Stakeholder Identification Method in Goal Oriented Requirements Elicitation Process

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***Abstract*—In any software project, different stakeholders participate in requirements elicitation process to identify the requirements of software. Stakeholder Identification (SI) is an important part of requirements elicitation process. Despite its importance, SI methods have received less attention by goal oriented requirements engineering (GORE) community. Goals are high level objective of an organization; and are the basis of GORE. In literature, we identify that goal oriented requirements elicitation process (GOREP) like knowledge acquisition for automated specification (KAOS), attributed goal oriented requirements analysis (AGORA), and goal oriented idea generation (GOIG) etc. do not support SI methods. Therefore, to address this issue, we present a method for SI in GOREP which includes the following steps: specify stakeholder types, specify stakeholder roles, selecting and classifying stakeholders using fuzzy based approach, and stakeholder's analysis. Finally, the utilization of the proposed method is demonstrated with the help of an example.**

***Index Terms*—Requirements engineering, Goal oriented requirements engineering, Requirements elicitation processes, and Stakeholder identification**

I. Introduction

Requirements engineering is a process which is used to identify the requirements of software according to the need of stakeholders like customers, users etc. [7, 25]. These stakeholders' works with the team of software engineers to develop the software system. For the successful development of a software system it is indispensible to investigate the constantly changing human and cooperative aspects of software development [1]. A successful software system is that system which is completed on time, within budget and meets customer requirements [9]. In literature, we identify that lack of user involvement, lack of executive management support, and incomplete requirements are primary reason for software failure [5, 7, 8, 9, 12, 17]. We can't elicit the complete set of requirements of software until we have identified the stakeholders in requirements elicitation process.

Stakeholder identification (SI) is an important activity of requirements elicitation process [23]. A stakeholder in an organization is any group or individual who can affect or is affected by the achievement of the organization [10]. There are different categories of stakeholders. For example, Macaulay [20] identifies the following types of stakeholders: stakeholders responsible for design and development, maintenance, sale and purchase, and use. During our study, we have identified following research issues (RI) that are present in GOREP:

RI- 1: GOREP like AGORA, KAOS, and GOIG etc. do not support the selection and prioritization of requirements when stakeholder preferences are in the form of linguistic variables.

RI- 2: GOREP also don't support stakeholder identification (SI) method in requirements elicitation process. SI is an important activity of requirements elicitation process. Therefore, stakeholders must be identified before the actual development takes place.

To address the first research issue, in [24] we proposed a fuzzy based approach for requirements prioritization in GOREP. We then extend this work with the help of fuzzy extent analytic hierarchy process for the prioritization of requirements [26]. In [27] we proposed a fuzzy based approach for the selection of goals in GOREP. We demonstrate the utilization of these methods with the help of a case study.

The objective of this paper is to address the second research issue, i.e., to "propose SI method in GOREP". In literature, there are various methods for SI. For example, Sharp et al. [28] proposed a method for SI in requirements engineering process by identifying the baseline stakeholders like users, developers, legislators, and decision makers. Alexander and Stevens [2] presents a practical guide for SI. These methods do not support the need of inter-organizational environment where stakeholders are geographically dispersed. Therefore, in 2008, Ballejos and Montagna [4] proposed a SI method in inter-organizational environments. This method includes the following steps: specify stakeholder types, specify stakeholder roles, select stakeholder, associate stakeholder with roles, and analyze stakeholder influence and interest. Andre et al. [3] used these steps for identifying and analyzing stakeholders in climate change adaptation processes.

In 2013, Susniene et al. [30] proposed a fuzzy logic model for measuring stakeholder influence according to the following attributes: interest, power, benevolence, and reliability. If in an organization all the stakeholders have been identified, then it is indispensible to define the importance of the satisfaction of the stakeholder requirements, i.e., which stakeholder's requirements should be considered for the current release of software and which requirements should be postponed for the future [12, 23]. Current methods of SI don't classify the requirements according to the stakeholder's priorities [4, 23]. Therefore, it motivates us to present a SI method which considers the classification of requirements according to an evaluation of stakeholder's priorities.

In literature [14, 15, 16, 18, 22], we identify that GOREP do not support SI method. For example, AGORA [14] and GOIG [22] focuses on the interaction between stakeholders [23]. In 2013, we proposed a fuzzy based approach for requirements prioritization in which we have categorize stakeholders into two parts, i.e., primary stakeholders and secondary stakeholders [24]. In this method there is no discussion about the selection and classification of stakeholders, stakeholder's analysis and so on. SI method has received less attention by GORE community. Most of the work in GORE literature is related to goal decomposition, goal refinement, selection and prioritization of goals etc [15, 16]. Therefore, in order to address the above issue, this paper presents a SI method in GOREP which includes the following steps: (a) specify stakeholder types, (b) specify stakeholder roles, (c) selecting and classifying stakeholders using fuzzy based approach, and (d) stakeholders analysis. This paper is organized as follows: In section II, we briefly review the basic concepts of fuzzy sets, linguistic variable, fuzzy triangular numbers, and fuzzy preference relation. Section III presents a proposed method for stakeholder identification. An example applying each stage of the proposed method is presented in section IV; and finally conclusions are drawn in section V.

