REASONING ABOUT GOAL SATISFACTION FOR EARLY REQUIREMENTS ENGINEERING IN THE *i** FRAMEWORK USING INTER-ACTOR DEPENDENCY

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Abstract

In the software development cycle, requirements engineering plays a major role in the success of a software system. In early requirement engineering, various alternative design options for software are explored and the best ones are selected. The requirements analyst uses goal models to analyse different design alternatives. Goal models like the i*, and Tropos include inter-actor dependencies where an actor depends on other actors for its goal accomplishment. However, goal models like Non-Functional Requirements(NFR), Knowledge Acquisition in Automated Space (KAOS) do not include these type of inter-actor dependencies. Whilst there have been a number of both qualitative and quantitative proposed approaches to analysing goal models without using inter-actor dependency, this paper presents an approach to the automate analysis of goals using inter-actor dependencies and fuzzy concepts. A simulation for the proposed approach was developed in Visual C++ and was evaluated with case studies from the existing literature. The evaluation results show that the proposed approach is feasible and offers a guidance in the decision making of alternative options.

Keywords: Requirements Engineering, Goal Model, Inter-actor Dependency, *i** Framework, Goal Satisfaction.

1. INTRODUCTION

Requirements engineering (RE) emphasises "*the use of systematic techniques to ensure the completeness, consistency, and relevance of the system requirements*" (Chung et al. 2000). Requirements of software system are classified as functional or behavioural requirements (goals) and non-functional requirements (soft goals). Functional requirements define the function of the system or its components. Non-functional requirements are the criteria for checking the system's operation rather than specific behaviour. Non-functional requirements like usability, integrity and security have more impact on software systems than the functional requirements(K.Pohl et al. 2011). Many methods have been developed to meet the modeling of requirements of a given system. One type of approach is Goal-Oriented Requirement Engineering (GORE) which is tailored for requirements analysis in the early stages of software development cycle. The popular GORE frameworks are Non-Functional Requirements (NFR) framework (Chung et al. 2000), Knowledge Acquisition in Automated Space (KAOS) (Dardenne et al. 1991), i* framework (E.Yu 1995), Tropos (Bresciani et al. 2004) Goal-Oriented Requirement Language (GRL) (D. Amyot et al. 2010) and Attributed Goal-Oriented Requirements Analysis (AGORA) (Motoshi Saeki et al. 2002).

In addition to modeling, analysts use goal models to find goals satisfaction, to evaluate design alternatives, to choose the system design, analyse risk and decide the requirements' prioritization. During design alternatives evaluation, analysts explore different design alternatives and select the best ones using some evaluation criteria. Soft goals in goal models are used as evaluation criteria in existing approaches such as quantitative and qualitative (J. Mylopoulos et al. 1992). During the evaluation process, the qualitative or quantitative values are propagated from the bottom soft goals to the top soft goals in a goal model. The satisfaction levels of soft goals are assessed based on the selected design alternative. The design alternatives that best gives best satisfaction to the soft goals are selected. Compared with KAOS and NFR, the frameworks like i*, GRL and Tropos goal model shows different actors and their dependencies. Each actor depends on other actors for goal accomplishment. These interdependencies are also influential in the decision-making of alternative design options (Bresciani et al. 2004, D. Amyot et al. 2010 and E. Yu et al. 2011).

There is a paucity of studies of inter-actor dependencies in goal analysis in the existing RE literature. In a goal model an actor may depend on other actors for goal achievement, task performance and for resources. Therefore, inter-actor dependencies play an important role in goal analysis of any system. In the qualitative approach proposed by Horkoff and Yu (2009), one or more goals may contribute the same label to a soft goal; hence leading to uncertainty in decision-making. The main concern with the quantitative approach proposed by D. Amyot et al. (2010) is the limitations from the use of numeric numbers. It is hard to assign exact numerical values to the links and the intentional elements. Stakeholder's requirements are often specified in linguistic terms and are therefore difficult to represent in exact numeric numbers. Fuzzy numbers can be more easily used to represent the vagueness associated with stakeholder's requirements (Zadeh 1965 and Zadeh 1975).

The use of fuzzy numbers can be an improvement over existing approaches which assign a single point value to the qualitative labels like -0.5 for hurt, -1 for break. The expressiveness is therefore somewhat better than the point-value approach, taking into account the "fuzziness" that comes with qualitative concepts such as "partially" or "hurt" versus "break". Sidiq and Jain (2014) have used fuzzy based Analytical Hierarchy Process (AHP) to prioritize the requirements in goal elicitation. Therefore, the objective of this paper is to propose a fuzzy-based approach to evaluate goals using inter-actor dependencies in an i* framework and is based on our previous work (Chitra et al. 2015) of quantitative reasoning of goals / tasks by fuzzy numbers. Furthermore, the central issue associated with goal models is Scalability, which makes decision making a challenging task (Chung et al. 2000, Lamsweerde et al. 2004, Heaven et al. 2011 and Liaskos et al. 2010). This paper proposes to overcome the scalability issue by automating the goal analysis. Automation can support quick decision-making by avoiding the need for customer interaction. As such, this paper presents an automated fuzzy-based approach to evaluate goals using inter-actor dependencies in the i* framework.

The remainder of the paper is structured as follows: Section 2 provides an overview of the *i** framework and an overview of fuzzy numbers; Section 3 explains our proposed fuzzy-based goal analysis using inter-actor dependency; Section 4 presents the simulation and evaluation of the proposed approach using two case studies from existing literature; Section 5 discusses related works; Section 6 concludes and outlines the future work of the paper.

