Journal of Theoretical and Applied Information Technology
20th March 2014. Vol. 61 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A METHOD TO RISK ANALYSIS IN REQUIREMENT ENGINEERING THROUGH OPTIMIZED GOAL SELECTION TROPOS GOAL LAYER

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ABSTRACT

The requirement engineering is a field, in which software are modeled according to the requirements of the user. The software developed under requirement engineering will satisfy the users mostly on their perspective. So, recent researches are concentrating on the software development and analysis based on requirement engineering. The requirement engineering processes are also challenged by the risks in developing the software. So an efficient risk analysis system and risk management system is inevitable for the software development process under requirement engineering. In the proposed approach, an effective node selection approach for grouping the nodes in tropos goal model is plotted. The tropos goal model uses three layers for the risk analysis. Usually all the attributes regarding domain is used to plot the goal model. In the proposed approach, the goal model will be constructed in specific to attributes that will have the chances of raising risk. This process will reduce the time in terms of risk analysis and could help in prioritizing the risk as there are limited numbers of attributes considered in the three different layers. The goal risk model will be modified and used in the proposed approach. The experimental analysis will be conducted to analyses the relevance and effectiveness of the proposed approach.

Keywords: *Requirement Engineering, Tropos Goal model, Candidate solutions, Goal layer, Event layer*

1. INTRODUCTION

Generally risk analysis is used for studying all the considerations, which lead to the frailer of the program. It is a methods and techniques for documenting the impact of extenuation strategies [2] and for judging system criticality [3]. Risk analysis is also shown important in the software design phase to assess criticality of the system [4] where risks are examined and necessary steps are introduced. Usually, countermeasures correspond to a design, system fine tuning and then with a limited margin of change. However, it may happen that the risk reduction results in the revision of the entire design and possibly of the initial requirements, introducing thus extra costs for the project [5]. Requirements engineering is a process based method for defining, realizing, modeling, relating, documenting and maintaining software requirements in software life cycle that help to understand the problem better [6]. It has been shown that a large proportion of the publications in software development can be related back to requirements engineering (RE) [7]. RE is the process of discovering the purpose in the software development, by identifying stakeholders and their needs, and documenting these in a form that is amenable to analysis, communication and subsequent implementation [8]. Failures during the RE procedure have a significant negative impact on the overall development process [8]. Reworking requirements failures may take 40% of the total project cost. If the requirements errors are found late in the development process, e.g. during maintenance, their correction can cost up to 200 times as much as correcting them during the early stages of the development process [10]. Adequate necessities are therefore essential to ensure that the system the customer expects is produced and that unnecessary exertions are avoided.

According to Goal-Oriented Requirements Engineering, analysis of stakeholder goals leads to

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

substitute sets of functional requirements that can each accomplish these goals. These alternatives can be evaluated with respect to nonfunctional necessities posed by stakeholders. In the previous paper, they propose a goal-oriented approach for analyzing risks during the requirements analysis phase. Risks are analyzed along with stakeholder interests, and then countermeasures are identified and introduced as part of the system's requirements. This work extends the Tropos goal modeling formal framework suggesting new concepts, qualitative reasoning techniques, and methodological procedures. The approach is based on a conceptual framework composed of three primary layers: assets, events, and treatments.

In the field of software engineering, the requirement engineering is getting special attention as it is based on the stakeholder's interests. The main factors that a requirement engineering process considers are business requirements and user requirements. The requirements are used to enhance the development of the software product with low cost and the time it should satisfy all the requirements. One of the sensitive areas, which every software development process concentrate is the risk involved with the process. So, particular assessment measures have to be taken in order to minimize the risks in software development process. YudistiraAsnar and Paolo Giorgini [14] have proposed a method for risk analysis in requirement engineering. The method deals with a software development method called, Tropos Goal Model and with a Probabilistic Risk Analysis (PRA). Inspired from their work, we are planning to propose an approach on extending the Tropos model with risk analysis feature. Tropos goal model consists of three layers, mainly Goal layer (GL), Event layer (EL) and Treatment layer (TL). The GL consists of set of goals that has to fulfill by the process and EL contains the constructs which helps to achieve the goals. The TL is working as the input, which helps in achieving the goals.