II. Fuzzy Set Theory

In this section, we briefly review the basic concepts of fuzzy sets, linguistic variable, fuzzy triangular numbers, and fuzzy preference relation. The fuzzy set, originally proposed by Zadeh in 1965 [31], is defined as follows: In a universe of discourse U_x, a fuzzy subset A of U_x is characterized by a membership function $f_A(x)$, where $f_A : U_x \rightarrow [0, 1]$ and the membership function associates with each member of x of U_x a number of $f_A(x)$ in the interval [0,1], representing the grade of membership of x in A. Linguistic variables are variables whose values are words or sentences in a natural or artificial language [31, 32]. For example, poor is a linguistic variable if its values are assumed to be the fuzzy variables labeled very poor, poor, fair, good, and very good; rather than the numbers 0,1,2,3 etc.

There are several formats of fuzzy numbers, such as Triangular, Trapezoidal, Gaussian, or Sigmoid that can be used in decision making processes. In practical applications, *triangular fuzzy numbers (TFNs*) are widely used to represent the approximate value range of linguistic variables [26]. In the proposed method we adopt TFNs because of their simplicity in both concepts and computation [19, 26, 27]. TFNs can be defined as follows:

Let **R** is the real line, which is viewed as a universal set of all fuzzy sub-sets. A triangular fuzzy number A is normal, convex fuzzy subset of **R**, with a piece wise linear relationship function μ_A, defined by:

$$\mu_A(x) = \begin{cases} \frac{(x-a)}{(b-a)}, a \le x \le b, \\ \frac{(c-x)}{(c-b)} b \le x \le c, \\ 0, \quad otherwise \end{cases} \quad (1)$$

The TFNs can be denoted by A = (a, b, c) as depicted in Fig. 1. The parameters a, b, and c respectively, indicate the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event. There are several operations that can be performed on triangular fuzzy numbers (TFN) like addition, subtraction, inverse etc.

Let $A_1 = (a_1, b_1, c_1)$ and $A_2 = (a_2, b_2, c_2)$ then:

Addition: $A_1 \oplus A_2 = (a_1+a_2, b_1+b_2, c_1+c_2)$ (2)

Subtraction: $A_1 \ominus A_2 = (a_1-c_2, b_1-b_2, c_1-a_2)$ (3)

Multiplication: $A_1 \odot A_2 = (a_1.a_2, b_1.b_2, c_1.c_2)$ (4)

Inverse: $(A_1)^{-1} = (1/c_1, 1/b_1, 1/a_1)$ (5)

Negation of $A_1 = (-c_1, -b_1, -a_1)$ (6)

Division: $A_1 / A_2 = (a_1/c_2, b_1/b_2, c_1/a_2)$ (7)

Preference relation is a useful tool for representation of information used in decision making problems. It is used when we want to aggregate expert's preferences into group preferences. A fuzzy preference relation P on **R** is a fuzzy subset of **R** x **R** with membership function $f_P(A, B), \forall A, B \subseteq R$, where $f_P(A, B)$ represents the degree of preference of A over B [19]:

1. P is reciprocal iff $f_P(A, B) = 1 - f_P(B, A)$, $A, B \subseteq R$.
2. P is transitive iff $f_P(A, B) \geq 1/2$ and $f_P(B, C) \geq 1/2 \Rightarrow f_P(A, C) \geq 1/2$, $\forall A, B, C \subseteq R$.
3. P is a fuzzy total ordering, iff P is reciprocal, transitive, and comparable.

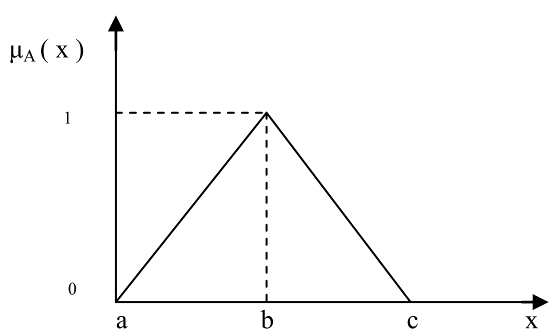

Fig. 1. The membership function of TFN A= (a, b, c)

III. Proposed Method for Stakeholder Identification

This section presents the proposed method for stakeholder's identification (SI) in GOREP. In GORE literature, SI methods are often neglected and are not considered at the same level of details as goal concepts, goal links, and goal refinements etc. Proposed SI method includes following steps (See Fig 2):

A. Specify stakeholder types;
B. Specify stakeholder roles
C. Selecting and classifying stakeholders using fuzzy based approach;
D. Stakeholder analysis

A. Specify stakeholder types

The first step of our method is to specify the list of all stakeholders. We identify the following five criteria for specifying the stakeholders in GOREP: (1) functional criterion (FC) (2) non-functional criterion (NFC) (3) geographical criterion (GC) (4) knowledge and abilities criterion (KAC) and (5) organization level criterion (OLC). We have identified these criterions from Ballejos and Montagna's SI method [4] except second criterion, i.e., non functional criterion. We include this criterion in our method because software requirements can be functional and non-functional [11].

