

Design of Automatic User Identification Framework in Crowdsourcing Requirements Engineering : User Mapping and System Architecture

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Abstract

The requirement elicitation is the initial stage of requirement engineering where information collected from users. The process are significantly determined by the quality and quantity of information collected. The crowdsourcing is a method of information gathering from many users. The number and variety of users in the crowdsourcing are both advantages and challenges in the elicitation process. This study purposes a framework for user identification that consists of user mapping and architecture system. The identification process consists of 8 main states, start with defining context, user target and scope determination, data source determination, user data collection, data pre-processing, feature selection, data classification and user identification. The results of this study is an initial state for development of an automated tool for user identification to elicit requirement through crowdsourcing. By the framework can be generated the user classification, which can be used to apply the appropriate method for gathering information in elicitation process.

Keywords — *Requirements Elicitation, User Identification, Crowdsourcing Requirements Engineering, CRE*

1. INTRODUCTION

The early state in software engineering process is requirements engineering (RE). This activity focuses on gathering information from stakeholders. Stakeholders consist of various parties such as users, parties who fund the project, and those who will manage the system. There are various methods that can be used for information gathering process. In general, this method is grouped into 2 categories there are direct method that requires direct interaction between the development team in this case the system analyst with stakeholders and method of information gathering through technological devices called as device based method^[1]. Direct interaction between the development team and stakeholders does have several advantages such as analysts can dig in depth and direct information from the stakeholders, the information processing process becomes simpler because it is carried out directly by analysts, and there is emotional bond between analysts and stakeholders. However this method is time consuming and the number of stakeholders that can be reached is also limited^[2]. The time factor becomes very important because it relates to funding and a software engineering project is required to be able to produce quality and timely products. Therefore the method of information gathering through technological devices is a method that is currently widely used for engineering requirements processes.

The information gathering from stakeholders through technological devices can be done through computer assisted development for the process of interviews, surveys, interface simulation, and discussion forums. Some computer assisted applications for interviews and surveys have been developed^{[3][4][5][6][7]}. Besides interviews and surveys, discussion forum is also one of the important sources of information in engineering requirements. Nowadays, information gathering through media that has many users such as social media and discussion forum, is mostly done by software developers. This information gathering model is known as crowdsourcing.

Crowdsourcing is defined as a distributed problem solving model by combining human and computation using machines^[8]. Crowdsourcing has been used for various purposes including promoting products^{[9], [10]}, knowing user reviews for products or applications developed^{[11][12]}, and disaster management^[13]. Crowdsourcing is also used in software engineering processes.

A lot of research has been done regarding to the development of crowd model for software engineering. Crowdsourcing Software Engineering (CSE) is a model that uses an open call mechanism, for the process of online and global workers' recruitment for software-related works such as needs extraction, design, coding and testing^[8]. In particular, a lot of research has been done regarding users of the crowdsourcing method for the RE process. The Crowdsourcing Requirement Engineering (CRE) is the application of the crowdsourcing method for the RE process. The dominant CRE application is carried out in the process of requirement elicitation or information gathering. The user is the main actor in CRE. The process of determining, selecting, and involving users is an important factor that must be considered at CRE.

User identification is a process for determining which users/stakeholders who will be involved in CRE. To identify potential users, data users are needed, consisting of profile, online data, knowledge, and user's soft competency. Based on the data collected, a selection process of potential users will be carried out to support the requirement elicitation process. User selection will be done by classifying users according to the characteristics and elicitation method that will be applied. Determination of the right user for elicitation process is still one of the challenges in implementing CRE. The accuracy of the user will affect the quality and effectiveness of data collection and data processing.

2. RESEARCH METHOD

This section discusses the methodology used to conduct this research. The activities carried out refer to figure 1, beginning with literature study, followed by user identification, user mapping, and design of system architecture.



Figure 1. Research Methodology

Literature study is intended to determine the implementation of crowd approach in the RE process. Next stage is the identification of users involved in the RE process. After identification, user mapping is carried out based on the characteristics of users involved in crowd requirements engineering. the next step is to arrange the stages for user identification on CRE followed by designing the system architecture.

