techniques, and supporting tools. Requirements elicitation involves the movement of data to meaningful information. It involves process of discovering, communicating and negotiating in order to achieve an agreement of the software requirements among the stakeholders (Grunbacher&Braunsberger 2003; Grunbacher et al. 2004). Gold and Wohlin (2005) stated in general that the process involves communication, setting priorities, negotiation and cooperation with stakeholders. Based on Noraini& Abdullah, 2011 in the context of knowledge in the requirements elicitation process, mostly can group the knowledge into human, software, infrastructure, and techniques.

### **III THE STUDY ON HUMAN, INFRASTRUCTURE, SOFTWARE AND TECHNIQUE ROLES IN REQUIREMENTS ELICITATION**

An empirical study has been conducted to highlight the important components that involved during requirements elicitation process. The following sub topics discuss each of the components in detail.

#### **Software**

There are many software tools to support the requirements elicitation process. This including diagramming tools, layout designer and report

generators, analysis tools, repositories, documentation generators and code generators (Hoffer *et.al.*2008). Based on the findings (Noraini, 2009), the most common analysis tools used for diagramming are Rational Rose, Enterprise Architect and Microsoft Visio. As for preparing software requirements document, the most common applications used are Microsoft Word, Microsoft Excel dan Microsoft Project. Principally, the software uses complex routines to create, organize, and store explicit knowledge. Knowledge on software basically depends on their ability to support the requirements elicitation activities. For example, knowledge about the software is where we can use the software for diagramming in order to share same interpretation and consistency of meaning for the software requirements. The knowledge on software is likely on ability to search repositories (i.e., database management system) for non-redundant information and data mining. Hence, we can use the repositories for managing the standardization and evolution of terminologies, rules and regulation, and business procedures. Thus, the knowledge should be included in organizational routines and preserve as explicit knowledge to be communicated among the stakeholders that involved in the process.

#### **Infrastructure**

Normally, in requirements elicitation process, stakeholders communicate through phone, and face-to-face meeting. However, there are many communication and collaboration technologies are available nowadays to make communication and collaboration easier. For example, there are networks, Internet, and mobile technologies for communication. The communication facilities should be available in order to function and be able to initiate and maintain communication among stakeholders. As for collaboration technologies, we have web browser, video conferencing, email and online meeting. Finding (Noraini, 2009) shows that stakeholders preferred to used combination of ways. It shows that the most common ways used for communication and collaboration is e-mail, telephone and face to face and meeting. Thus, elicitation process can use these technologies for gathering, creating and sharing information, in which we consider that as a tacit knowledge. The tacit knowledge can be transformed to explicit knowledge. For example, domain understanding as a tacit knowledge can be shared among the stakeholders by transforming it to software requirements document via Internet technology. By

using the infrastructures, stakeholders can share the distributed resources and their own resources within and beyond organizational networks.

### Techniques

There are many requirements elicitation techniques such as interviews, document analysis, workgroup, ethnography, prototyping, questionnaires, focus group, scenarios, Viewpoint (e.g., Hassan, S., & Salim, S.S., 2004), and recently Soft System Methodology (SSM) (e.g., Hassan, S., et. al., 2006). The most widely used are interview and document studies (Noraini & Abdullah 2011). These techniques can be divided into two categories which are personal and non-personal interaction. This selection of techniques is also influenced by types of problem, solution and system domain (Noraini & Abdullah 2011). For discovering requirements, basically, the experience, having knowledge on similar system and cognitive skill will be considered. Techniques used for discovering requirements such as interview, document studies, and questionnaire. Usually, for requirements prioritization and negotiation, the knowledge is related on the ability to conduct election process in order to reduce requirement's conflict and to achieve agreement among the stakeholders. Techniques used for requirements prioritization and negotiation such as voting, and focus group. For proposing solution of the problem, normally it will be based on stakeholders' request, consideration on product quality and user satisfaction. Techniques that are used for example prototyping.

### Human

In software development, human or stakeholders have technical knowledge, managerial knowledge and domain knowledge. In practice (Noraini, 2009) most of the stakeholders have knowledge and experiences in conducting software development. Technical knowledge required for requirements elicitation process such as knowledge on computer science, requirements model, design, software architecture, network, programming and project management. In practice (Noraini, 2009) most of the stakeholders have knowledge on modeling requirements using flow chart, data flow diagram (DFD) and Unified Modeling Language (UML) notations. As for the managerial knowledge, it involved communication for acquisition, and negotiation among stakeholders. For example, in requirements negotiation, the stakeholders should have an ability to gain commitment, achieve

agreement and willing to accept information exchange. Table 1 below summaries the managerial knowledge in requirements elicitation process.

Table 1 Managerial Knowledge in Requirements Elicitation Process

Process	Managerial Knowledge
Requirements Acquisition	<ol style="list-style-type: none"> <li>1. gain understanding</li> <li>2. encourage innovative and creative thinking</li> <li>3. reduces conflict and redundant information</li> </ol>
Requirements Negotiation	<ol style="list-style-type: none"> <li>1. gain commitment</li> <li>2. achieve agreement</li> <li>3. willing for information exchange</li> </ol>
Requirements Documentation	<ol style="list-style-type: none"> <li>1. follow standard</li> <li>2. configuration management</li> <li>3. conformance of requirements</li> </ol>

Knowledge in technical, managerial and domain are important to ensure the requirements are clearly described, completed, understandable and agreed by the entire stakeholders. Moreover, this will ensure the requirements interpreted appropriately in requirements document.