Functional criterion specifies a function that the system must be able to perform; it also specifies the behavior aspects of the systems [11]. *Non- functional criterion* is defined as how a system is supposed to be. There are different types of NFR like reliability, security, performance etc [11]. *Geographical criterion* is used to analyze the various places or geographical areas of stakeholders. The objective of this criterion is identifying the stakeholders located in different geographical locations, with cultural and idiomatic differences [4]. *Knowledge and abilities criterion* refers to those stakeholders who have certain knowledge and skills related to software development process. In *organizational level criterion*, stakeholders are identified from different organizational level [29], i.e., strategic, tactical, and operational level. Strategic level goals are broadly defined by top management of the organization. Tactical level goals support the strategic levels goals and are set by and for middle managers. Operational goals are determined at the lowest level of the organization and are set by and for the low level managers to support the tactical goals [29].

B. Specify stakeholder roles

This step identifies the different stakeholder roles according to the need of project. This step can be done simultaneously with the previous step, i.e., stakeholders types. Based on literature review [4, 23, 26], we classify stakeholders into four parts, i.e., primary stakeholders, secondary stakeholders, external stakeholders, and extended stakeholder. *Primary stakeholders* include those who are central to any project initiative like beneficiaries, officials at local, national, and regional levels, international agencies who control policies, laws, or funding resources.

Secondary stakeholders includes consumer, company employee etc. These stakeholders have less priority than primary stakeholders. Secondary stakeholders need to be involved in collaborative process; and the project manager of the collaboration project need to plan when and how to include both primary and secondary stakeholders. *External stakeholders* are not the direct part of project team. For a public sector sponsored projects, external stakeholders includes: government, regulatory agencies, and treasury. *Extended stakeholders* are those who do not fit in one of the previous three groups, i.e., primary stakeholders, secondary stakeholders, and external stakeholders. These stakeholders include those that undergo some kind of damage as a consequence of the system implementation or are adversely impacted by its development (for example, losing their jobs, losing power for decision making etc.).

C. Selecting and classifying stakeholders using fuzzy based approach.

In requirements elicitation process, stakeholders have different opinion for the same requirements because of different levels of stakeholders' experience, understanding, and knowledge level. In general most of the stakeholders use linguistic terminology instead of exact numbers in describing their requirements [19, 24]. There is a vagueness in human judgments and often difficult to represent in exact numbers. The weights assigned to requirements by stakeholders are often described qualitatively. Fuzzy logic handles imprecise and linguistic variables mathematically [24]; the terms such as high cost, low performance, and medium quality etc. can be expressed in well defined manner using fuzzy logic. Several researchers advocate the use of fuzzy based multi-criteria decision making methods in different areas of management, science and engineering. For example, Chan et al. [6] proposed an extended fuzzy AHP approach for the evaluation of green product design. In 2014, Kaa et al. [13] proposed a method using fuzzy analytic process for decision making in technology standards battles. Therefore, in this step, we select and classify stakeholders using fuzzy based approach. In this step, we adopt triangular fuzzy numbers (TFN) because of their simplicity in both concepts and computation. There are several operations that can be performed on TFNs like addition ($A_1 \oplus A_2$), subtraction ($A_1 \Theta A_2$), Multiplication ($A_1 \odot A_2$) etc., where A_1 and A_2 are TFNs.

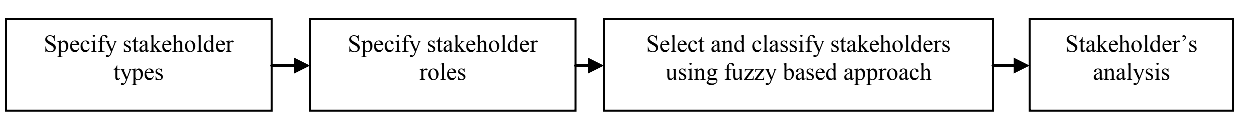

Fig. 2. Steps of proposed SI method

For the selection and classification of stakeholders, we aggregate fuzzy performance rating through all decision maker by means of extended addition and scalar multiplication to form a comprehensive performance matrix P, in which performance rating:

$$p_{ij} = (1/n) \odot (p^1_{ij} \oplus p^2_{ij} \oplus, ..., \oplus p^n_{ij}) \quad (8)$$

is a triangular fuzzy number of the form:

$$(p_{1ij}, p_{2ij}, p_{3ij}) = \left(\frac{1}{n}\sum_{k=1}^{n} p^k_{1ij}, \frac{1}{n}\sum_{k=1}^{n} p^k_{2ij}, \frac{1}{n}\sum_{k=1}^{n} p^k_{3ij} \right)$$

Fuzzy performance rating is the priority which a stakeholder gives to requirements in terms of linguistic variables. Now calculate the fuzzy weight through all decision makers by means of extended addition and scalar multiplication to form a comprehensive weight vector W. Once we have obtained the comprehensive performance and weight matrix then apply the following steps [19]:

Aggregate fuzzy performance ratings with fuzzy weights by means of extended multiplication to form a weighted, comprehensive decision matrix D, in which

$$d_{ij} = p_{ij} \odot w_j \quad (9)$$

is a fuzzy number with parabolic membership functions in the form of :