3. RESEARCH RESULTS AND DISCUSSION

This section contains the result and discussion of the research and consists of five parts, namely the literature study related to CRE, user identification process, user mapping, user identification process and architecture design, and analysis and discussion.

3.1. Crowdsourcing in Requirement Engineering

RE is the initial stage of the software engineering process. RE is a set of activities and techniques used to be able to understand the needs of a software engineering (SE) project. In this process, defining, documenting, modeling, and maintaining requirements are carried out. There are 5 stages of RE, such as elicitation, analysis, specification, verification, and requirement management. Elicitation is a stage to explore, discover, and understand the needs of users and all their limitations. Requirements analysis is a step to analyze and determine the priority of user needs. The analysis process will produce user specifications in form of modeling for RE. After further modeling, verification will be carried out to test the consistency between the needs and the developed RE model. The final stage of RE is planning and controlling of all RE processes^[14]. Obtaining users/stakeholders' needs and modeling needs is the main activity in RE. Therefore, interactions with stakeholders becomes a very important part in RE. The more and various stakeholders involved, then the results of RE can be more complete. CRE is a method that can support the involvement of many stakeholders in the RE process.

A considerable amount of research has been done regarding of CRE. Some of them produce tools or platforms to support CRE. The tools or platforms that have been developed including StakeNet, StakeSource, StakeRare, Crowd Require, Winbook, iThink, Requirement Bazaar, and Refine^{[15][16][17][18] [19]}. A list of tools that have been developed for the RE process can be seen in Table 1.

Table 1. List of CRE Tools

Tools	Reference	Method			
		Social Networking	Collaborative Filtering	Crowdsourcing	Gamification
StakeNet	[15]	V		V	
StakeSource	[16]	V		V	
Stakesource 2.0	[17]	V	V	V	
StakeRare	[18]	V	V	V	
CrowdRequire	[20]			V	
Winbook	[21]	V		V	

Tools	Reference	Method			
		Social Networking	Collaborative Filtering	Crowdsourcing	Gamification
Requirement Bazaar	[22]	V		V	
iThink	[23]				V
REfine	[24]			V	V

StakeNet is a tool used to build network among stakeholders. There are 3 main activities in StakeNet, such as identifying stakeholders and other recommended stakeholders, building a social network where stakeholders are nodes and recommendation as links, and giving priority values to each stakeholder based on the value of variations of the social network^[15]. As a continuity of StakeNet^[16] then StakeSource is developed. StakeSource is a tool for analyzing stakeholders. StakeSource is able to identify potential problems faced by stakeholders related to involvement and communication, and display information about stakeholders. In the development version of StakeSource 2.0, tools have the ability to provide recommendations regarding stakeholders' requirements of interest and highlight stakeholders who experience conflict with requirements preferences^[17]. Furthermore^[18] developed StakeRare to carry out requirement elicitation. StakeRare is a web-based tool to support requirement elicitation. At StakeRare, stakeholders are to provide an assessment for the initial list of requirements. Based on the assessment carried out, the system will conduct screening needs using a collaborative filtering approach. Almost similar to StakeRare, CrowdRequire, Winbook, Requirement Bazaar, iThink, and Refine are also a web-based tool that applies crowdsourcing methods for requirement elicitation process^[19].

CrowdRequire is a tool that supports CRE. This tool provides a communication feature to connect RE professionals with the software developer team. CrowdRequire provides regular responses for stakeholders. CrowdRequire's stakeholders consist of Client, Crowd, and CrowdRequire administration and staff^[20]. Almost similar to CrowdRequire, Winbook is a tool for RE using the social networking approach. Winbook is a tool developed using the WinWin method. This tool has a function to collaborative requirement management and negotiation on the requirement elicitation process^[21]. Another tool that uses the social network approach is Requirement Bazaar. Requirement Bazaar is a tool for Social Requirement Engineering (SRE). This tool supports the negotiation process between communities and service providers. Requirement Bazaar focuses on four aspects, such as requirement specifications, a workflow for co-creation, workspace integration, and personalizable requirement prioritization^[22].

Two other tools, iThink and REfine use the gamification approach for tool development. iThink is a web collaborative tools to elicit requirements. The tool uses the gamification approach and the six hats of thinking. iThink can be used to gather needs for new system as well as provide feedback for the existing system. iThink is packaged in form of a collaborative game^[23]. REfine is a tool developed using the crowdsourcing and gamification approach. REfine focuses on the process of clarifying the identification of needs of stakeholders. The process of stakeholders' participation is carried out through intensive gamification^[24].