2.BACKGROUND

The modeling in requirements engineering has seen an evolution from conceptual entity relationship modeling to object-oriented, use case modeling and goal-oriented modeling (Mylopoulos et al. 1999). Goal-oriented modeling is tailored for early requirement analysis, whereas other models are tailored for late requirement analysis in the software development cycle. Among the different goal-oriented models, the *i** framework captures the social elements of the system and can be used for reasoning, especially at the requirements level (E. Yu, 2009). This section briefly describes the *i** framework and the fuzzy numbers that are used in the proposed approach.

2.1 *i** Framework

The *i** framework proposed by Eric Yu (1995) deals with two kinds of models: the Strategic Dependency (SD) model and the Strategic Rationale (SR) model (E. Yu 1995). In the following section, the Strategic Dependency diagram (Figure 1) represents a stakeholder's relationships, while the Strategic Rationale diagram (Figure 2) represents the detailed level of modeling of stakeholders that can provide internal intentional relationships.

An SD model is a graph in which the nodes represent the actors and the links represent the interdependency between the actors. Goal, soft goal, task and resources are the intentional elements. A dependency can be any one of the intentional elements. An SD model is a higher level of abstraction representing the actors' dependency upon each other. An SD model targets external relationships and does not disclose details of internal structure. An example of an SD diagram is shown in Figure 1. In this figure, actors are represented by circles, goals by ovals, soft goals by cloud symbols, resources by rectangles and tasks by hexagonal shapes.

An SR model assigns the intentional elements goals, tasks, resources and soft goals to actors. It describes how actors achieve their goals. Intentional elements are linked by MEANS-END relationships, TASK decomposition and soft goal contributions. An SR model can be viewed as a graph that shows the decomposition of high-level goals into lower level goals by MEANS-END / TASK decomposition. In means-end relationships, a mean node can represent a soft goal or a task, and an end node can be a goal, a soft goal, a resource or a task. A means-end links a task to a goal, implying that a particular method is used to achieve a goal. Task decomposition shows the sub-goals, resources and soft goals that are to be carried out to ensure success of a task. A soft goal contribution can be any of the following types: help, make, some+, some-, hurt, or break. An instance of SR model is shown in Figure 2. The figure shows three actors *Kids and Youth*, *Organisation* and *Counsellors*. The detailed intentional elements are shown for the actor *Kids and Youth*. There are inter-actor dependencies between the actors. The actor *Organisation* depends on actor *Counsellor* through soft goal dependency *HighQualityCounselling*. These inter-actor dependencies influence the decision making of each actor. The proposed approach uses these inter-actor dependencies in goals evaluation. Readers may refer to E.Yu for further details (E.Yu et al. 2011).

2.2 Fuzzy Numbers

In RE, when the requirements are vague, imprecise and represented by linguistic terms, it is convenient to represent them by fuzzy numbers. The proposed approach uses fuzzy numbers to represent the

stakeholder's requirements. A Fuzzy number is an extent of real number that represents a related set of values, where each value has its own weight between 0 and 1.

Fuzzy set is a notion introduced by Zadeh and is defined as "A collection of objects with graded membership between 0 and 1" and represent a fuzzy set A as {(x, µA(x))| x ∈ X, 0 ≤µA(x) ≤ 1}, where µA(x) is a membership function (Zadeh 1965 and Zadeh 1975).