$(\lambda_{1ij}, \lambda_{2ij}, \lambda_{3ij} / d_{ij} / \Delta_{1ij}, \Delta_{2ij}, \Delta_{3ij})$;

where

$\lambda_{1ij} = (w_{2j}-w_{1j})(p_{2ij}-p_{1ij})$

$\lambda_{2ij} = w_{1j}(p_{2ij}-p_{1ij}) + p_{1ij}(w_{2j}-w_{1j})$

$\lambda_{3ij} = w_{1j}p_{1ij}$

$\Delta_{1ij} = (w_{3j}-w_{2j})(p_{3ij}-p_{2ij})$

$\Delta_{2ij} = w_{3j}(p_{3ij}-p_{2ij}) + p_{3ij}(w_{3j}-w_{2j})$

$\Delta_{3ij} = w_{3ij}p_{3ij}$ and

$d_{ij} = w_{2j}p_{2ij}$

Define each sub-goal/requirement as a fuzzy number A_i, i=1, 2 ...m by means of extended addition and scalar multiplication through the following criteria/NFRs (i.e., m):

$$A_i = 1/m \odot (d_{i1} \oplus d_{i2} \oplus, ..., \oplus d_{iC}) \quad (10)$$

with parabolic membership function in the form of:

$(\lambda_{1i}, \lambda_{2i}, \lambda_{3i} / EA_i / \Delta_{1i}, \Delta_{2i}, \Delta_{3i})$; where

$\lambda_{Ii} = \frac{1}{m}\sum_{j=1}^{m} \lambda_{Iij}$, I= 1,2,3;

$\Delta_{Ii} = \frac{1}{m}\sum_{j=1}^{m} \Delta_{Iij}$, I=1, 2, 3, and

$EA_i = \frac{1}{m}\sum_{j=1}^{m} d_{ij}$.

Define extended average (EA) by means of extended addition and scalar multiplication through all alternatives/FRs (i.e., n).

$$A_{1i} = 1/n \odot (g_1 \oplus g_2 \oplus, ..., \oplus g_h) \quad (11)$$

with parabolic membership function in the form of:

$(\lambda_1, \lambda_2, \lambda_3 / Sum\_EA / \Delta_1, \Delta_2, \Delta_3)$; where

$\lambda_I = \frac{1}{n}\sum_{j=1}^{n} \lambda_{Ii}$, I=1, 2, 3;

$\Delta_I = \frac{1}{n}\sum_{j=1}^{n} \Delta_{Ii}$, I=1, 2, 3, and

$Sum\_EA = \frac{1}{n}\sum_{j=1}^{n} EA_i$.

Define the extended difference, $EA_i \ominus Sum\_EA$, for each $A_i \in R$, with parabolic membership function in the form of [19]:

$((\lambda_{1i} - \Delta_1), (\lambda_{2i} + \Delta_2), (\lambda_{3i} - \Delta_3) / EA_i - Sum\_EA / (\Delta_{1i} - \lambda_1), (-\Delta_{2i} - \lambda_2), (\Delta_{3i} - \lambda_3))$.

Calculate ranking values of each requirements: In this step, we calculate the ranking values (rv_i) for each requirements A_i by means of F-preference relation R [19]:

if $(\lambda_{3i} - \Delta_3) < 0$, $(\Delta_{3i} - \lambda_3) \geq 0$, $EA_i \geq Sum\_EA$; then

$rv_i = \mu_R(A_i \ominus EA, 0) = \prod^+ / (\prod^+ + \prod^-)$;

else if

$(\lambda_{3i} - \Delta_3) \leq 0$, $(\Delta_{3i} - \lambda_3) > 0$, $EA_i \leq Sum\_EA$; then $rv_i = \mu_R(A_i \ominus EA, 0) = \Psi^+ / (\Psi^+ + \Psi^-)$;

else if

$(\lambda_{3i} - \Delta_3) = 0$, $(\Delta_{3i} - \lambda_3) = 0$, $EA_i = Sum\text{-}EA$; then $rv_i = \mu_R(A_i \ominus EA, 0) = 0.5$;

else if

$(\lambda_{3i} - \Delta_3) \geq 0$, $(\Delta_{3i} - \lambda_3) > 0$, $EA_i \geq Sum\_EA$; then $rv_i = \mu_R(A_i \ominus EA, 0) = 1$;

else if

$(\lambda_{3i} - \Delta_3) < 0$, $(\Delta_{3i} - \lambda_3) \leq 0$, $EA_i \leq Sum\_EA$; then $rv_i = \mu_R(A_i \ominus EA, 0) = 0$. Where,

$\prod^+ = -[1/4(\Delta_{1i} - \lambda_1) - 1/3(\Delta_{2i} + \lambda_2) + 1/2(\Delta_{3i} - \lambda_3)] + [1/4(\lambda_{1i} - \Delta_1)(1-Z^4) + 1/3(\lambda_{2i} + \Delta_2)(1-Z^3) + 1/2(\lambda_{3i} - \Delta_3)(1-Z^2)]$;

