Advances in Computer Science and Information Technology (ACSIT)
Print ISSN: 2393-9907; Online ISSN: 2393-9915; Volume 2, Number 9; April-June, 2015 pp. 38-42

http://www.krishisanskriti.org/acsit.html

Elicitation of Preference Matrix and Contribution Values in Goal Models using Fuzzy Based Approach

Farha Ashfaque[1] and Rupak Kumar[2]

[1]M.Tech Scholar, Department of Computer Engineering, Al-Falah University, Dhauj, Faridabad, Haryana, India
[2]Department of Computer Engineering Al-Falah University Dhauj, Faridabad, Haryana, India
E-mail: [1]farha.a123@gmail.com, [2]rupak.verma@gmail.com

Abstract—*The goal oriented requirements elicitation method is used to classify the requirements of the goal model according to the need of the stakeholder. In literature,we identify that existing goal oriented requirements elicitation process like KAOS, i* do not support the prioritization of the stakeholder's needs in the decision making approach, to overcome with this problem we present a method using fuzzy based approach to prioritize the requirements. We use AND/OR graph with preference matrices and contribution values to represent graphically the requirements of a goal for the selection and prioritization of goals requirement. In this paper, we propose an effective method to get the prioritized list of requirements. Finally the utilization of proposed method is demonstrated with the help of an example.*

Keywords: *Requirements Elicitation, Attributed Goal-Oriented Requirements Analysis (AGORA), Functional Requirements (FR), Non-functional requirement (NFR), Fuzzy Set Theory.*

1. INTRODUCTION

A goal model is a component of Requirements Engineering (RE) which is used more broadly in business analysis [1]. Related elements include stakeholder analysis and context analysis and scenarios, among other business and technical areas. We visualize RE is an approach that includes five sub-approaches like requirements elicitation, requirements modeling, requirements analysis, requirements verification and validation and requirements management [2,3]. Requirements elicitation is the first approach in requirement engineering used for identifying the needs of the stakeholder with the support of various techniques like survey, interviews, questionnaire, and goal oriented methods on the basis of careful analysis of the application of an organization [2, 3].In goal oriented approach, a high level goal is decomposed into sub-goals. The decomposition is done by using AND-decomposition and OR-decomposition [4]. In Goal Oriented Requirement Analysis (GORA) methods like i*, Knowledge Acquisition in Automated Specification (KAOS) [14,15], and Goal-Oriented Requirements Language (GRL) [5,6,16] method are used for refining and decomposing the requirements of the stakeholders into more existing goals for filling the stakeholders requirements.

On the basis of our literature review, we identify that Attributed Goal Oriented Requirements Analysis (AGORA) does not support how to prioritize the FRs and NFRs when multiple decision makers involved. Therefore, the objective of this paper is to propose an AGORA method for the analysis and prioritization of software's requirement using AHP method and graded mean integration of triangular fuzzy number. In AGORA, the stakeholders attach the value individually; there is no systematic technique like Analytic Hierarchy Process (AHP) method to decide the more objective values [6].

Therefore, in order to elicit the value objectively, in this paper, we proposed a method to elicit the value of preference matrices and contribution values of AGORA method using AHP and fuzzy based approach objectively. This paper is organized as follows: In section II, we present an insight into AGORA. Section III contains the description of AHP and Fuzzy Logic. Proposed method is given in section IV. In section V, A Case Study shows how proposed method works. Finally, conclusion and future work is given in section VI.

2. AGORA METHOD

In requirement elicitation process, AGORA method is used which is an extension to the GORA where attributes values are attached to the goals by an analyst at the time of refinement and decomposing a goal to form AND/OR graphs (see Fig.1.). Attribute values are contribution values and preference values that are attached to the edges and nodes of the goal graphs. In AGORA, an analyst decides which goal is to be added to the AND-decomposition or OR-decomposition. Attaching a rationale is very useful in AGORA goal-graphs; it is attached to the attribute of the sub-goals as well as to an edge and node. AGORA is the management of the goal's complexity [6].