Triangular and Trapezoidal fuzzy numbers are commonly used fuzzy numbers. Triangular fuzzy numbers (TFN) are in the form $\bar{A}$= (a1, a2, a3) as in Figure 3. The parameter a2 is the value where the membership function of a fuzzy number is 1.0; a1 is the left distribution of the confidence interval and a3 the right distribution of the confidence interval:
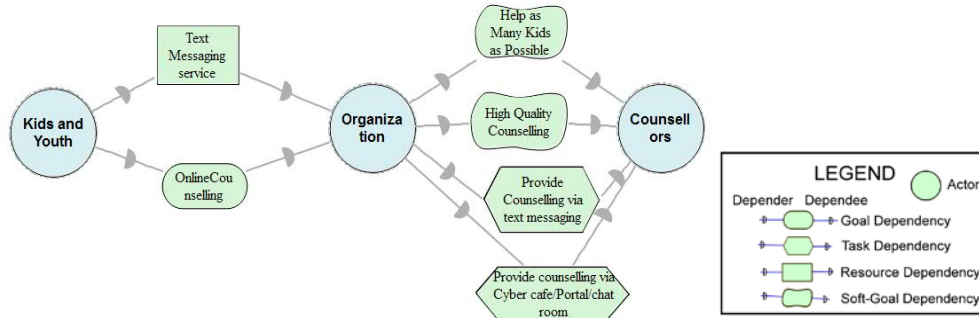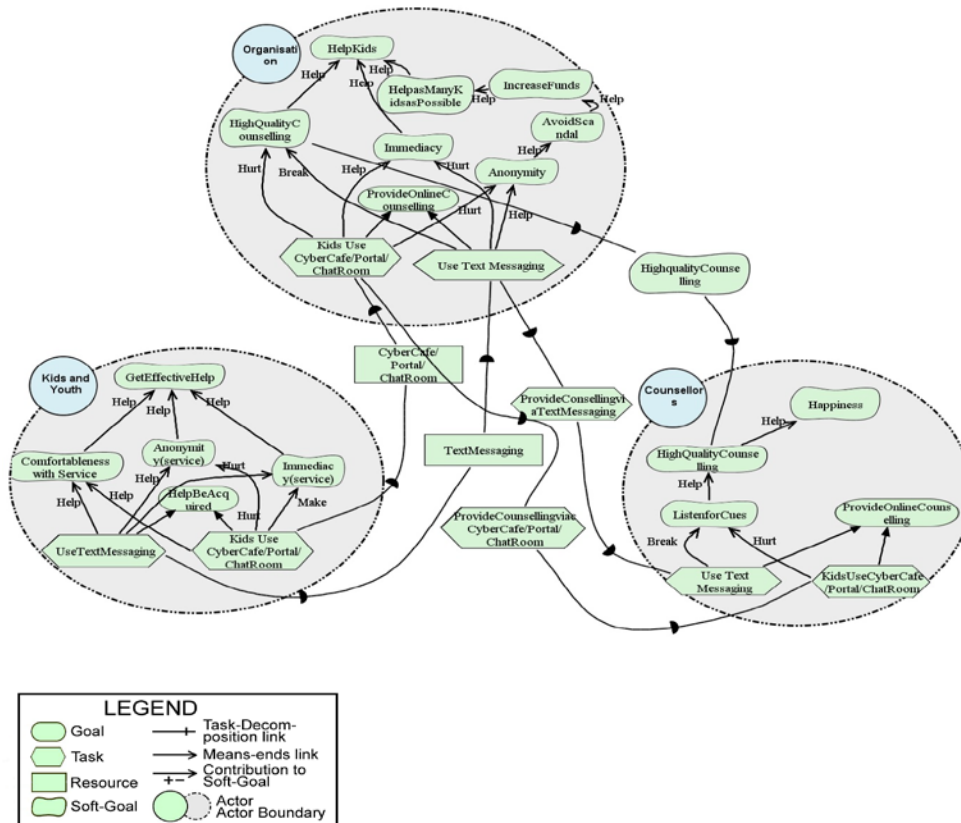

Figure 1: SD Model.

Figure 2: SR Model: Youth Counseling Example (adapted from Horkoff and Yu, 2009).

$$\mu \overline{A}(x) \ = \ \begin{cases} \frac{x-a1}{a2-a1}, a1 \leq x \leq a2 \\ \frac{a3-x}{a3-a2}, a2 \leq x \leq a3 \\ \quad 0, otherwise \end{cases}$$

A few arithmetic operations that are performed on TFN are addition, subtraction, multiplication, and division, α- cut (Gani 2012).

Let $\overline{A}$ = (a1, a2, a3) and $\overline{B}$ = (b1, b2, b3) are two fuzzy numbers then,
Addition:

$$\overline{A} + \overline{B} = \text{(a1+b1, a2+b2, a3+b3)}.$$

Subtraction:

$$\overline{A} - \overline{B} = \text{(a1-b3, a2-b2, a3-b1)}.$$

Multiplication:

$$\overline{A} * \overline{B} = \text{(min (a1*b1, a1*b3, a3*b1, a3*b3), a2*b2, max (a1*b1, a1*b3, a3*b1, a3*b3))}.$$

Division:

$$\overline{A} / \overline{B} = \text{(min (a1/b1, a1/b3, a3/b1, a3/b3), a2/b2, max(a1/b1, a1/b3, a3/b1, a3/b3))}.$$

α- cut: is the set of elements whose membership values exceed the threshold level α.

$$\text{i.e., } \overline{A}_\alpha = \{x \mid \mu\overline{A}(x) \geq \alpha\}$$

A crisp interval of a fuzzy number $\overline{A}$ can be obtained by α-cut operation. Thus

$$\overline{A}_\alpha = \text{[(a2 − a1) α + a1, a3− (a3 − a2) α]}.$$

3.FUZZY-BASED GOAL ANALYSIS USING INTER-ACTOR DEPENDENCY

Apart from modeling, goal models support the requirements analyst to assess the satisfaction of goals, to determine the high-level requirements and to assess design alternatives (D.Amyot et al 2010). Many approaches which include both quantitative and qualitative analysis procedures have been proposed to assess the satisfaction of goals (D.Amyot et al 2010, Horkoff et al. 2009 & Lamsweerde et al. 2004). Both the KAOS and NFR the goal models show the goals decomposition and there is no actor dependency. However, the i*, Tropos and GRL models, the actor dependency is included. The existing literature has discussed the actor dependencies and formalisation (Morandini et al. 2007). However, in the current RE literature these dependencies have not been considered in relation to calculating the goal satisfaction (Lamsweerde 2009; Affleck et al., 2012). This paper presents an approach of finding soft goal satisfaction using the inter-actor dependencies of the i* framework. It uses fuzzy concepts to capture requirements, which can be stated in linguistic terms. Fuzzy logic helps in converting the linguistic terms in quantitative manner.

An actor depends on one or more other actors for its goal achievement. Goals have to be analysed by considering the dependencies amongst the actors. The goal model shown in Figure 3 illustrate the proposed approach. In this example, the Actor1 depends on Actor2 and Actor3 for its goal accomplishment. Whilst performing the goal analysis for Actor1, it results in the following three cases:

Case 1: Goals analysis using the dependency from Actor2 only

Case 2: Goals analysis using the dependency from Actor3 only

Case 3: Goals analysis using the dependencies from Actor2 and Actor3 simultaneously.