$\prod^- = (1/4(\lambda_{1i} - \Delta_1)Z^4 + 1/3(\lambda_{2i} + \Delta_2)Z^3 + 1/2(\lambda_{3i} - \Delta_3)Z^2)]$;

$Z = [-(\lambda_{2i} + \Delta_2) + \{(\lambda_{2i} + \Delta_2)^2 - 4(\lambda_{1i} - \Delta_1)(\lambda_{3i} - \Delta_3)\}^{1/2}] / [2(\lambda_{1i} - \Delta_1)]$;

$\Psi^+ = 1/4(\Delta_{1i} - \lambda_1)P^4 + 1/3(-\Delta_{2i} - \lambda_2)P^3 + 1/2(\Delta_{3i} - \lambda_3)P^2$;

$\Psi^- = -[1/4(\lambda_{1i} - \Delta_1) + 1/3(\lambda_{2i} + \Delta_2) + 1/2(\lambda_{3i} - \Delta_3)] - [1/4(\Delta_{1i} - \lambda_1)(1-P^4) - 1/3(\Delta_{2i} + \lambda_2)(1-P^3) + 1/2(\Delta_{3i} - \lambda_3)(1-P^2)]$;

$P = [(\Delta_{2i} + \lambda_2) - \{(-\Delta_{2i} - \lambda_2)^2 - 4(\Delta_{1i} - \lambda_1)(\Delta_{3i} - \lambda_3)\}^{1/2} / [2(\Delta_{1i} - \lambda_1)]$.

D. Stakeholders Analysis

This step includes the assessment of stakeholders on the basis of influence and interest. Influence indicates a stakeholder's relative power over and within a project. In our method, we have adopted the concept of influence and interest from [4] and categorize it into 4 parts in order to facilitate the stakeholder's analysis. The meaning of each category is the following:

Category 1: These stakeholders have high influence on the project and are very interested in it. Therefore, their viewpoints and goals must be understood and their objection should also be considered during group elicitation techniques. For example, coordinator, beneficiaries' etc. Note that stakeholders in this category would be considered as key stakeholders. This is the area where we should focus our attention when the project is suffering rather than targeting individual in the remaining categories.

Category 2: These stakeholders may be highly interested in the project but their influence may be low, i.e., expert and administrators. Such types of stakeholders are considered as a valuable source of information.

Category 3: These stakeholders have high influence and low interest. They have influence on the project success. The goal of the relationship with these stakeholders must be to provide enough information about the project, so they do not become obstacle. For example, financer, politicians etc.

Category 4: These stakeholders are not interested in the project and cannot help the project team to perform its job. Therefore, project team must devote least amount of time to those stakeholders who have low influence and low interest in the project. For example, agent, operators etc.

IV. An Example

In this section, we have applied the proposed method to identify the stakeholder of an institute examination system. This system is used to provide the facility to submit online examination form and generate the results of the students; and display the news related to examinations. After submitting the examination form, the system will generate the examination fee receipt and students will be able to take the printout of that receipt. The system will also generate the patterns of the sitting arrangement.

A. Specify stakeholder types

In our case study, we identify different types of stakeholders like administrators (Director and funding agencies or financer), requirements analysts, developer, consultants, financers and students or end users. The roles of these stakeholders are defined in next section.

B. Specify stakeholder roles

In this section, we specify the roles of stakeholders. Table 1, presents the different types of stakeholders along with their roles. Let us assume that S_1 is the primary stakeholder, i.e., Director of the institute; and its objective is to develop an institute examination system; the objective of S_1 is represented by G. S_1 is also the beneficiary and sponsor of the system, who wants to develop a system. S_2, S_3, and S_4 are the secondary stakeholder and are responsible for the identification of FR of student module, teacher's module, administrative module respectively. The objective of stakeholder S_5 is to elicit the non functional requirements and also to take the decisions related to the organizations goals and objective. Stakeholder S_6 is the in charge of the system throughout all the life cycle phases. Stakeholder S_7 is developer and is directly involved in information system development. S_8 is consultants. S_9 is the financers and S_{10} is the students or end users. Therefore, as a result, we have identified ten stakeholders, i.e., S_1, S_2,..., S_{10} on the basis of various criterions like functional, non-functional etc.

TABLE I. Stakeholders and their roles for IES

S. No.	Stakeholder types	Stakeholder's roles
1	Administrators	Director of the institute (S_1) Financer(s) or Funding agencies (S_9)
2	Requirements analysts (RA) for the elicitation of functional (FR) and non functional requirements (NFR)	S_2 : responsible for the elicitation of functional requirements (FRs) of students module S_3 : responsible for the elicitation of functional requirements (FRs) of teachers module S_4 : responsible for the elicitation of functional requirements (FRs) of administrators module S_5 : responsible for the elicitation of non functional requirements of IES
3	Developer	S_6: In-charge of the system throughout all SDLC models S_7 : Developer
4	Consultants	S_8: Consultant
5	Students or end users	S_{10}: least considerable stakeholders

C. Selecting and classifying stakeholders using fuzzy based approach

In goal oriented requirements elicitation process, goal of S_1 is decomposed and refined into sub goals to identify the requirements by asking what, why , how and how else questions [18]. As a result, we have identified following requirements for S_2, S_3, and S_4:

(i) fr_1: printout of bank receipt of student's fee;
(ii) fr_2: Entry of internal and external marks;
(iii) fr_3: View semester result;
(iv) fr_4: Generate examination sitting arrangement;
(v) fr_5: Online conduct of examination;
(vi) fr_6: Fill examination form; and after successful submission of the form system will generate the following information:
(a) Roll number, (b) Name of the students, (c) Examination name, (d) Subject code, (e) Subject name(s), (f) Number of backlogs, if any (g) Examination fee(s);
(vii) fr_7: Upload any exam related activities ;
(viii) fr_8: Generate examination hall ticket;
(ix) fr_9: Approve examination form;
(x) fr_{10}: On line payment of examination fee.