CRE is a method that can optimize the role of stakeholders in RE. There are some challenges that must be faced in implementing CRE. These challenges include several important issues related to crowd members, elicitation feedback, analyzing feedback, monitoring context and data, and issue related with CRE in practice^[25]. The challenges related to crowd member issues include coordination, communication, and motivating the crowd members. Privacy and personalization are still challenges related to elicitation. Automation of analysis and monitoring processes are still a challenge in applying CRE. Further, various problems related to the CRE application in various SE projects is still a challenge that requires a lot of research.

3.2. User Identification

User identification is a series of activities that aim to determine users who are in accordance with the predetermined criteria. In RE, it involves 2 main actors, such as the user and the system analyst. Users on RE consist of owners/leaders/funders, end users, and system observers. System analysts must have a set of analyst standard competencies including knowledge, skill, and attitude^[26]. Stakeholders as important actors in the RE process must also have capability standards that are adjusted to the method that will be used for the RE process. The application of the CRE method requires stakeholders who are accustomed to use technological devices and are accustomed to interact with applications on the internet or mobile technology.

There are various user categories, Barricelli, Cassano, Fogli, & Piccinno^[27] categorizes 3 user groups, such as generic user, domain expert, and student. Particularly for online users, Deshpande & Deshpande^[28] categorizes users into 21 types of users, such as advertisers, students, Facebook users, general users, Online Social Networks (OSN) users, general users with crawlers, elder users, older OSN users, Twitter and Disqus users, bank customers, mobile users, youngsters users, enterprise users, digital museum users, website users, microblog users, abnormal group users, web based learner users, railway users, broadband users, and web forum users.

For Facebook users there are several classifications such as spammer, interactive users, message sender, photo poster, like adder, and fake users^[29]. Microblogs users are categorized as Ghost writers, sellers, official accounts, and end users^[30]. On the crowd approach, the user is called a member. There are 7 types of members in the crowd such as privacy-tolerant and socially ostentatious, privacy-fanatical but generous, passive and stingy, loyal and passionate, incentive seekers, perfectionists and complainers, and impact seekers^[25]. Summary of user categories from various studies can be seen in table 2.

Table 2. User Categories Summary

Literature	Type of Users	Categories
[27]	General	Generic user, domain expert, student
[28]	Online User	Advertiser, student, facebook users, general users, Online Social Network (OSN) users, general user with crawler, elder user, older OSN users, Twitter and Disqus users, bank customer, mobile users, youngsters user, enterprise user, digital museum users, website users, microblog users, abnormal group users, web based learner user, railway users, broadband users, and web forum users

Literature	Type of Users	Categories
[29]	Facebook User	spammer, interactive users, message sender, photo poster, like adder, and fake users
[30]	Microblogs User	Ghost-writer, seller, official account, and end user
[25]	Crowd User	privacy-tolerant and socially ostentatious, privacy-fanatical but generous, passive and stingy, loyal and passionate, incentive seekers, perfectionists and complainers, and impact seekers

In conducting classification and categorization of the user, some specific indicators are needed. Indicators are formulated based on the characteristics of the system which will be developed and the environment that creates interactions between users and the system. In the research, Doerr, Hess, & Koch^[31] formulate dimensions or variables that can be used to classify users. The dimensions of user classification will then be related to the dimensions of RE methods. The relationship between user class and RE method characteristics will produce the formulation of appropriate empowerment method for involving users in the RE process. There are 8 dimensions for end users class, such as domain experience, attitude towards IT/digitalization, degree of impact, context of system usage, motivation of participation, locality preference, interaction preference, and availability. For RE methods there are 12 dimensions for class determination such as atmosphere, responsible, presence of moderator, transparency, goal, interactivity, IT-Support, frequency, number of participants, location, duration, and time. Table 3 is a table of dimensions in user classification.

The classification process for users can be done automatically or semi-automatically. Various methods can be applied to automate the classification or grouping of users including graph clustering^[32], ontology^{[33] [34] [35]}, and machine learning classifier^{[36][37][38]}.

