Advances in Computer Science and Information Technology (ACSIT)
Print ISSN: 2393-9907; Online ISSN: 2393-9915; Volume 2, Number 9; April-June, 2015 pp. 33-37

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

Integration of Agora into Analytic Hierarchy Process

Farha Ashfaque[1], Yusra[2] and Rupak Kumar[3]

[1,2]M.Tech Scholar, Department of Computer Science and Engineering, Faculty of Engineering and Technology Al-Falah University, Dhauj, Faridabad, Haryana, India
[3]Department of Computer Engineering Al-Falah University Dhauj, Faridabad, Haryana, India
E-mail: 1farha.a123@gmail.com, 2graceyusra2013@gmail.com, 3rupak.verma@gmail.com

Abstract—*In requirements elicitation process, Attributed Goal-Oriented Requirement Analysis (AGORA) method is used to construct AND/OR graph, in which attribute values are contribution values and preference matrix are added to the edges and nodes of the goal graph at the time of refining and decomposing of a goal. Analytic Hierarchy Process (AHP) is a method, which helps decision makers for facing a composite problem with multiple confliction and subjective criteria. In this paper, we are integrating AGORA method into AHP. Finally, the utilization of proposed method is demonstrated with the help of an example.*

Keywords*: Requirements Engineering, Analytic Hierarchy Process, Attributed Goal-Oriented Requirement Analysis, Non-Functional Requirements.*

1. INTRODUCTION

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, use-case diagram, meetings and goal oriented methods on the basis of careful analysis of the application of an organization [2, 3]. In [4], the requirements elicitation techniques are categorize on the basis of traditional, cognitive, collaborative, and contextual techniques. Traditional techniques are used to classify the limitation of the present system by using different methods like interview, questionnaire etc. Cognitive technique comprises task analysis, and knowledge acquisition technique etc.

Actions like selecting and prioritizing of software requirements uses Collaborative techniques [3]. In Contextual technique, requirements are identified at the work space of the customer. [3]. In Literature,we identifyseveral methods are proposed to elicit the requirements of the stakeholder like use-case diagrams,goal-oriented methods. In goal oriented approach, a high level objective of an organization is decomposed into sub-goals. The decomposition is done by using AND-decomposition and OR-decomposition [2]. In Goal Oriented Requirement Analysis (GORA) methods like i*, Knowledge Acquisition in Automated Specification (KAOS) [15, 16], and Goal-Oriented Requirements Language (GRL) [6,8,17] method are used for refining and decomposing the requirements of the stakeholders into more existing goals for filling the stakeholders requirements. Kaiya et al. [6], in 2012 identified that these methods do not include the holds for assisting the following actions:

1. Selection of goals to be decomposed
2. Prioritizing and solving the confliction among goals and confliction among goals and stakeholders
3. Choosing and adaptation of a goal from the alternatives of the goals as a requirements
4. When requirements change analyze the impacts
5. To improve quality of a developed method based on the quality of requirements

To solve the above problems and support the goal oriented methods, Kaiya et al. [6], proposed AGORA method i.e., used for requirement elicitation which is an extended description of GORA, where attribute values are contribution values and preference matrices are added to the goal graphs [6]. 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 of integration of an extended version of GORA with AHP to elicit the value of preference matrices and contribution values objectively. This paper is organized as follows: In section II, we present an insight into AGORA. Section III contains the description of AHP and NFRs. 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. OVERVIEW OF AGORA

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 Here, we identify that how to construct the AGORA graph for a given goal in the following manners [6]:

1. Establishing stakeholders needsas 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 goals

2.1. Establishing initial goals

Initials goals are the requirements of the stakeholders, and placed at the root nodes of the AGORA graph by an analyst [6].

2.2. Decomposing and refinementof goals

This is the second step of AGORA graph represents the decomposing and refinement of the organizational goal into sub-goals. The sub-goals are attached to its parents by direct edges with AND/OR decomposition with contribution values and preference values are added to the goals by an analyst [6].

2.3. Choosing and adopting the goals from the alternatives

In this step, one sub-goal is selected for attaining its parent goal if there is an OR-decomposition of the parent goal. The contribution and preference values supports analyst to select the appropriate sub-goals [6].

2.4. Detecting and resolving confliction on goals

The conflictions are of two types on goals; one is the conflict among goals and the other conflict is on goal and among the stakeholders, an analyst detects and resolves the right confliction among these [6].