The main contributions of the paper are,

- A goal oriented approach is furnished to analyze the cost and risk associated with requirement engineering
- A goal node optimization is introduced to enhance the goal model

The rest of the paper is organized as; section 2 describes the literature survey regarding the requirement engineering and risk analysis. The 3rd section contains the problem description behind in proposing the approach. The 4th section includes the proposed goal model and case study used for it to analyze the risks and costs in requirement engineering. The 5th section consists of the experimental analysis of the proposed goal model. Finally, the 6th section includes the conclusion of the work

2. LITERATURE REVIEW

The following section describes review about some recent works regarding the requirement engineering and risk analysis related to it. Security risk assessment in the requirements phase is challenging because probability and damage of attacks are not always numerically measurable or available in the early phases of development. Selecting proper security solutions is also problematic because mitigating impacts and side-effects of solutions are not often quantifiable either. In the early development phases, analysts need to assess risks in the absence of numerical measures or deal with a mixture of quantitative and qualitative data. GolnazElahietal[15] propose a risk analysis process which intertwines security requirements engineering with a vulnerability-centric and qualitative risk analysis method. The method is qualitative and vulnerability-centric, in the sense that by identifying and analyzing common vulnerabilities the probability and damage of risks are evaluated qualitatively. They also provided an algorithmic decision analysis method that considers risk factors and alternative security solutions, and helps analysts select the most cost-effective solution. The decision analysis method enables making a decision when some of the available data is qualitative. JacKyAng*et al* [11] has developed an expert system that has least focus on requirement engineering. In facts, requirement engineering is important to get all the requirements needed for an expert system. If the requirements do not meet the clients' needs, the expert system is considered fail although it works perfectly. Currently, there are a lot of studies proposing and describing the development of expert systems. However, they are focusing in a specific and narrow domain of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

problems. Also, the major concern of most researchers is the design issues of the expert system. Therefore, we emphasize on the very first step of success expert system development – requirement engineering. Hence, we are focusing in the requirement engineering techniques in order to present the most practical way to facilitate requirement engineering processes. They have analyzed expert system attributes, requirement engineering processes in expert system developments and the possible techniques that can be applied to expert system developments. Lukas Pilat*et al*[12] have proposed an approach for problem in requirements engineering is the communication between stakeholders with different background. This communication problem is mostly attributed to the different "languages" spoken by these stakeholders based on their different background and domain knowledge. We experienced a related problem involved with transferring and sharing such knowledge, when stakeholders are reluctant to do this. So, they take a knowledge management perspective of requirements engineering and carry over ideas for the sharing of knowledge about requirements and the domain. We cast requirements engineering as a knowledge management process and adopt the concept of the spiral of knowledge involving transformations from tacit to explicit knowledge, and vice versa. In the context of a real world problem, we found the concept of "knowledge holders" and their relations to categories of requirements and domain knowledge both useful and important. This project was close to become a failure until knowledge transfer has been intensified. The knowledge management perspective provided insights for explaining improved knowledge exchange. Mina Attarha and Nasser Modiri [13] have adopted a critical and specific software systems last longer and they are ought to work for an organization for many years, maintenance and supporting costs of them will grow to high amounts in the upcoming years. In order to develop and produce special aimed software, we should piece, classify, combine, and prioritize different requirements, pre-requisites, co-requisites, functional and nonfunctional requirements (by using requirements engineering process, they can classify the requirements). Development and production of special software requires different requirements to be categorized (different requirements can be categorized using software requirements engineering). In other words, we have to see all requirements during the software's life cycle, whether they are important and necessary for our software at present time or they are not important currently but will become important in future. Requirements engineering aim is to recognize the stockholder' requirements and their verifications then gaining agreement on system requirements, is not just a phase completed at the beginning of system development not required any more, but includes parts of next phases of software engineering as well. To achieve this purpose, we acquired a comprehensive knowledge about requirements engineering. First, they defined requirements engineering and explained its aim in the software production life cycle. The main activities and purpose of each requirements engineering activity is described. Moreover, the techniques used in each activity are described for a better comprehension of the subject