Preference Matrix- The preference matrices are attached to the nodes of a goal graph which represents the preference of the goal for each stakeholder. It expresses what degree a stakeholder should choose for the satisfaction of its goal. The values of preference matrices lie between the integer values -10 to +10. Each stakeholder attaches its own values with the estimate preference values of other stakeholder. In the result, the preference values of a goal are represented in the form of preference matrix [6].

Contribution values- The contribution values are added to the edges of the goal graph, stands the degree of the involvement of the sub-goals, the value can be an integer value which lies between -10 to 10. These values express the achievement of the sub-goals to its parent goal, higher the value positive value means more contribution provided by the sub-goals. Higher the negative values means less involvement or sub-goals blocked the achievement to the parent goal [6].Here, we identify that how to construct the AGORA graph for a given goal in the following manners [6]:

1. Establishing stakeholders needs as initial goals
2. Decomposing and refinement of goals into sub-goals using AND/OR decomposition
3. From decomposed goals choosing and adopting the alternatives of goals
4. Detecting and resolving confliction on goal.

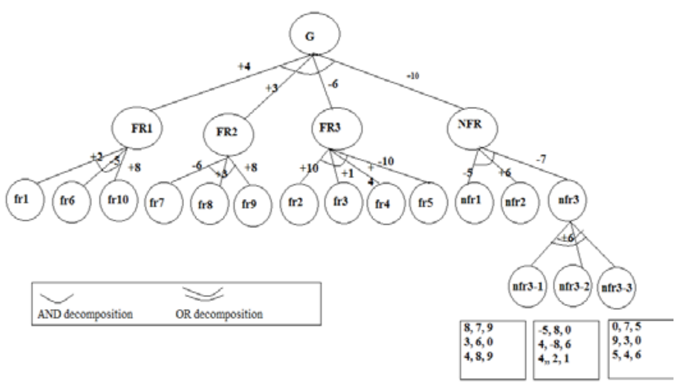

Fig. 1: AND/OR graph with contribution values and preference matrices.

Fig. 1 shows an example of a preference matrix. In this example, three stakeholders, a customer(C) i.e. FR1, an admin(A) i.e.FR2 and a user(U) i.e.FR3 participate in a requirements elicitation phase and they estimate their preference values

3. ANALYTIC HIERARCHY PROCESS

T. L. Saaty proposed the method of Analytic Hierarchy Process (AHP) in 1972 [5]. AHP is a multi- principles decision making method that permits the hierarchical structure on the basis of set of criteria and set of alternatives as per the need of the problem definition [8, 9, 10]. It is used globally in a wide variety of decision making fields like education, industry, banks, government, requirement prioritization, and in software development to select the appropriate models for developing etc. [10, 11, 12].

Table 1: Saaty Rating Scale

Intensity of Importance	Definition
1	Equal importance
3	Somewhat more importance
5	Much more important
7	Very much important
9	Absolutely important
2,4,6,8	Intermediates values (when compromise is needed)

4. FUZZY LOGIC

The concept of fuzzy logic was given by Lotfi A. Zadeh in the year of 1965. In order to calculate vague and imprecise queries fuzzy logic is used. It is a multi-valued logic that uses different values between interval [0, 1]. According to Zadeh fuzzy set is defined as: "In universe of discourse Ux, a fuzzy subset A of Ux is characterized by a membership function f A(x) where f (A): Ux [0, 1]". Fuzzy membership function associates with each member of X of Ux of a number of f(x) in the interval [0, 1], represents degree of membership function of X in A. Linguistic variables are words whose values are imprecise e.g., very low, low, average, high, very high etc. To represent linguistic variables we use fuzzy numbers. They give graphical representation of vague queries (imprecise queries). There are several types of fuzzy numbers e.g., triangular fuzzy number, bell shaped fuzzy number, Gaussian fuzzy number, triangular fuzzy number [3].

In this section, we applied the proposed method with help of five decision makers (DMs) view on FRs and NFR degree assessment of criteria. These decision makers (DMs) use five ranking parameters i.e. Very Weak (VW), Weak (W), Medium (M), Strong (S), Very Strong (VS) fuzzy assessment parameter is shown in Table 1.

Table 2: Triangular Fuzzy Linguistic variables set for FRs and NFR.