The results obtained from these three cases can be analysed to find the impact from one or more actors on an actor in goal accomplishment and satisfaction.

Using our fuzzy based approach(Chitra et al. 2015), alternatives for the actors will be selected in given goal model. The soft goal satisfaction analysis for a selected alternative option is performed by using the following steps of 'a' through 'd':

a. **Selection of leaf soft goals weights:** The leaf soft goal weight is represented by ω_L and is assigned values from 0 to 100 based on their relative importance in percentage.

b. **Fuzzy weights for the correlation between goals and soft goals:** The contributions of goals or tasks to soft goals described by *make*, *help*, *hurt*, *break* are expressed as fuzzy numbers. Both Triangular and Trapezoidal fuzzy numbers are simple to implement and fast for computation. TFN are used in the proposed approach because starting with Triangular membership function is the simplest approach. Moreover TFN represents fuzzy numbers and Trapezoidal represents fuzzy intervals. Table 1 shows our representation of the contributions of goals/tasks to leaf soft goals(LSG). The fuzzy values and its membership function for the soft goal contribution are shown in Figure 4. It is referred to as $\bar{C}_{A*L}$ where A is an alternative option that is selected and L is a leaf soft goal.

c. **Calculation of leaf soft goal score:** The leaf soft goal score is referred to as $\bar{S}_L$ and it is calculated using weights of the leaf soft goal and the soft goals impact on the selected alternative. It also takes into account any dependencies on the other actor. The dependency link is considered as 'MAKE' contribution. If the dependency score and dependency impact are denoted by $\bar{S}_d$ and $\bar{I}_d$ correspondingly and there are 'n' dependencies then the equation for score calculation of a leaf soft goal is given by the Equation 1 below:

$$\bar{S}_L = \bar{C}_{A*L} * \omega_L + \sum_{i=1}^{n} (\bar{S}_{di} * \bar{I}_{di}) \tag{1}$$
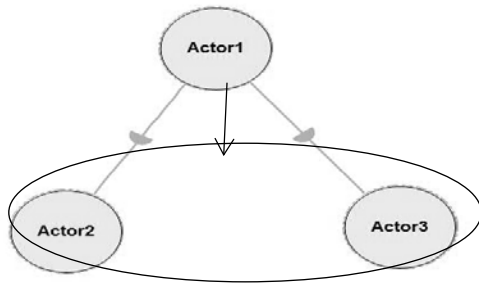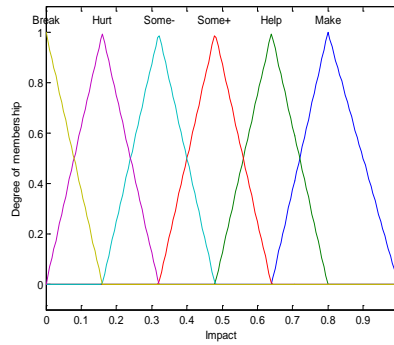

Figure 3: Inter-actor dependency.

Figure 4: Membership Functions for Impact.

Name	Fuzzy contribution
Make	(0.64, 0.80, 1)
Help	(0.48, 0.64, 0.80)
Some+	(0.32, 0.48, 0.64)
Some-	(0.16, 0.32, 0.48)
Hurt	(0, 0.16, 0.32)
Break	(0, 0, 0.16)

Table 1: Fuzzy values for goal and soft goal correlation

d.   Propagation of leaf soft goal scores to find satisfaction of the soft goals: The LSG scores are propagated backwards to find the scores of the soft goals that are higher in the hierarchy. The soft goals that are at the root level of the goal graph are called top soft goals. The propagation is done until top soft goals are reached. The soft goal (SG) score is referred to as $\bar{S}_{SG}$. Any goal dependent on other actor goals is taken into consideration for score calculation. It is given by Equation 2 below:

$$\bar{S}_{SG} = \sum_{i=1}^{n} (\bar{C}_{SCi} * \bar{S}_{LCi|SCi}) + \sum_{i=1}^{m} (\bar{S}_{di} * \bar{I}_{di}) \tag{2}$$

where $\bar{C}_{SCi}$ is the correlation link between a soft goal and its ith child, $\bar{S}_{LCi|SCi}$ is the score of its ith child, $\bar{S}_{di}$ is the score of its ith dependent, $\bar{I}_{di}$ is the ith dependent impact, 'n' is the number of its children and 'm' is the number of dependencies.

Once the top soft goals scores are computed, it is defuzzified to produce a quantifiable result. The defuzzified results are checked to view the satisfaction of soft goals for the selected alternative. The quantified value shows the degree of satisfaction of the soft goals.

4. SIMULATION AND EVALUATION OF THE APPROACH WITH CASE STUDIES

A simulation for fuzzy based inter-actor goal analysis was developed in Visual C++. A SR model was considered as collection of directed graphs with each graph corresponding to an actor. Directed graphs represent the soft goal interdependencies and inter actor dependencies. The directed graph was implemented using list representation. Inputs to the goal analysis was lists and the alternative option for whom soft goals satisfaction are calculated. The output of the simulation is each actor's top soft goals satisfaction for the given alternative option. The inter-actor goal analysis pseudo code is given in Figure 5.