Table 3. Dimension for End Users and RE Methods Classification^[31].

Classification Class	Dimension	Sub-dimension
End Users	Domain Experience	Low; medium; high
	Attitude towards IT/Digitalization	Negative, dismissive; open, but deliberative; positive, welcoming
	Degree of impact	Key; primary; secondary stakeholder
	Context of system usage	Professional; private; mixed
	Motivation of participate	Intrinsically/motivated; not intrinsically motivated; but possibly motivated externally; not motivated/ hard to motivated
	Locality preference	Nature; inside buildings; doesn't care/mixed
	Interaction preference	Active: activity-oriented; active : talking-oriented; active : mixed; passive
	Availability	Flexible; limited; very busy

Classification Class	Dimension	Sub-dimension
RE Methods	Atmosphere	Informal; semi-formal; formal
	Responsible	Familiar; known; unknown person
	Presence of Moderator	No presence; remote; on-site
	Transparency	Non-transparent; mixed; transparent
	Goal	Elicit requirement; collect ideas; validate requirement; inform people
	Interactivity	Passive; active with limited interaction; active with high degree of interaction
	IT-Support	IT-Based; some steps are IT supported; human based
	Frequency	Continuous; multiple times; once
	Number of participants	Single person; small groups; large group; crowd
	Location	At home; places that people visit in their spare time; places where people sit and wait; public buildings
	Duration	Few minutes up to one hour; few hours up to half a day; full day; several days
	Time	Fixed; anytime

3.3. User Mapping in CRE

Users are an important element in the crowdsourcing model. A crowd consists of many users who have a variety of characteristics, needs, and abilities. Therefore, user modelling is an important issue in implementing crowdsourcing. This issue is also an important matter regarding CRE. In RE process there are several characteristics that users must have to support requirement elicitation. There are 12 important characteristics of users that influence the optimality of the CRE process such as the degree of impact, age, education level, job, location, internet experience, social media experience, mobile device experience, user attitude toward IT, motivation of participation, interaction preference, and availability. Each characteristic has sub-characteristics. Table 4 is a characteristic and sub-characteristics mapping for CRE.

In Table 4, each characteristic has 3 – 4 sub-characteristic. The first characteristic is degree of impact, reflects the users influence on the system, whether as key, primary or secondary person. The second to fourth characteristic is user general information related to age, education level, job, and user location. The next three characteristics are user characteristics related to their experience using the internet, social media, and mobile devices. Characteristics related to the user's view of technology are reflected through attitude, motivation and interaction preference. The last characteristic reflects the user's availability to be involved in the RE process. These twelve characteristics are coded using C01 to C12, while sub-characteristics are coded according to their main characteristics. For example the first characteristic of C01 will have sub characteristics C011, C012, and C013.

Table 4. User Characteristic and Sub-Characteristics Mapping

Characteristic	Sub-characteristic 1	Sub-characteristic 2	Sub-characteristic 3	Sub-characteristic 4
Degree of impact (C01)	Key person (C011)	Primary person (C012)	Secondary person (C013)	
Age (C02)	Young (C021)	Middle (C022)	Old (C023)	
Education Level (C03)	Less than Senior High School (C031)	Senior High School (C032)	More than Senior High School (C033)	
Job (C04)	Entrepreneur (C041)	Employer (C042)	Professional (C043)	Student (C044)
Location (C05)	Rural (C051)	City/urban (C052)		
Internet experience (C06)	Low (C061)	Medium (C062)	High (C063)	
Social Media experience (C07)	Low (C071)	Medium (C072)	High (C073)	
Mobile Device Experience (C08)	Low (C081)	Medium (C082)	High (C083)	
Attitude toward IT (C09)	Negative, dismissive (C091)	Open, but deliberative (C092)	Positif, welcoming (C093)	
Motivation of participate (C10)	Not motivated/hard to motivated (C101)	But possible motivated externally (C102)	Non intrinsically motivated (C103)	Intrinsically motivated (C104)
Interaction preference (C11)	Passive (C111)	Active, activity oriented (C112)	Active, taking oriented (C113)	Active, mixed (C114)
Availability (C12)	Very busy (C121)	Limited (C122)	Flexible (C123)	

Each user on CRE will have a certain characteristic class. This value will be used as a reference to determine the classification of users related to the appropriate method for each group of users in the process of requirement elicitation. Mapping on the table 4 is done after the user classification process is carried out for each characteristic that the user has. The determination of the elicitation method is based on the class that is owned by the user for all characteristics. The mapping of user characteristics and requirement elicitation methods can be seen in table 5.