In this step, we classify these requirements according to an evaluation of stakeholder's priorities. For the selection and classification of stakeholder we employ fuzzy based approach. Now we define the linguistics values of the importance weight of each functional requirement (FR) and the relationship between FR and non functional requirements (NFR). In our case study, five ranks are used to evaluate the importance of each FR, i.e., *Very Low (VL), Low (L), Middle (M), High (H),* and *Very High (VH)*; and five ranks are used to evaluate the relationship between functional and non functional requirements, i.e., *Very Week (VW), Weak (W), Medium (M), Strong (S),* and *Very Strong (VS)*. The triangular fuzzy numbers of linguistic values for each FR and the relationship between FR and NFR are listed in Table II and Table III respectively. Ten stakeholders were asked to evaluate the importance of each requirement. The relationship between functional and non functional requirements is evaluated by cross functional team with five decision makers given in Table IV. The fuzzy importance weight of each NFR is given in Table V. FRs of student's module includes fr_1, fr_6, and fr_{10}. FRs of teacher's module includes fr_2, fr_3, fr_4, and fr_5. FRs of administrative module includes fr_7, fr_8, and fr_9. Requirements of S_5 include security (nfr_1), reliability (nfr_2), and performance (nfr_3). These are the non functional requirements. The requirement of S_9 is that system should be economic and S_{10} is the student or end user of systems.

TABLE II. Triangular fuzzy numbers of linguistic values for each FR

S.NO.	Linguistic values	Triangular fuzzy number
1	VL (Very Low)	(0,0,0.25)
2	L (Low)	(0,0.25,0.5)
3	M (Middle)	(0.25,0.5,0.75)
4	H (High)	(0.5,0.75,1)
5	VH (Very High)	(0.75,1,1)

TABLE III. Triangular fuzzy numbers of linguistic values for the relationship between FR and NFR

S.NO.	Linguistic values	Triangular fuzzy number
1	VW (Very Weak)	(2,2,4)
2	W (Weak)	(2,4,6)
3	M (Medium)	(4,6,8)
4	S (Strong)	(6,8,10)
5	VS (Very Strong)	(8,10,10)

TABLE IV. Relationship between FRs and NFRs evaluated by five DM

DM	Functional Requirements (fr)	Non functional requirements (NFRs)			Functional requirements (fr)	Non functional requirements (NFRs)		
		nfr_1	nfr_2	nfr_3		nfr_1	nfr_2	nfr_3
DM_1	fr_1	W	S	VS	fr_6	S	S	VS
DM_2		S	VS	VW		VS	VS	W
DM_3		M	S	S		S	S	S
DM_4		S	VS	W		M	W	M
DM_5		VS	S	S		S	VS	M
DM_1	fr_2	S	VS	W	fr_7	VW	M	S
DM_2		VS	S	VS		S	VS	S
DM_3		W	M	S		M	S	VW
DM_4		S	VW	VW		M	M	W
DM_5		M	W	S		M	VS	S
DM_1	fr_3	VS	S	VW	fr_8	S	VS	M
DM_2		W	W	S		S	W	S
DM_3		M	VS	VS		W	S	W
DM_4		VS	M	M		S	W	S
DM_5		VW	VW	S		S	M	S
DM_1	fr_4	S	S	M	fr_9	VS	S	M
DM_2		VS	M	M		M	M	S
DM_3		W	VS	S		W	VW	VS
DM_4		S	W	VS		VS	VS	S
DM_5		S	M	S		S	M	S
DM_1	fr_5	VW	M	S	fr_{10}	S	S	W
DM_2		W	S	M		S	VS	S
DM_3		M	W	W		VS	W	VS
DM_4		S	VW	VW		W	S	S
DM_5		M	S	S		VW	VS	VS

TABLE V. Fuzzy importance weight by 10 stakeholders for each NFR

Non functional requirements (NFRs)	Stakeholders									
	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
nfr_1	VH	H	VH	H	M	L	M	VL	H	L
nfr_2	H	L	VH	VH	H	M	L	M	M	VL
nfr_3	M	VH	L	H	VH	H	VH	L	VL	M

TABLE VI. Comprehensive weight matrix

Non functional requirements (nfr)	**Fuzzy importance weight**
nfr_1	(0.35,0.58,0.78)
nfr_2	(0.33,0.55,0.75)
nfr_3	(0.38,0.6,0.78)