3. PROPOSED APPROACH

The risk analysis has become one of the advanced area in software engineering. In the prior sections, we have discussed about the requirement engineering and the cost risk analysis. The goal risk model in this paper is adapted from the Tropos goal model. A modified Tropos goal model in explained in the [1] based on optimizing the candidate solutions. The Tropos goal model concentrates on the goal nodes to predict the cost and risk regarding software. The proposed approach concentrates on optimizing the number of goals to efficiently analyze the cost and risk. The goal nodes are limited or optimized in sequential manner that the most relevant goals are preserved and rest are avoided. The scenario of the bank and profit is considered in the approach also. We used the same modified Tropos goal model for the proposed approach. As per the definition, the tropos goal model contains three layers namely, Goal layer, Event layer and support layer. The aim of the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

proposed approach is to optimize the number of goals in the goal layer to reduce the cost

4. TROPOS GOAL RISK MODEL

Tropos goal model is a software development model, which is characterized by concepts of agent goal, task, and resource and uses them throughout the development process from early requirements analysis to implementation. Early requirements analysis model provides the organizational settings, where the system-to-be will eventually operate. The Tropos model is extended by adding constraints and relation in order to assess the risk factor. The Tropos GR model mainly consist three tuples, i.e. the number of node (N), number of relations (R) and uncertain events (U). Considering a Goal Risk (GR) model, the Tropos G-R model consists of mainly three layers, namely goal layer, event layer and support layer. The goal layer consists of goals, which are the needs that have to be achieved. The event layers consists of event nodes, which serves to achieve the goals and the bottom layer, the support layer, which contains the node which support either the event nodes or goal nodes. Each of the three constraints is characterized by severity value and the severity is marked with four measure strong positive (++), positive (+), negative (-) and strong negative (--). The constructs possess two attributes, satisfaction and denial, represented by SAT (c) and DEN (c), where c is the construct either goals, events and supports. The evidence of construct c will be satisfied for SAT(s) and denied DEN(c). In probability theory, if Prob(A) = 0.1 then we can infer that probability of $\neg$A is 0.9. Conversely, based on the idea of Dumpster-Shafer theory [1[38], the evidence of a goal being denied (DEN) cannot be inferred from evidence on the satisfaction of the goal (SAT), and vice versa. For instance, the software development company has the goal to develop *business development software*, which is affected by the event *procurement_of_raw_materials*. The event may trigger the goal to either SAT() or to DEN() according to the support value. If the support *user_requirement* has severity (--) then the goal result in Den (). The attribute values are specified more clearly by representing the value in different range like fully (*f*), partially (*p*) and none (*n*) and the priority of those values like *f*>*p*>*n*. The evidence for the satisfaction of a goal means that there is (at least) ‘‘sufficient’’ (‘‘some’’, ‘‘no’’) evidence to support the claim that the goal will be fulfilled. Analogously, Full evidence for the denial of a goal means that there is ‘‘sufficient’’ evidence to support the claim that the goal will be denied. According to the severity the events and goals are listed and the SAT value and DEN value are calculated. The other feature that is concentrated on the proposed approach is the relationship between the goals, events and the support. The relations R is the relations defined over different nodes in the defined goal risk model. The relation can be represented as $R = [N_1, \ldots, N_n \mapsto N]$, where N is the target node and the $N_1, \ldots, N_n$ are the source nodes. The relations are defined as three types, decomposition relation, contribution relation and alleviation relation. The decompositions relation, which used are AND / OR, for refining the goals, events and supports. Contribution relation points the impact of one node to another. Our framework distinguishes four levels of contribution relations, ++, +, - and --. Each one of these types can propagate either evidence for SAT or DEN or both. For instance, the ‘‘++ ’’ contribution relation indicates that the relation propagates both SAT and DEN evidence, and the ‘‘++s’’ contribution relation means the relation only propagates SAT evidence toward target nodes. Alleviation relations are similar to contribution relations but slightly differ in the semantics. The goal model depicted in the figure 1 projects a main goal, which is associated to a number of associate goals. The affinities of these associate goals are the main criteria behind the success of the main goal. The success rate is projected based on the cost to which the main goal is achieved with an acceptable risk. The usual costs to risk analysis are based on the SAT value and DEN value of the associated goals. In the proposed approach, we define a methodology, which give priority to the associate goals to minimize the cost and tolerate the error to a certain limit. The proposed approach describes the cost to risk analysis through a case study based on the software development company The following figure depicts