Linguistic variables Set	Abbreviation	Triangular fuzzy numbers S1(n1,n2,n3,n4)(i=1,……,5)
S1:Very Weak	VW	(0,0,0.25)
S2:Weak	W	(0, 0.25,0.5)
S3:Medium	M	(0.25, 0.5, 0.75)
S4:Strong	S	(0.5,0.75,1)
S5:Very Strong	VS	(0.75,1,1)

These DMs allocate fuzzy values to the measuring parameters according to their understanding weight for each parameter is calculated in table 2 and table 3 using equation (1)

$$\mathrm{TFN(K)} = \frac{1}{6}(a + 2b + c)\ldots\ldots\ldots\ldots\ldots\ldots \quad \ldots\ldots(1)$$

Where, TFN(K) is weight of linguistic variables using TFN and a, b and c are column wise average. In table 2 we assign fuzzy assessment of decision makers, and in table 4 evaluated weights for NFRs using equation (1)

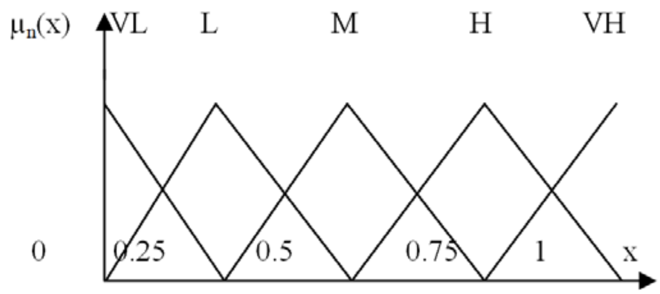

Fig. 2: Membership functions for linguistic values

(VW, W, M, S, VS) for each FRs and NFRs.

5. PROPOSED METHOD

In this section we present the proposed method which is based on FRs and NFRs. NFRs plays an important role for software requirements and prioritization. In our proposed methodology; we are prioritizing the NFRs using decision makers (DMs) opinion. DMs are stakeholders that are involved in the process of development of software project. NFRs selection and prioritization plays an important role. Hence, we form a team of five DMs for our proposed work. It includes the following steps:

1. Identification of the stakeholder of the goal.
2. Classification of functional requirements (FR) and non-functional requirements (NFRs) for Online Railway Ticket Reservation System.
3. Collect expert fuzzy assessment of FRs and NFRs.
4. Apply extent AHP for pair-wise comparisons of NFRs.
5. To elicit the DMs weight vectors we use the $L^{-1} - R^{-1}$ inverse function arithmetic principle and graded mean integration representation.
6. Construct Binary Search Tree graph.

1. Identification of stakeholder

In the first step of our proposed method we identify stakeholder. Stakeholder identification is the most important activity of a requirements elicitation process. Therefore, the first step of our method is to identify the primary and secondary stakeholders [3]. Primary stakeholders include those who are central to any project initiative, i.e., beneficiaries, financial, politicians, sponsors, and decision maker. Secondary stakeholders include developers, experts, operators etc [3].

2. Classification of Functional and non-functional requirements of anOnline Railway Ticket Reservation System (ORTRS).

In the second step we classify the functional and non-functional requirement on the basis of ORTRS []. The detail is given below:

In this step, we classify our functional and non-functional requirement on the basis of *Online Railway Ticket Reservation System.* The detail is given below:

(i). fr1: printout of payment receipt of customers; (a) Customers details: Customers name, phone number, address, destination (b) Payment details: name of bank, bank scroll number, date, CVC number, account id,
(ii). fr2: Processed for booking;
(iii). fr3: Update profile;
(iv). fr4: choose emergency/ normal ticket;
(v). fr5: ticket send to mail/ print ticket ;
(vi). fr6: fill ticket form; and after successful submission of the form system will generate the following information: (a) name of customer, (b) train number, (c) seat number, (d) destination, (e) arrival time , (f) departure time(g) Date/Time
(vii). fr7: upload any up-down information related to train;
(viii). fr8: generate ticket;
(ix). fr9: approve ticket form;
(x). fr10: online payment of ticket.