TABLE VII. Comprehensive performance matrix

FRs	**nfr_1**	**nfr_2**	**nfr_3**
fr_1	(5.2,7.2,8.8)	(6.8,8.8,10)	(4.8,6.4,8)
fr_2	(5.2,7.2,8.8)	(4.4,6,7.6)	(4.8,6.4,8)
fr_3	(4.8,6.4,7.6)	(4.4,6,7.6)	(5.2,6.8,8.4)
fr_4	(5.6,7.6,9.2)	(4.8,6.8,8.4)	(5.6,7.6,9.2)
fr_5	(3.6,5.2,7.2)	(4,5.6,7.6)	(4,5.6,7.6)
fr_6	(6.4,8.4,9.6)	(6,8,9.2)	(4.8,6.8,8.4)
fr_7	(4,5.6,7.6)	(6,8,9.2)	(4.4,6,8)
fr_8	(5.2,7.2,9.2)	(4.4,6.4,8)	(4.8,6.8,8.8)
fr_9	(5.6,7.6,8.8)	(4.8,6.4,8)	(6,8,9.6)
fr_{10}	(4.8,6.4,8)	(6,8,9.2)	(6,8,9.2)

Now we aggregate fuzzy importance weight for each NFR by applying formula (8); and then we aggregate the fuzzy relationship between functional and non functional requirements; and the results are given in Table VI and Table VII respectively. A weighted comprehensive decision matrix, depicted in Table VII, can be established by applying the extended multiplication discussed in formula (9), where QF denotes the quadratic membership function of the form of:

4.176_{QF}= 0.46,1.896,1.82/4.176/0.32,3.008,6.86
4.84_{QF}=0.44,2.156,2.24/4.84/0.24,2.90,7.50
3.84_{QF}=0.352,1.664,1.824/3.84/0.288,2.687,6.24
4.176_{QF}=0.46,1.896,1.82/4.176/0.32,3.008,6.864
3.3_{QF}=0.352,1.496,1.452/3.3/0.32,2.72,5.7
3.84_{QF}=0.352,1.664,1.824/3.84/0.29,2.69,6.24
3.712_{QF}=0.368,1.664,1.68/3.712/0.24,2.46,5.93
3.3_{QF}=0.352,1.496,1.452/3.3/0.32,2.72,5.7
4.08_{QF}=0.352,1.752,1.98/4.08/0.288,2.76,6.55
4.408_{QF}=0.46,1.98,1.96/4.408/0.32,3.09,7.176
3.74_{QF}=0.44,1.716,1.58/3.74/0.32,2.88,6.3
4.56_{QF}=0.44,1.992,2.13/4.56/0.29,2.9,7.18
3.02_{QF}=0.36,1.388,1.26/3.02/0.40,3.0,5.62
3.08_{QF}=0.35,1.408,1.32/3.08/0.4,3.02,5.7
3.36_{QF}=0.352,1.488,1.52/3.36/0.36,2.93,5.93
4.87_{QF}=0.46,2.172,2.24/4.87/0.24,2.86,7.49
4.40_{QF}=0.44,1.98,1.98/4.4/0.24,2.74,6.9
4.08_{QF}=0.44,1.816,182/4.08/0.29,2.75,6.55
3.25_{QF}=0.37,1.48,1.40/3.25/0.4,3.08,5.93
4.40_{QF}=0.44,1.98,1.98/4.4/0.24,2.74,6.9
3.6_{QF}=0.35,1.58,1.67/3.6/0.36,3,6.24
4.18_{QF}=0.46,1.896,1.82/4.18/0.4,3.4,7.18
3.52_{QF}=0.44,1.63,1.45/3.52/0.32,2.8,6.0
4.08_{QF}=0.44,1.82,1.82/4.08/0.36,3.14,6.86
4.408_{QF}=0.46,1.98,1.96/4.408/0.24,2.69,6.86
3.52_{QF}=0.352,1.58,1.58/3.52,2.80,6.00
4.80_{QF}=0.44,2.08,2.28/4.80/0.288,2.97,7.49
3.712_{QF}=0.37,1.67,1.68/3.712/0.32,2.85,6.24
4.4_{QF}=0.44,1.98,1.98/4.4/0.24,2.74,6.9
4.8_{QF}=0.44,2.08,2.28/4.8/0.22,2.59,7.17

The values of quadratic membership function are given in Table VIII. After applying the formula (10) and formula (11), the extended average of all FR by means of extended addition and scalar multiplication is in the form of:

3.98QF=0.406,1.78,1.79/3.98/0.306,2.86,6.54.

Now we calculate the ranking values of each requirement; and as a result, we get the following ranking values of FR: fr_1 = 0.587, fr_2=0.50, fr_3=0.41, fr_4=0.571, fr_5=0.27, fr_6=0.625, fr_7=0.435, fr_8=0.488, fr_9= 0.573 and fr_{10}=0.588. On the basis of these results, we select and classify the stakeholders, as shown in Table IX.