Table 5. User Characteristic and Requirement Elicitation Method Mapping

Characteristic	Requirement Elicitation Method			
	Interview	Survei	Crowd-Data	Roleplay
Degree of Impact	C011; C012	C011; C012; C013	C011; C012; C013	C011; C012
Age	C022; C023	C022; C023	C021; C022; C023	C021; C022; C023

Characteristic	Requirement Elicitation Method			
	Interview	Survei	Crowd-Data	Roleplay
Education Level	C032; C033	C031; C032; C033	C031; C032; C033	C031; C032; C033
Job	C042; C043	C041; C042; C043	C041; C042; C043; C044	C041; C042; C043; C044
Location	C051; C052	C051; C052	C051; C052	C051; C052
Internet experience	C062; C063	C062; C063	C061; C062; C063	C062; C063
Social Media experience	C071; C072; C073	C071; C072; C073	C072; C073	C071; C072; C073
Mobile Device Experience	C082; C083	C082; C083	C082; C083	C082; C083
Attitude toward IT	C093	C093; C094	C093; C094	C094
Motivation of participate	C103; C104	C102; C103; C104	C101; C102; C103; C104	C103; C104
Interaction preference	C112; C114	C112; C113; C114	C111; C112; C113; C114	C112; C113; C114
Availability	C122; C123	C122; C123	C121; C122; C123	C122; C123

3.4. User Identification Process and System architecture.

The mapping process that has been carried out will be the basis for the user identification process. There are several stages in identifying users. The stages include context definition, user target and scope determination, data source determination, user data collection, data pre-processing, feature selection, data classification and user identification. The stages in the user identification process can be seen in Figure. 2.

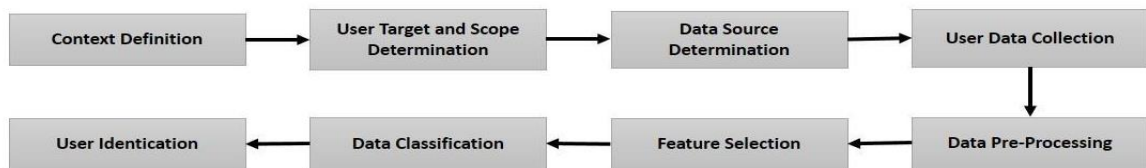


Figure 2. User Identification Process

The initial stage in the process of identifying users is determining the context of software development. At this stage, defining the objectives and goals of the software is done. After defining the context, an analysis is then carried out to determine the target user, the limits of the user and the data sources that form the basis of the identification process. After that, it proceeds with the process of collecting data. Then the pre-processing stage will be carried out for data and feature selection. Furthermore, the system will do the classification process automatically by applying the classification method. User identification will be carried out by the system based on the results of the classification process. Based on the stages of user

identification that was formulated, system architecture development is carried out as shown in Figure. 3.