Customer module (FR1) is decomposed into three sub requirements, i.e., fr1, fr6, and fr10; and there is an AND decomposition among these requirements. Admin module (FR2) is decomposed into three sub-requirements, i.e., fr7, fr8, fr9; and there is also an AND decomposition among these requirements. User module (FR3) is decomposed into four sub-requirements, i.e., fr2, fr3, fr4, and fr5. Similarly, Trustworthiness (NFR) is further decomposed into four sub-requirements, i.e., nfr1: Security; nfr2: Maintainability and nfr3: Reliability. There is also an AND decomposition among these requirements. Reliability, i.e., nfr3is further decomposed into three sub- requirements, i.e., nfr3-1: recoverability; nfr3-2: accuracy; and nfr3-3: fault-tolerance. There is an OR decomposition among these requirements. OR decomposition means that the selection of any requirements leads to the achievement of the parent requirements [11].

3. Collect expert fuzzy assessment of NFRs.

In this step we collect experts view in form of linguistic variables such as Very Weak (VW), Weak (W), Medium (M), Strong (S), Very Strong(VS) for FRs and NFRs as shown in table 2.

4. Apply extent AHP for pair-wise comparisons of NFRs.
In this step, we use AHP for pair-wise comparisons of NFRs which was introduced by T.L. Saaty using Table 1.

5. Elicitation of DMs weight for the each NFRs L^{-1}, R^{-1} inverse function arithmetic principle and graded mean integration representation.
We apply L^{-1}, R^{-1} function arithmetic principal and graded mean method for the elicitation of decision maker's weight. A brief introduction is given below:

Let A1 = (a1, b1, c1) and A2 = (a2, b2, c2) be two trapezoidal fuzzy numbers as Fig. 1. The addition of A1 and A2 at h-level is:

Generalized triangular fuzzy number K = (a,b,c,) is a special case of generalized trapezoidal fuzzy number. The graded mean integration representation of the triangular fuzzy number Y becomes

$$\mathrm{TFN(K)} = \frac{1}{6}(a + 2b + c +)................ \qquad ....(1)$$

6. Construct the Binary Tree graph using the calculated weight.
Finally in this step we construct the Binary Search Tree. The BST lists the elements in ascending order.

6. CASE STUDY

In this section, we applied the proposed method with help of five decision makers (DMs) analysis on FRs and NFR degree assessment of criteria. These decision makers (DMs) use five ranking parameters i.e. Very Weak (VW), Weak (W), Medium (M), Fair (F), Strong (S), Very Strong(VS) fuzzy assessment parameter is shown in Table 2.

These DMs allocate fuzzy values to the measuring parameters according to their understanding. Weight for each parameter is calculated in table 3 using equation (1).

Table 3: Fuzzy importance weight by five Decision Makers for each FRs.

Commonly used FRs	DM1	DM2	DM3	DM4	DM5	WEIGHT
fr1	H	VH	VH	H	VH	0.87
fr2	VH	H	VH	M	H	0.78
fr3	H	L	M	VH	M	0.53
fr4	VH	M	H	VL	H	0.60
fr5	H	VH	L	VH	M	0.68
fr6	M	H	VH	H	L	0.59
fr7	L	H	VL	H	M	0.46
fr8	H	VL	L	M	M	0.43
fr9	M	M	VL	L	H	0.38
fr10	H	L	VH	H	M	0.64

Pairwise comparisons of three NFRs using AHP method values given by five Decision Makers using T. L. Saaty Rating Scale using Step 4.

Overall Preference matrix =

$$\begin{array}{c} \\ \mathrm{nfr1} \\ \mathrm{nrf2} \\ \mathrm{nfr3} \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr1} & \mathrm{nfr2} & \mathrm{nfr3} \end{array} \\ \begin{bmatrix} 1 & 1/2 & 3 \\ 2 & 1 & 4 \\ 1/3 & 1/4 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .30 \\ .60 \\ .10 \end{bmatrix}$$