We evaluated the fuzzy-based inter-actor goal analysis with two distinct case studies: Youth Counselling (Horkoff et al. 2009) and Meeting Scheduler (Lamsweerde et al. 2004). The computer based Youth Counselling provides a friendly, confidential service for young people who are in need of counselling. It supports phone counselling for youth but is primarily concerned with reaching more youth using the Internet. In the Youth Counselling example, the two different alternative tasks are

- Kids Use CyberCafe/Portal/Chat Room
- Kids Use TextMessaging

In this case study, an analyst has to select an alternative that achieves good satisfactions for soft goals *GetEffectiveHelp*, *Happiness* and *HelpKids* of actors *Kids and Youth*, *Counsellor* and *Organisation* respectively.

By using first alternative *Kids Use CyberCafe/Portal/ChatRoom,* goal analysis was performed using steps 'a' through 'd' presented in section 3 and the calculated scores of the soft goals are shown in Figure 6. In this case study by considering only the soft goal dependencies, it is apparent that the existence of the Case 1: actor *Organisation* depends on actor *Counsellor*.

As seen from the Figure 6, the first alternative option Kids *Use CyberCafe/Portal/ChatRoom was* estimated to achieve the top soft goals *GetEffectiveHelp (Kids and Youth), Happiness (Counsellor)* and *HelpKids (Organisation)* in 100%, 5% and 78% of the cases correspondingly. To analyse the estimated values, these values are compared with the satisfaction values from the second alternative element *Kids UseTextMessaging.* The satisfaction percentage of *GetEffectiveHelp (Kids and Youth), Happiness (Counsellor)* and *HelpKids (Organisation)* are 83%, 1% and 29% respectively for the second alternative option. The top soft goals values are given in Table 2. The satisfaction comparison for these two alternatives is also outlined in Table 2 and from the table it can be seen that the first alternative *Kids Use CyberCafe/Portal/ChatRoom* outperforms the *Kids UseTextMessaging* in the view of the relative weights assigned to each soft goal.

To check the feasibility of our model, we have demonstrated the method for another case study. The second case study is Meeting Scheduling System. A computer based Meeting Scheduling System should effectively organise meetings by finding appropriate dates and locations for invited participants. All potential information about the participants is obtained by the meeting initiator. The intended participants may express their constraints requested by email or the requested information may be obtained by access to their electronic agenda.

This example is different from the previous case study. In the Kids Youth Counseling, all the actors have the same type of alternatives and the same number of alternatives. However in the Meeting Scheduling system each actor has a different number and different types of alternatives. The selected alternative options are different for each actor and goal analysis is performed in accordance with that alternative point of view.

Algorithm: Goal Analysis using inter-actor dependencies using backward propagation in *i**
framework.

Input: i) Set of interconnected graph representing the soft goals interdependencies and actor dependencies.

ii) Given a task/goal of each actor and their impacts with the leaf soft goals.

Output: The top soft goals satisfaction percentage in each actor.

// compute leaf soft goals scores

for each graph in the given set of graphs
{

      The leaf soft goals are assigned weights to reflect their relative importance

      Compute the leaf soft goals score by multiplying its weight with impact of the given goal.

}

// compute soft goals score in backward propagation

do
{

      if (graph is independent and scores are not calculated)
      {
         do
         {
        Compute the Soft goals score by adding all its children multiplied score with its
           impact
        } until (top soft goal is reached)
      }

      else // depends on other graphs
      {
         if (leaf soft goal depends on other actors)
            for each graph it depends
               add the depended score to this leaf soft goal score
         do
         {
        Compute the Soft goals score by adding all its children multiplied score with its
           impact
         } **until** (top soft goal is reached)
      }

} **until** (all graphs are calculated)

Figure 3 : Pseudo code for Goal Analysis using inter-actor dependencies in i* framework