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

the illustration of the SDC over the Tropos goal model.

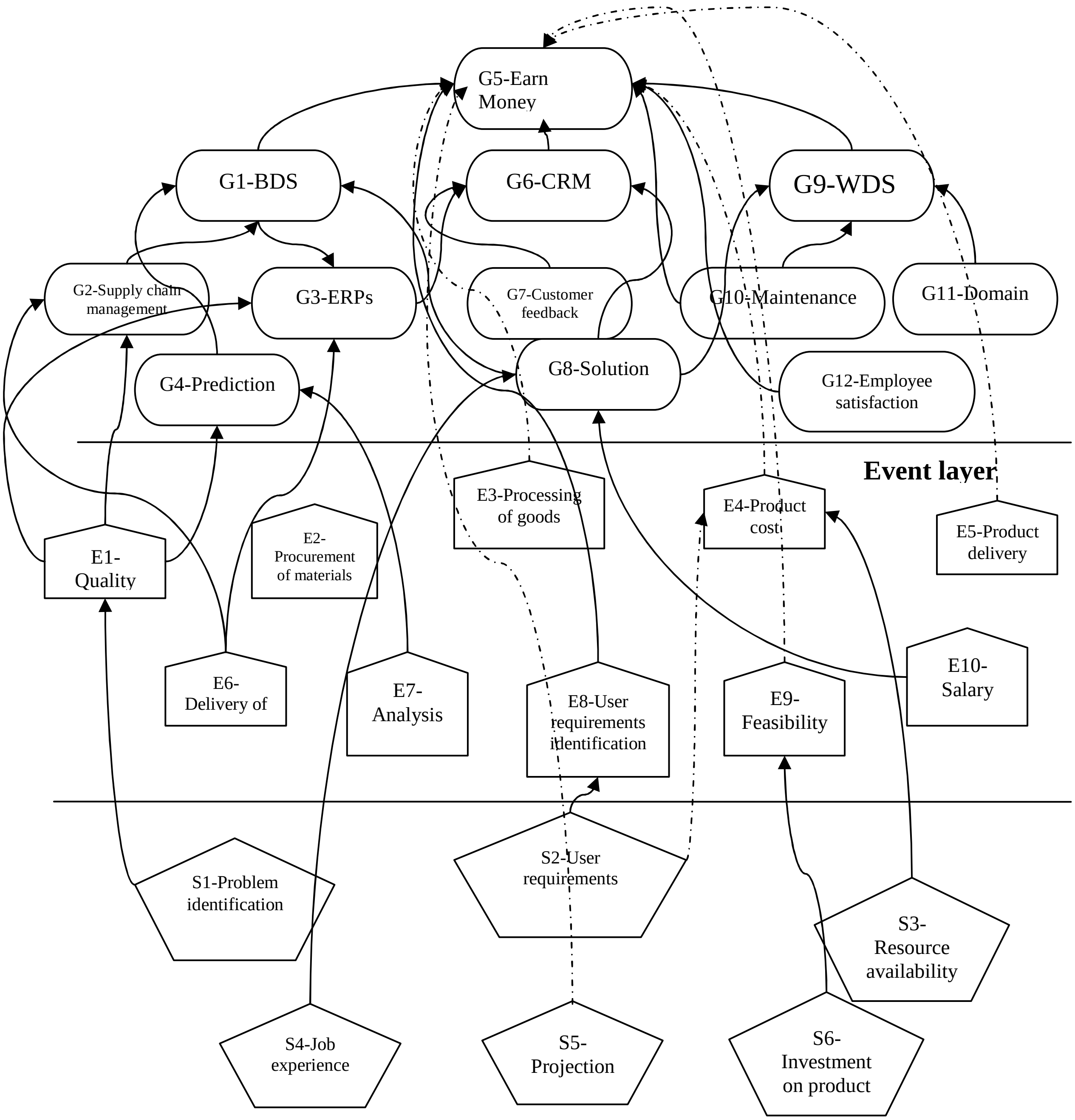

Fig.2. Tropos Goal Model for SDC

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

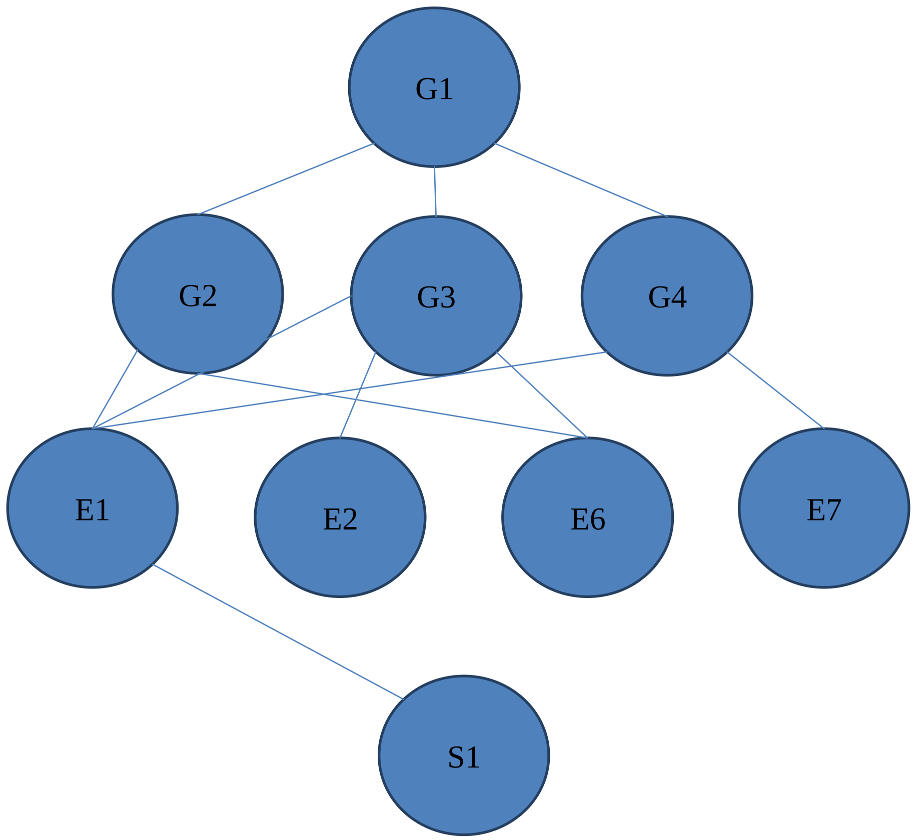

Fig.3. Tree Extracted For G1 Based On SDC

The figure 2 shows the illustration of the proposed software development company in the model of Tropos goal model. In the figure, it is shown that the top layer of model contains the target goals and associate goals. The above depicted SDC will be used for the proposed approach also. The proposed approach introduces two new steps to process the Tropos goal model to improve the efficiency of the risk analysis. The initial step introduced by the proposed approach is to extract undirected trees from the Tropos goal model. Later on the frequency calculation of the important events in the event layer is done as second step