D. Stakeholder analysis

In Table IX, S_1 and S_9 are the primary stakeholders. These stakeholders have high influence in the project. Therefore, these stakeholders have high priority during the elicitation and prioritization of requirements. NFR are considered as the criteria for the prioritization of requirements. Therefore, the priority of S_5 and S_8 is two. The selection criterion for S_2, S_3, and S_4 is functional. These three stakeholders are prioritized on the basis of the priority of requirements. In our case study, fr_6 has the highest priority, i.e., $fr_6 = 0.625$. Therefore, the priority of stakeholder S_2 is three. Similarly, the priority of S_3 and S_4 are identified from the ranking values of requirements. So, the priorities of these two stakeholders i.e., S_3 and S_4 are five and four respectively. S_6 and S_7 have the same priority, i.e., three. Finally, S_{10} has the lowest priority, i.e., 6. On the basis of our analysis, we identify that S_1 has the highest priority and has the high influence and high interest for the project, i.e., director of institute.

The objective of Table X is to classify the stakeholders on the basis of interest and influence in the project. In this Table, S_1 has high influence and high interest in the project. Therefore, the goal of this stakeholder must be understood. Requirements analyst should devote more time in order to identify the requirements of those stakeholders who belong to this group, i.e., high influence and high interest. These stakeholders provide the support for the successful development of the projects. S_9 has also the highest priority; but this stakeholder has high influence and low interest. S_2, S_3, S_4, S_5, S_6, S_7, and S_8 have high interest and low influence in the project. The priorities of such types of stakeholders are decided on the basis of the priority of the requirements. (See Table IX). Finally, S_{10} has low influence and low interest.

Those stakeholders who have high influence and low interest do not pay attention to the project details. For example S_9. These stakeholders have influence on project success and their requirements must be met. These stakeholders are helpful for the successful development of the project because of the following reasons: (i) They can vote for project approval (ii) They are the source for funding the project. S_2, S_3, S_4, S_5, S_6, S_7, and S_8 have low influence and high interest. Such types of stakeholders are valuable source of information and are helpful to identify the possible challenges. For example, S_2, S_3, S_4 are responsible for the elicitation of FRs of student module, teacher's module, and administrative modules respectively. Requirements analyst should devote less time to those stakeholders who have low influence and low interest, i.e., S_{10}.

TABLE VIII. Quadratic membership functions

FRs	**Non-functional requirements**		
	nfr_1	**nfr_2**	**nfr_3**
fr_1	4.176_{QF}	4.84_{QF}	3.84_{QF}
fr_2	4.176_{QF}	3.3_{QF}	3.84_{QF}
fr_3	3.712_{QF}	3.3_{QF}	4.08_{QF}
fr_4	4.408_{QF}	3.74_{QF}	4.56_{QF}
fr_5	3.02_{QF}	3.08_{QF}	3.36_{QF}
fr_6	4.87_{QF}	$4.\ 40_{QF}$	4.08_{QF}
fr_7	3.25_{QF}	$4.\ 40_{QF}$	$3.\ 6_{QF}$
fr_8	4.18_{QF}	3.52_{QF}	4.08_{QF}
fr_9	4.408_{QF}	3.52_{QF}	4.8_{QF}
fr_{10}	3.712_{QF}	$4.\ 40_{QF}$	4.8_{QF}

TABLE IX. Selection and classification of stakeholders

Type of stakeholder	Criteria for the selection	Requirements of stakeholders	Priority's of stakeholders
S_1	KAC, OLC	G	1
S_2	FC	fr_1, fr_6,and fr_{10}	3
S_3	FC	fr_2, fr_3, fr_4, and fr_5	5
S_4	FC	fr_7, fr_8, and fr_9	4
S_5	NFC	nfr_1, nfr_2, and nfr_3	2
S_6	FC	fr_1, fr_2, ..., fr_{10}	3
S_7	FC	fr_1, fr_2, ..., fr_{10}	3
S_8	NFC	nfr_1, nfr_2, and nfr_3	2
S_9	FC, NFC	R_{11}	1
S_{10}	FC, NFC, GC	fr_1, fr_2, ..., fr_{10}	6

TABLE X. Stakeholder Interest- Influence matrix

Influence/Interest		**Interest**	
		High	**Low**
Influence	**High**	S_1	S_9
	Low	S_2, S_3, S_4, S_5, S_6, S_7, and S_8	S_{10}

V. CONCLUSION

This paper presents a method for SI in GOREP; and includes 4 stages: specify stakeholder types, specify stakeholder roles, selecting and classifying stakeholders using fuzzy based approach, and stakeholder's analysis. In our case study, we have prioritized and categorized stakeholders on the basis of influence and interest matrix; and as a result we have identified that S_1 and S_9 have first priority because these are the primary stakeholders. Stakeholder S_5 and S_8 have second priority. S_2, S_6, and S_7 have third priority. Stakeholder S_3 and S_4 have fifth and fourth priority respectively; and finally, S_{10} has low priority among all stakeholders. The future research agenda can be listed as follows:

1. To improve the requirements elicitation processes of GORE techniques by using the proposed SI method in early phase of RE so that a complete list of stakeholders can be identified from different organization levels.
2. To explore the relationship between stakeholders using social network analysis approach [21].
3. To develop a tool to classify the requirements elicited from stakeholders according to the evaluation of their priorities on the basis of software risk and cost.

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