## IV CODIFICATION KNOWLEDGE FOR REQUIREMENTS ELICITATION PROCESS

There is a need for bridging tacit knowledge to explicit knowledge in order to sustain software development. In requirements elicitation process, a bridge will allow for exchanging and setting up information and knowledge during conversation among stakeholders for using and reusing knowledge. We propose an approach for bridging the tacit knowledge in software, techniques, infrastructure and human to explicit knowledge by using codification technology.

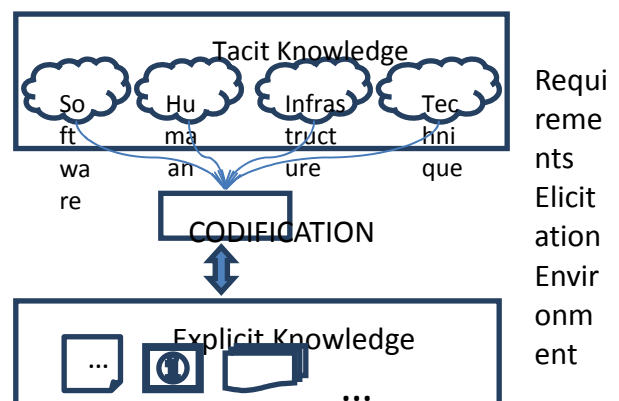


Figure 1. A Codification Knowledge for Requirements Elicitation

As depicted in Figure 1, the requirements elicitation process consists of groups of tacit knowledge that can be transformed through codification into explicit knowledge. The process will be repeated until the stakeholders are satisfied with the explicit knowledge that was gathered. The tacit knowledge in the requirements elicitation environment can be categorized into software, infrastructure, techniques and human.

Initially, we identify the knowledge and related facilities for software, infrastructure, techniques, and human that involved in requirements elicitation process.

Table 2 Group of Knowledge and Facilities

Group of Knowledge	Tacit Knowledge Description	Facilities/Roles
Software	create, organize, store explicit knowledge	diagramming tools, screen and report generators, analysis tools, repositories, code generators and documentation generators
Infrastructure	make communication and collaboration easier.	communication and collaboration technologies
Human	ensure the requirements are clearly described, completed, understandable and agreed by the entire stakeholders. interpret the requirements appropriately in requirements document.	technical knowledge, managerial knowledge and knowledge domain
Techniques	discover requirements, classify requirements, organize and prioritize requirements, negotiate requirements, reduce conflict and achieve the	<ul style="list-style-type: none"> <li>requirements discovery: interview, questionnaires, etc,</li> <li>requirements classification: hierarchy</li> <li>requirements prioritization: decision</li> </ul>

agreement among the stakeholders, document requirements	matrix <ul style="list-style-type: none"> <li>negotiation: voting</li> <li>documentation: template</li> </ul>
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We can identify the tacit knowledge from each of them through codification technologies (refer Table 2). For example, tacit knowledge in software can be classified into to create, organize, and store knowledge. First of all, we identify the facilities for each classification such as diagramming tools, screen and report generators, analysis tools, repositories, code generators and documentation generators. Then, we proposed codified knowledge for each of them.

Table 3 describes the knowledge codification design for software. For example, diagramming tools shows standard notation by using UML, DFD or flow chart. In UML, the Use Case diagram used to show interaction in the system as well as interaction with systems outside the system's boundary. Documentation generators provide various facilities such as for preparing document, template, and standards format in writing requirements document. Most of the software requirements specification follows the standard provided by IEEE that includes the organization of the contents, and also writing the functional, non-functional requirements and external attributes.

Table 3 Knowledge Codification Design for Software

Facilities	Knowledge Codification-Explicit
Diagramming Tools	Standards notation: UML, DFD or flow chart
Screen and Report Generators	Standards, template, organization specification, user interface
Analysis Tools	UML standards
Repositories,	data dictionary, database
Code Generators	Algorithm, program structure, program specification
Documentation Generators	Documentation rules and structure, standards format (e.g., IEEE)

While, tacit knowledge in human is for ensuring the requirements so that they are clearly described, completed, understandable and agreed by the entire stakeholders. Knowledge codification by using the standard (IEEE), template and guidance for clearly described and ensure completeness of the requirements. This can be supported with their domain knowledge such as, their experience on

software development and experience on similar development. The required managerial knowledge such as soft skill, motivate others, writing and presenting ideas, communicate and negotiate skills. Whereas, tacit knowledge insupported by infrastructure such as telephone, e-mail, Internet, mobile devices, and video conferencing, is aim to make communication and collaboration easier among the stakeholders. While, tacit knowledge in requirements discovery techniques such as interview, focus group, brainstorming and meeting to indentify the sources of the requirements such as process, procedure, rules, quality attributes (e.g. reliability, performance and security), functionalities and services

## V CONCLUSION

A knowledge codification acts as a bridge for representing information and tacit knowledge of organizational routines explicitly. For codification, groups of knowledge which are human, software, infrastructure and techniques in requirements elicitation process are considered. As a result, the knowledge codification routine allows the building of the knowledge repository of software requirements elicitation process for use and reused in support of sustain software development. This study offers multiple grounds for future research as for example to concentrate more on the knowledge codification approach itself in software requirements elicitation process. In addition, we will look for adopting the ontology techniques and decision tree to present the approach in detail.

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