Goal analysis was performed first by selecting the alternative options *ConstraintsAcquiredbyEmail* of actor *MeetingScheduler*, *FindAgreeableDateByTakingToInitiator* of actor *MeetingParticipants* and *LetSchedulerScheduleMeeting* of actor *MeetingInitiator*. Figure 7 shows the analysis of goals of the case study Meeting Scheduling System for the first alternative options of each actor. The first alternative *ConstraintsAcquiredbyEmail* of *MeetingScheduler was* estimated to satisfy 35% for *EffectiveScheduling.* Similarly *FindAgreeableDateByTakingToInitiator* of actor *MeetingParticipants* contributes to 29% and 85% for *ConvenientMeetingDates* and *LowEffort* respectively. The option *LetSchedulerScheduleMeeting* of actor *MeetingInitiator* was estimated to satisfy 100% for *Happiness*.
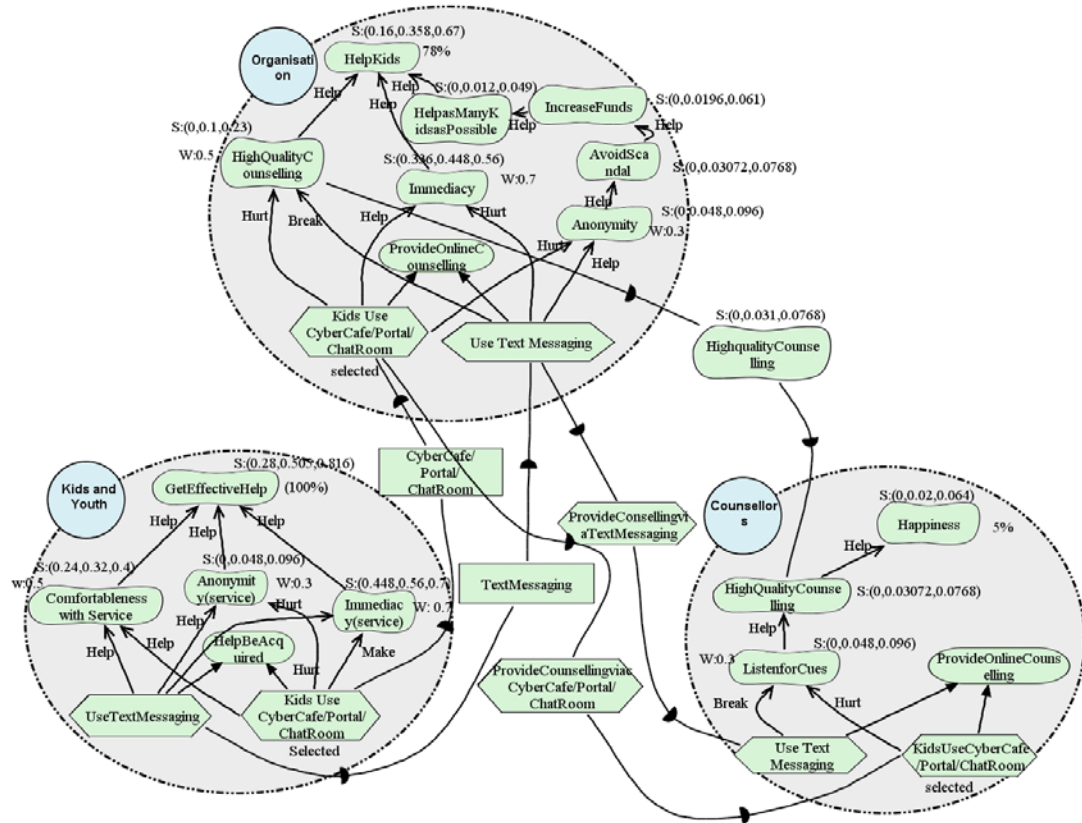

Figure 6: Quantitative Analysis of Goals for Kids Youth Counseling case study.

Actor	Top Soft Goals	Alternative option Score		Defuzzified scores	
		Use Text Messaging	Use CyberCafe/Portal/ ChatRoom	Use Text Messaging	Use CyberCafe/P ortal/ChatRo om
Kids and Youth	Get Effective Help	(0.18, 0.39, 0.69)	(0.29, 0.51, 0.82)*	0.83 (83%)	1 (100%)
Counsellors	Happiness	(0, 0, 0.03)	(0, 0.02, 0.064)*	0.01 (1%)	0.052(5%)
Organization	Help Kids	(0.007, 0.10, 0.37)	(0.16, 0.29, 0.45)*	0.29 (29%)	0.78 (78%)

Table 2: Top Soft Goals Satisfaction Scores for Kids Youth Counseling (indicates goal selection).*

Similarly, the analysis was performed by considering other the alternatives of the three actors. When the alternatives are different for each actor, many different combinations of the alternatives exist. This case study include twelve combinations which include (i) *ConstraintsAcquiredbyEmail* of *MeetingScheduler*, *ScheduleMeeting* of *MeetingInitiator*, *FindAgreeableDateUsingScheduler* of *MeetingParticipants* (ii) *ConstraintsAcquiredbyE-Agenda* of *MeetingScheduler*, *ScheduleMeeting* of *MeetingInitiator*, *FindAgreeableDateUsingScheduler* of *MeetingParticipants* (iii) *ConstraintsAcquiredbyDefault* of *MeetingScheduler*, *ScheduleMeeting* of *MeetingInitiator*, *FindAgreeableDateUsingScheduler* of *MeetingParticipants*.
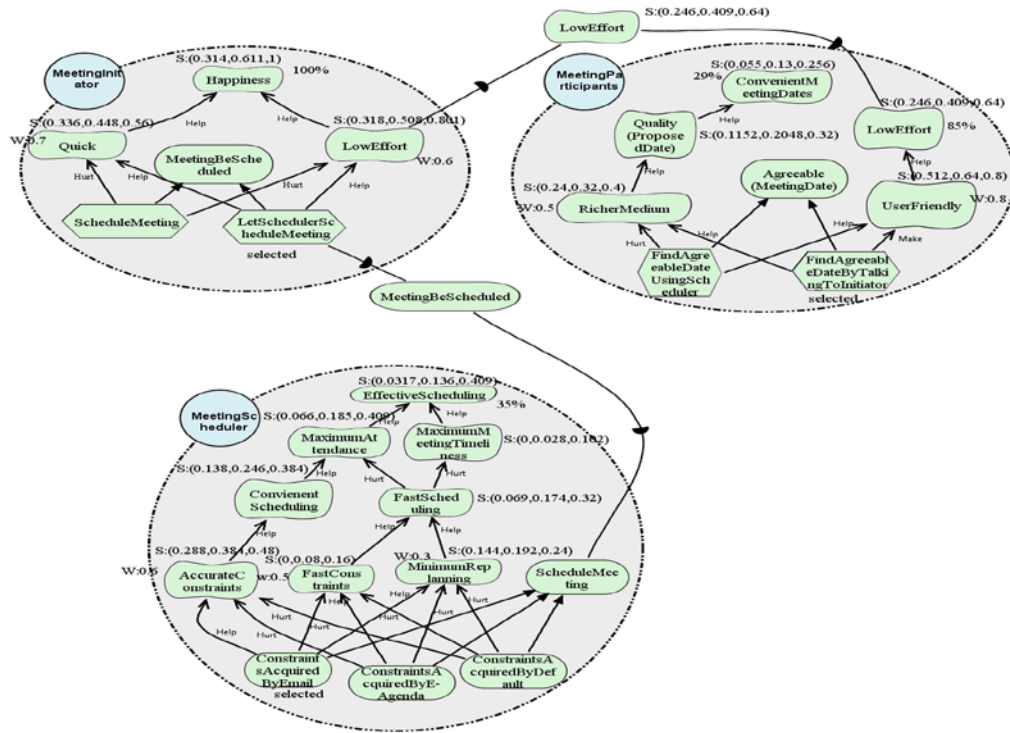