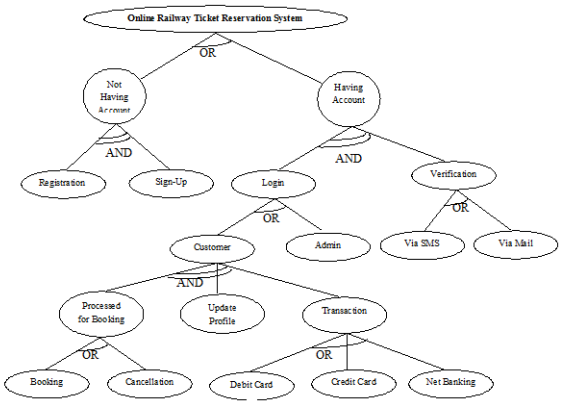

Fig. 1: AND/OR graph

3. ANALYTIC HIERARCHY PROCESS

T.L. Saaty proposed AHP in 1972 [5]. AHP is a multi-criteria decision making procedure that constructs the hierarchical structure of the organizational goal on the basis of sets of criteria and sets of alternatives by allotting the weights to the criteria for best solutions [8, 9]. 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]. The four steps involved in AHP method which are as follows: (i) problem description (ii) pair-wise comparisons of all criteria (iii) calculate the eigenvector to compare the rank of the criteria (iv) check consistency. After recognizing the criteria of a problem definition by the stakeholder then decision makers find the alternatives with respect to the criteria. Then, pair-wise comparison is done on the basis of alternatives, and a pair-wise matrix is constructed according to the Saaty rating scale [4].

Table1: 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)

As in AGORA, the stakeholders attach the value subjectively; there is no systematic technique like AHP method to decide the more objective values [6]. So, we decomposed the problem definition on the basis of NFRs as criteria. NFRs are those requirements that require criteria that can be used to justify the operation of a goal activity [8]. We classified the criteria as security, usability,maintainability and reliability (see Fig.2.).

Security- Security requirement is concerned to avoid the illegal use to the system or the data of program from an unauthorized user [7, 14].

Usability- Usability requirement is concerned with the communication between the system and the user (like-login process of user/admin/customer) [7, 14].

Maintainability- Maintainability is the ability of the software to modify information or to make changes in the data (like-updating of data/ update profile) [7, 14].

Reliability- Reliability is the ability to perform the process without failure or fault; it performs the operation of the system on the basis of correctness, recoverability, fault-tolerance etc (like- booking/cancellation/transaction) [7, 14].

Algorithm-

Consider [$Ax = \lambda_{max} X$] where

i. A is the comparison matrix of size n×n, for n criteria, also known as priority matrix.
ii. X is the Eigenvector of size n×1, also known as priority vector.
iii. λ_{max} is the Eigenvalue,

To find the ranking of priorities with the Eigen Vector X:

1) Normalization of the column entries by dividing each entry by the sum of the column.

2) Calculate the overall row averages.

4. PROPOSED METHOD

In this section, we present the proposed method Integration of Attributed Goal-Oriented Requirements Analysis into Analytic Hierarchy Process. Proposed method includes the following steps (see Fig: 2):

(a) Identify the problem definition.
(b) Identify the criterion on the basis of NFRs.
(c) Construct the hierarchical structure.
(d) Construct the decision matrix to calculate the eigenvector.
(e) Calculate the consistency
(f) Identifies the ranking values of alternatives.

Identify the problem definition

In this step an analyst identifies the problem and the requirements of the activity of an organization according to the need of the customers and users and tries to find out the best possible solution to choose and adopt the parameter.

Identify the criterion on the basis of NFRs

On the basis of literature review, we have identified the following criterion using NFRs for decision making process to find out the appropriate parameter to book a ticket like Security, Usability, Maintainability and Reliability.

Construct the hierarchical structure

In this step, we break our problem definition into sub-problems using NFRs. The hierarchical structure consists of three levels. In step 1, we identify our problem definition, in step 2, we identify the criteria and at step 3, we identify alternatives of the problem (see Fig. 2) on the basis of AND/OR graph using Fig. 1.

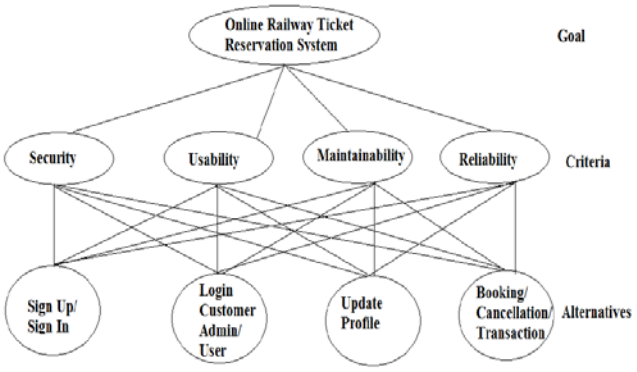

Fig. 2: Hierarchical Structure for Reservation of Ticket Selection Problem

Construct the decision matrix to calculate the eigenvector

With the help of T.L. Saaty Rating Scale, we create a decision matrix which is known as overall preference matrix using AHP method to calculate the eigenvector.

Identifies the ranking values of alternatives

Ranking values of alternatives are calculated by the pair-wise comparison of criteria and one-by-one comparison of alternatives for the selection of parameter which has more prioritization than others.