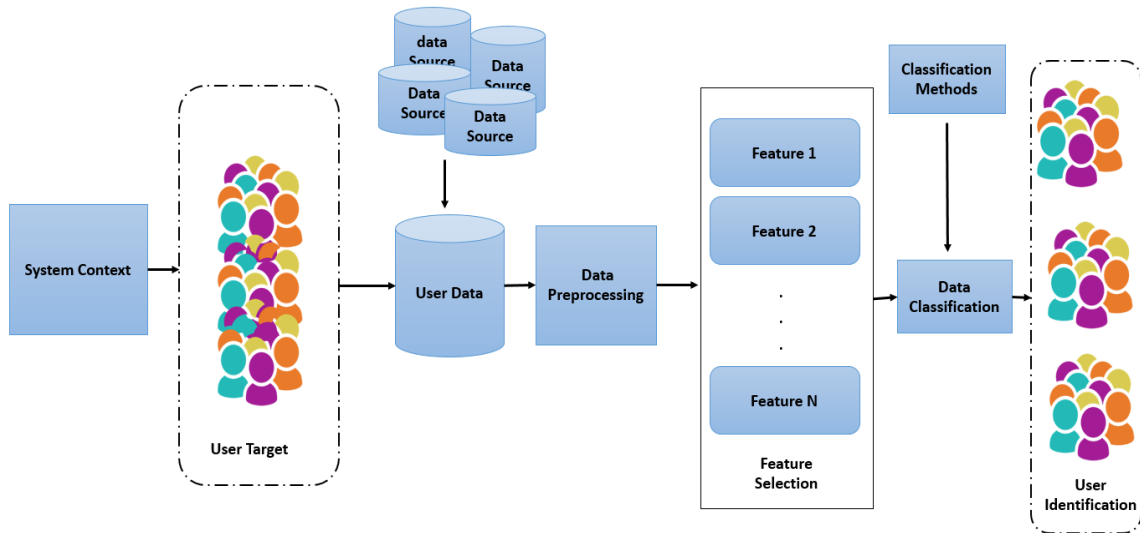


Figure 3. System Architecture for Automatic User Identification in CRE

3.5. Analysis and Discussion

Determination of 12 characteristics and sub-characteristics on table 4 is based on the type of crowd that will be used as the object of research and some previous studies. Crowd who will be the object of research is a targeted crowd. Specifically, the crowd is a community which exists in a certain area or certain community. Regions can include hamlet, sub-districts, or villages. While the community can be in form of people's organizations, agricultural communities, or other social communities. Based on the observations of the crowd in the region and community, it's found that age (C02), education level (C03), job (C04), and location (C05) are distinguishing attributes in crowd members. The characteristics of the degree of impact (C01), attitude toward IT (C09), motivation of participation (C010), interaction preference (C11), and availability (C12) are adopted from the research^[31]. Meanwhile, characteristics such as Internet experience (C06), social media experience (C07), and mobile device experience (C08) are derived from domain experience characteristics^[31].

The four requirement elicitation methods to be applied are formulated based on the application of participatory method for requirement elicitation activities^[39]. The selection of participatory method is based on the fact that the success of software development is determined by the quality and quantity of information collected on the RE stage. For this reason, the active role of the user is one of the keys of the success of the RE process and the participatory method is a method that can support increased user participation.

Mapping user characteristics and requirement elicitation methods are done through analysis of characteristics with the suitability of the application of the elicitation method. The analysis carried out based on the author's knowledge and discussion with experts. For the characteristics of the degree of impact (C01) it is determined that interviews, surveys and role

play are only conducted for key and primary users. Secondary users are considered insignificant for the three methods. The same analysis are also applied to the characteristics of young age (C021), low internet (C061) and mobile experience (C081), Negative (C091) and open (C092) attitudes toward IT, Not motivated to participate (C101), Passive interaction preference (C111), and very busy user (C121). The characteristic for interviews is more rigid for interviews than surveys and role play. This is based on the condition that the survey is a method of collecting data that is easier for respondents to understand. Respondents only need to answer short and closed questions. Almost similar as surveys, data collection through role play is also easier to understand by respondents because respondents will be guided by instructions to do some activities as a form of interface simulation from the system prototype and role play system will record all activities carried out by the user. Different to survey and role play, interview is a method of collecting data that requires a context understanding and knowledge of the respondents. The RE method through crowd-data collection can be more accommodate various characteristics of users. This method can be applied to almost all user characteristics, except low internet (C061) and mobile experience (C081), Negative (C091) and open (C092) attitude toward IT.

4. CONCLUSION

In this article a mapping of the user characteristics with requirement elicitation activity on CRE is carried out. There are 12 characteristics of the user and 4 methods of requirement elicitation. After the mapping process is formulated, the process of identification and architecture of the system is done. The identification process is done through 8 stages, such as context definition, user target and scope determination, data source determination, user data collection, pre-processing data, feature selection, data classification and user identification. The user identification will produce a group of users who are suitable for each elicitation method in the RE.

5. SUGGESTED

For the sustainability of the research, it is necessary to develop and test the system so that there will be more in-depth evaluation toward the mapping and framework that have been developed.

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