$$\mathrm{DM1}= \begin{array}{c} \\ \mathrm{nfr3}-1 \\ \mathrm{nfr3}-2 \\ \mathrm{nfr3}-3 \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr3}-1 & \mathrm{nfr3}-2 & \mathrm{nfr3}-3 \end{array} \\ \begin{bmatrix} 1 & 7 & 5 \\ 1/7 & 1 & 5 \\ 1/5 & 1/5 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .70 \\ .22 \\ .08 \end{bmatrix}$$

$$\mathrm{DM2}== \begin{array}{c} \\ \mathrm{nfr3}-1 \\ \mathrm{nfr3}-2 \\ \mathrm{nfr3}-3 \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr3}-1 & \mathrm{nfr3}-2 & \mathrm{nfr3}-3 \end{array} \\ \begin{bmatrix} 1 & 5 & 5 \\ 1/5 & 1 & 7 \\ 1/5 & 1/7 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .64 \\ .28 \\ .08 \end{bmatrix}$$

$$\mathrm{DM3}== \begin{array}{c} \\ \mathrm{nfr3}-1 \\ \mathrm{nfr3}-2 \\ \mathrm{nfr3}-3 \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr3}-1 & \mathrm{nfr3}-2 & \mathrm{nfr3}-3 \end{array} \\ \begin{bmatrix} 1 & 1/5 & 7 \\ 5 & 1 & 7 \\ 1/5 & 1/7 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .28 \\ .64 \\ .08 \end{bmatrix}$$

$$\mathrm{DM4}== \begin{array}{c} \\ \mathrm{nfr3}-1 \\ \mathrm{nfr3}-2 \\ \mathrm{nfr3}-3 \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr3}-1 & \mathrm{nfr3}-2 & \mathrm{nfr3}-3 \end{array} \\ \begin{bmatrix} 1 & 1 & 5 \\ 1 & 1 & 1 \\ 1/5 & 1 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .50 \\ .30 \\ .20 \end{bmatrix}$$

$$\mathrm{DM5}== \begin{array}{c} \\ \mathrm{nfr3}-1 \\ \mathrm{nfr3}-2 \\ \mathrm{nfr3}-3 \end{array} \begin{array}{c} \begin{array}{ccc} \mathrm{nfr3}-1 & \mathrm{nfr3}-2 & \mathrm{nfr3}-3 \end{array} \\ \begin{bmatrix} 1 & 5 & 1 \\ 1/5 & 1 & 7 \\ 1 & 1/7 & 1 \end{bmatrix} \end{array} = \begin{bmatrix} .46 \\ .34 \\ .20 \end{bmatrix}$$

Ranking of Alternatives=

$$\begin{bmatrix} .70\ .64 & .28 & .50\ .46 \\ .22\ .28 & .64 & .30\ .34 \\ .08\ .08 & .08 & .20\ .20 \end{bmatrix} * \begin{bmatrix} .30 \\ .60 \\ .10 \end{bmatrix}$$

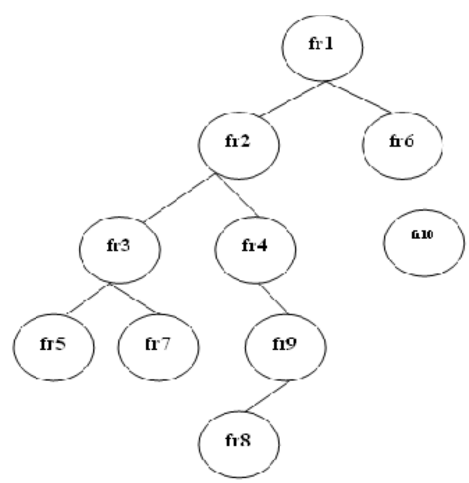

Fig. 2: Binary Search Tree

After the calculation, we identify the following values : (0.49, 0.22, 0.29). As a result, nfr3-1 1.e., recoverability is having highest weight values i.e., 0.49.After the assessment of all the commonly used NFRs we found that the Security has the highest priority value now we try to implement the Online Railway Ticket Reservation System using high values of all the commonly used FRs. Now we construct the Binary Search Tree according to the fuzzy assessment value of FRs using Table 3.