Figure 7: Quantitative Analysis of Goals for Meeting Scheduling System case study.
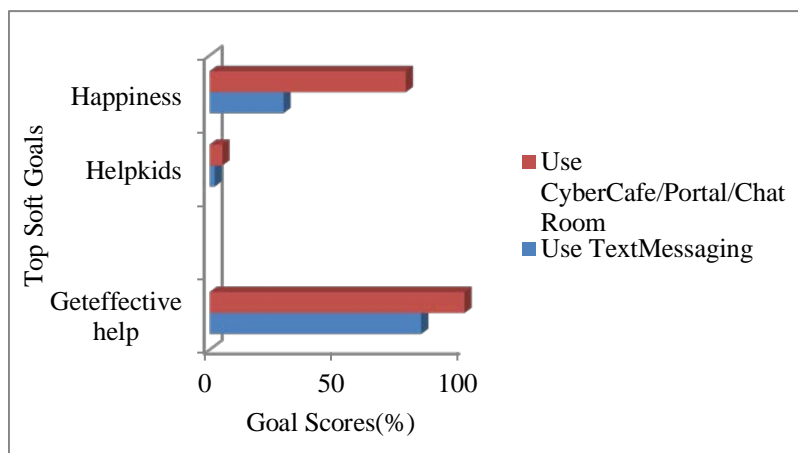

Figure 8: Comparison Graph for Kids Youth Counseling case study.

The scores of all alternative options were compared with each other to find an option that gives better satisfaction scores for top soft goals. Due to space restriction, a partial satisfaction comparison of scores is shown in Table 3 and it can be seen that for the actor *MeetingScheduler*, the alternative options *ConstraintsAcquiredbyEmail* has better satisfaction than the other alternatives, for the actor *MeetingParticipants* the alternative options *FindAgreeableDateByTakingToInitiator* has better satisfaction than the other alternative and for the actor *MeetingInitiator* the alternative options *LetSchedulerScheduleMeeting* has better satisfaction than other option. The graphical representation of scores comparison for Kids Youth Counseling is shown in Figure 8 and for the Meeting Scheduler System in Figure 9.

Actor	Top Soft Goals	Alternative options	scores	Defuzzified scores
Meeting Initiator	Happiness	ScheduleMeeting	(0.088, 0.342, 0.742)	0.758 (76%)
		LetSchedulerScheduleMeeting*	(0.314, 0.611, 1)	1 (100%)
MeetingParticipants	ConvenientMeetingDates	FindAgreeableDateUsingScheduler	(0, 0.0328, 0.1024)	0.08 (8%)
		FindAgreeableDateByTalkingToInitiator*	(0.055, 0.13, 0.256)	0.286 (29%)
	LowEffort	FindAgreeableDateUsingScheduler	(0.184, 0.327, 0.512)	0.675 (68%)
		FindAgreeableDateByTalkingToInitiator*	(0.246, 0.409, 0.64)	0.852 (85%)
MeetingScheduler	EffectiveScheduling	ConstraintsAcquiredByEmail*	(0.032, 0.136, 0.409)	0.357 (36%)
		ConstraintsAcquiredByE-Agenda	(0, 0.074, 0.3014)	0.224 (22%)
		ConstraintsAcquiredByDefault	(0, 0.0419, 0.2032)	0.143 (14%)

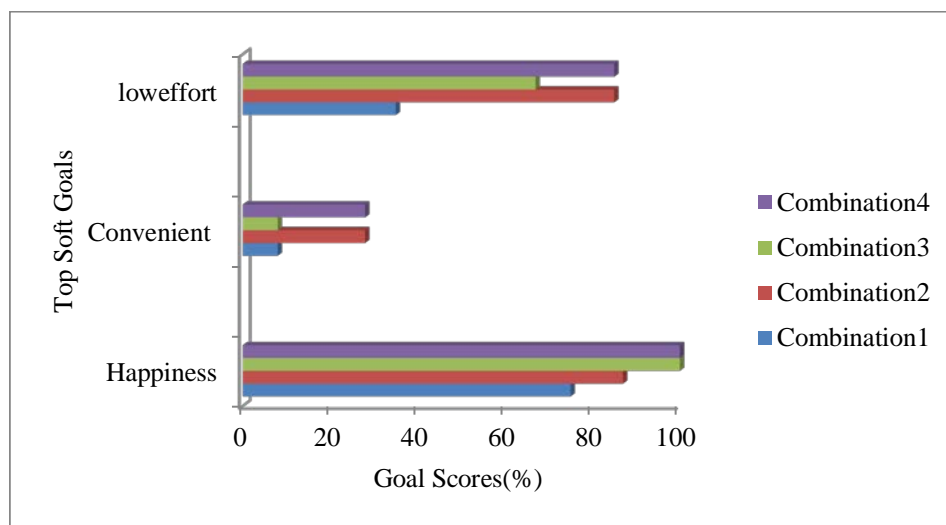*Table 3: Top Soft Goals Satisfaction Scores for Meeting Scheduling System (* indicates goal selection).*

Figure 9: Comparison Graph for Meeting Scheduling System case study.