5. CASE STUDY

In this section, we apply the proposed method on the Online Railway Ticket Reservation System for the selection of the best first alternative of the problem definition according to the stakeholders need to book a ticket. The objective of this proposed method is to select the first step to reserve a ticket. We have identified the resulting criteria for the selection (step I): security, usability, maintainability, reliability. The hierarchical structure of the first priority of selection problem is given in Fig: 2 (step II). In step III, we have distinct the initial matrix for the pair-wise comparison. The initial matrix contains the principal diagonal entries of 1 as each factor is significant as itself. To do the pairwise comparison between all the criteria, we decided that security is more important than usability. In the next matrix table, i.e., Table 3 is rated as 9 in the cell, security and usability is 1/9 and we likewise decided that maintainability is more important than reliability. By using Saaty Rating Scale we complete the matrix, the complete matrix is known as "Overall Preference Matrix (OPM)".

Table 2: Overall Preference Matrix

Criteria	Security	Usability	Maintainability	Reliability
Security	1	9	7	5
Usability	1/9	1	3	4
Maintainability	1/7	1/3	1	2
Reliability	1/5	1/4	1/2	1

To find the eigenvector related to each criterion is calculated by the above algorithm. After the calculation we find the following values of eigenvector: (0.64, 0.20, 0.10, 0.06). The acknowledged four values are of security, usability, maintainability, and reliability.

Calculation of Consistency

After the calculation of Eigenvector we find the consistency Ratio (CR) of the problem definition.

Calculation of λmax,

[$AX=\lambda max\ X$], where X is Eigenvector and A is the Overall Preference Matrix

$$= \begin{vmatrix} 1 & 9 & 7 & 5 \\ 1/9 & 1 & 3 & 4 \\ 1/7 & 1/3 & 1 & 2 \\ 1/5 & 1/4 & 1/4 & 1 \end{vmatrix} * \begin{vmatrix} 0.64 \\ 0.20 \\ 0.10 \\ 0.06 \end{vmatrix} = \begin{vmatrix} 3.44 \\ 0.810 \\ 0.37 \\ 0.28 \end{vmatrix}$$

λmax = avg [3.44/0.64, 0.81/.20, 0.37/0.10, 0.28/0.06]

= [5.37, 4.05, 3.7, 4.6]/4 = 4.43

CI= λmax-n/n-1=0.14

After finding the consistency we compare the criteria, one by one to find the ranking of alternatives for Table 4, Table 5, Table 6 and Table 7.

Table 3: for security

Security	A1	A2	A3	A4
A1	1	5	4	6
A2	1/2	1	1/4	¼
A3	1/5	4	1	4
A4	1/6	4	1/4	1

Table 4: For Usability

Usability	A1	A2	A3	A4
A1	1	2	5	1
A2	1/2	1	3	2
A3	1/5	1/3	1	1/4
A4	1	½	4	1

Table 5: For Maintainability

Maintainability	A1	A2	A3	A4
A1	1	6	4	1/2
A2	1/6	1	3	5
A3	1/4	1/3	1	6
A4	2	1/5	1/6	1

Table 6: For Reliability

Reliability	A1	A2	A3	A4
A1	1	1/4	4	1/6
A2	4	1	4	1/4
A3	1/4	1/4	1	1/5
A4	6	4	5	1

Row Averages of Security, Usability, Maintainability and Reliability are multiplied by eigenvector to find the ranking of alternatives.

$$\text{Ranking Alternatives} = \begin{vmatrix} 0.55 & 0.38 & 0.41 & 0.13 \\ 0.07 & 0.29 & 0.23 & 0.25 \\ 0.25 & 0.07 & 0.18 & 0.07 \\ 0.13 & 0.26 & 0.18 & 0.55 \end{vmatrix} * \begin{vmatrix} 0.64 \\ 0.20 \\ 0.10 \\ 0.06 \end{vmatrix}$$

After the calculation, we identify the following values : (0.47, 0.16, 0.19, 0.18) from Table 3, Table 4, Table 5 and Table 6. On the basis of our examination we have identified that Security Requirement is far important than Usability, Maintainability and Reliability. The value specifies that for booking an online ticket we emphasize only on NFRs. The stakeholders will sign-up/sign-in the system by using personal information, so there must be some security requirements in the system. So, the sign-up/sign-in are the security NFRs. And login of a stakeholder/ admin/ customer is the usability requirements of a system and update profile and booking/cancellation/transaction are the maintainability and reliability requirements of a system.

6. CONCLUSION AND FUTURE WORK

In this paper, we have presents an integration of AHP with AGORA, which is a method for requirement elicitation of which is an extension of GORE method in which attribute values are added to the goal graphs to construct a AND/OR graphs. We used a method for the selection of NFRs requirements to book an online railway ticket using the proposed method as: (a) Identify the problem definition. (b) Identify the criterion on the basis of NFR's. (c) Construct the hierarchical structure. (d) Construct the decision matrix to calculate the eigenvector. (e) Identify the ranking values of alternatives. For future work we will propose a fuzzy based approach for the decision making method using:

(i) Using hybrid hierarchical structure.
(ii) Using fuzzy AHP.

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 Maciaszek and P. Loucopoulos (Eds.):ENASE 2010, CCIS 230, pp.31-44, Springer-Verlag Berlin Heidelberg 2011.

[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, Vol2, 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.*CommunicationsOf the ACM*, 42(1):31–37, Jan. 1999.

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