7. CONCLUSION

This paper presents a method of fuzzy based approach. In order to strengthen the goal oriented requirements elicitation process in proposed approach, we used preference matrices and contribution values and AHP in group decision making process. To get the prioritized list of requirements we used binary tree sort method. To simply show how proposed approach works, a numerical example is shown to illustrate the fuzzy group decision making approach in goal oriented requirements elicitation process. In our example, we assumed that there are ten FRs, three criteria, i.e., security, maintainability and reliability for the prioritization of requirements and five DM are participating to prioritize the requirements. On the basis of our analysis, we identify that fr6 is the most important requirements and it would be implemented first; and fr5 would be implemented in the last. However, the method discussed in this paper can be further exploited by considering more sub-goals/requirements and criteria as well as much larger group of stakeholders in group decision making process. The future research agenda can be listed as follows:

1. By using hybrid hierarchical structure.

2. To propose a fuzzy Analytic Hierarchy Process

REFERENCES

[1] Kotonya, G. and Sommerville, I., Requirements Engineering, Process and Techniques, Willy New York 1998.

[2] Sadiq M and Jain SK "A Fuzzy Based Approach for the Selection in Goal Oriented Requirements Elicitation Process", International Journal of SystemAssurance Engineering andManagement, Springer, 2014.

[3] Sadiq M and Jain SK "Applying Fuzzy Preference relation for Requirements Prioritization in Goal Oriented Requirements Elicitation Process", International Journal of SystemAssurance Engineering andManagement, Springer Vol. 5 Issue 4 pp. 711-723, 2014.

[4] Mumtaz Ahmad Khan, Azra Parveen, Mohd. Sadiq "A method for the selection of software development life cycle models using Analytic Hierarchy Process" 2014 IEEE.

[5] Saaty T, "The Analytic Hierarchy Process", New York : Mc Graw-Hill, 1980Haruhiko Kaiya "AGORA: Attributed Goal-Oriented Requirements Analysis Method"2002 IEEE.

[6] Kaiya "AGORA: Attributed Goal-Oriented Requirements Analysis Method"2002 IEEE

[7] Mairiza Dewi and Zowghi Didar, "Constructing a Catalogue of conflicts among Non-functional requirements," L.A

[8] Sadiq M and Jain SK, "Stakeholders Identification Methods in Goal Oriented Requirements Elicitation Process," Fifth IEEE International Workshop on Requirements Prioritization and Communication at IEEE International Requirements Engineering Conference (RE), pp. 25-33, Karlskrona, Sweden.

[9] Mohd.Sadiq "Elicitation and Prioritization of Software Requirements" International Journal of Recent Trends In Emerging, Vol 2, No.3, November 2009y.

[10] A. Ishizaka and A. Labib, "Review of the Main development in the Analytic Hierarchy Process", Experts System with Applications, Vol.38, No.11,pp.14336-14345,2011.

[11] Mohd. Sadiq, Jawed Ahmad, Mohammad Asim, Aslam Qureshi, R,Suman ,"More On Elicitation Of Software requirements and prioritization using AHP", IEEE International Conference On Data Storage And Data Engineering pp 232-236, Bangalore, India, 2010.

[12] Mohd. Sadiq, Shabina Ghafir, Mohd. Shahid, "An approach for eliciting Software Requirements and its Prioritization using Analytic Hierarchy Process", IEEE International Conference on Advances in Recent Technologies in Communication and Computing, pp.790-795 Kerela, India, 2009.

[13] Sadiq M and Jain S.K. "A Fuzzy Based Approach for Requirements Prioritization in Goal Oriented Requirements Elicitation Process", 25th International Conference on Software Engineering and Knowledge Engineering, Boston, USA, June 29, 2013.

[14] Mairiza Dewi, Zowghi Didar, Nurmuliani Nurie "An Investigation into the Notion on Non-functional Requirements," SAC10 pp. 22-26, Sierre Switzerland March 2010.

[15] i* homepage. *http://www.cs.toronto.edu/km/istar/.*

[16] J. Mylopoulos, L. Chung, and E. Yu.From Object-Oriented to Goal-Oriented Requirements Analysis.*Communications Of the ACM*, 42(1):31–37, Jan. 1999.

[17] GRL homepage. *http://www.cs.toronto.edu/km/GRL/.*