To check the effectiveness of the proposed approach, the estimated values from inter-actor dependencies were compared with values obtained from without using inter-actor dependencies. In the first case study Kids Youth Counseling (YCS), the only soft goal that gets affected by interaction is *HighQualityCounseling* of the actor *Organisation*. By performing goal analysis without using inter-actor dependencies, the values were 73% for *Kids Use CyberCafe/Portal/ChatRoom* and 26% for *Kids Use TextMessaging*.

By analysing the above computed scores, it can be seen that, the proposed approach gives improved scores for soft goals than those without inter-actor dependencies. Similarly, an analysis from the second case study Meeting Scheduling System(MSS) shows that scores obtained from proposed approach are better than those from without inter- actor dependencies. Tables 4 and 5 demonstrate the comparison scores for the two case studies. For YCS with single soft goal dependency *HighQualityCounseling* between the actors *Organisation* and *Counsellor,* the soft goal *HelpKids* satisfaction is found to be increased by 4% for *Kids Use CyberCafe/Portal/ChatRoom* and 3% for *Kids Use TextMessaging*. Similarly for MSS with single soft goal dependency *LowEffort* between the actors *MeetingInitiator* and *MeetingParticipants* the soft goal *Happiness* is found to be increased by 9% for *LetSchedulerScheduleMeeting*. By considering single soft goal dependency, the proposed approach provides an improved score over the non-inter-actor dependencies. However, when there are a large number of dependencies, it is expected that the proposed approach will give significantly a better result comparatively and thus help in decision making.

5. RELATED WORKS

Since the development of concept of goal model, considerable amount of work on reasoning about goal achievement using qualitative and quantitative labels have been proposed.

Lamsweerde (2009) came up with a lightweight quantitative alternative evaluation system by blending the ideas of soft goals and goals into KAOS framework. In his approach, he used variables as gauge variable, ideal target value, maximum acceptable value associated with each soft goal. This approach obtained these values from the specification of the system. So to design a goal model in this method, one should have completely perceived the specification of the system. Another problem with this approach is it may be difficult in case of complex and large system.

Affleck et al., (2012, 2013 and 2015) proposed a quantitative approach for the decision process. It is process-orientated, lightweight, quantitative extension to the NFR Framework. The objective of their proposal is to minimise the operationalization. J. Mylopoulos et al. (2003) presented a quantitative reasoning of goal. It requires a strong mathematical knowledge as it uses first order logic.

D.Amyot et al. (2010) developed an approach to analyses the GRL model to evaluate the satisfaction levels of the actors and intentional elements. When stakeholders' requirements are vague, it is difficult to assign exact numeric numbers to requirements.

Actor	Top Soft Goals	Use CyberCafe/Portal/ChatRoom		Use Text Messaging	
		With Inter-actor Dependencies	Without Inter-actor Dependencies	With Inter-actor Dependencies	Without Inter-actor Dependencies
Organization	Help Kids	77%	73%	29%	26%

Table 4: Scores Comparison for Kids Youth Counseling (with and without inter-actor dependencies)

Actor	Top Soft Goals	ScheduleMeeting		LetSchedulerScheduleMeeting	
		With Inter-actor Dependencies	Without Inter-actor Dependencies	With Inter-actor Dependencies	Without Inter-actor Dependencies
MeetingInitiator	Happiness	100%	100%	76%	67%

Table 5: Scores Comparison for Meeting Scheduling System (with and without inter-actor dependencies)

Liaskos (2010) introduced quantitative approach to prioritise goals by using a mathematical method, Analytic Hierarchy Process. This approach requires certain structural features that a goal model to satisfy. These above approaches are appropriate for late analysis, while system's detailed information is completely disposed.

For early RE, Horkoff and Yu (2009) proposed a qualitative analysis of goal models, which requires customer intervention. However, the main issue with their approach is ambiguity of decision-making when one or more goals receive the same labels.

The approach proposed in this paper performs fuzzy based goal analysis by using inter-actor dependency. By using fuzzy numbers, the approach avoids the vagueness associated with stakeholder's requirements, ambiguities that arise in decision making, and the analysis does not require strong mathematical skills.

6.   CONCLUSION

This paper proposed a fuzzy-based approach for goal evaluation using inter-actor dependency in the *i** framework. The proposed approach was implemented and tested using the two case studies from the existing literature: Youth Counsellor and Meeting Scheduling System. Analysis was based on improvements to the top soft goal scores of each actor in the goal model. The proposed approach of inter-actor dependencies gives an improved result over non-inter-actor dependencies. The future research direction will include optimisation of goal models to select the weights for the LSG and to select the alternative options for which the soft goals levels of satisfaction are best. Furthermore, we also intend to prove its effectiveness by application of the proposed approach to real case study.

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