4.1 Extraction Trees Based On Goal Layers

The Tropos goal layer model is one prime model to analyze the risk and cost analysis. The important feature that illustrates the risk analysis is the goal based on the requirements. The SDC considered in the proposed approach has N number of nodes and associated risks. The goals represented in the tropos goal model can be categorized as prime goals and Non-prime goals. The idea behind the proposed approach is to reduce the number of non-prime goals so that the calculation of risk analysis becomes efficient. Initially, the proposed approach initiates a tree extraction process based on the goals. The tree of a particular goal constitutes of goal as the top node, the event and support node as child node. Considering the example plotted in the above section, the tree of goal, G1, can be represented as the figure 3 represents tree extracted for the goal G1, though G1 is associated to the G5 we consider G1 as the root node. In the similar passion, we extract trees for all the nodes. The trees are extracted as per relationship between the events and supports to the goals. Once all the goals are used to produce the tree, we subject a calculation based on the number of branches possessed by the goal.

$$B_{count}(G_i) = \sum C(E), C(S)$$

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The equation represents the sum of branches of a particular goal G can be calculated by calculating the number of branches to event and number of branches to support from the goal and then calculating the sum all together. Here the expression C(E) represents the count of branches to event layer from goal G_i. Similarly the expression C(S) represents the count of branches to the support layer. Once all the goals trees are calculated their branch values, we move on to the second step defined by the proposed approach.

4.2 Most Frequent Events

The second major step by the proposed approach includes the calculation of frequency of the events in the events layer. The frequency of each event in the branched of the tree is calculated. Each of the goal possess a tree and each tree contain a number of events. There will be chances that many goals can share single events. So we have to identify the most frequent events and the goals that possess the particular event can be considered as most relevant goal. The most frequent events are calculated as follows,

$$f(E) = \sum No.of\ E_i\ in\, each\ G_i$$

The f(E) represents the frequency of an event E in all the total branched of the goal trees possessed by the tropos goal model. In other words, f(E) is the sum of frequencies of event E in all their trees. Each goal possesses a tree and that tree possesses a number of events. In the similar passion the frequency of all the events in the event layer are calculated. Then based on the increasing order of the frequency, the events are sorted and 80% of the top frequent events are selected and rest is discarded

4.3 Most Relevant Goals

The final phase of the proposed approach is to calculate the most relevant goals from the Tropos goal model. The proposed approach composes a comparison between the tree of goal and top frequent events. A goal is considered as top relevant goal, if the tree of the particular goal contains the minimum number of top frequent Events. The minimum value of Events that a tree should possess is given by the user according to the software under test. In the current sample SDC, we set the minimum value as 2. Thus the goals which satisfy the above conditions are selected for generating candidate solutions and rest are discarded

5. EXPERIMENTAL ANALYSIS

The experiment is conducted in Java runtime environment in system configured to a processor of 2.1 GHz, 2 GB RAM and 500 GB hard disk. The experimental evaluations are provided in the following section. The proposed goal risk model is based on two analyses and those analyses are used to judge the relevant candidate solutions. The experiment uses the input data from a manually generated source as the goal model of Software Development Company

5.1 Dataset Description

The proposed approach uses a software development company as example of generating the tropos goal model. The different intentions of the software are listed as goal and their assisting values are listed as event nodes and support nodes. The evaluation of the proposed approach is carried out according to the candidate solutions generated from the tropos goal mode. The candidate solutions generated can be used to estimate the cost and risk of the software under test.

5.2 Performance evaluation

In usual situations, the tropos goal model is used to analyze the risk and cost of the software under test. On the other hand, the proposed approach concentrates on enhancing the tropos goal model by incorporating the node optimization parameter. So, the performance analysis will be carried out in concentration with the time and memory utilized for testing the software. The performance evaluation is conducted for the tropos goal model with goal node optimization and without goal node optimization. The experimentation is conducted by considering a software development company as example, which possesses a set of 20 goals.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table.1. Value table

Events	values	Goals	costs	supports	associations
E1	7	G1	4	S1	8
E2	7	G2	5	S2	0
E3	4	G3	4	S3	2
E4	7	G4	6	S4	4
E5	5	G5	1	S5	4
E6	0	G6	5	S6	2
E7	0	G7	3	S7	7
E8	2	G8	6	S8	9
E9	4	G9	3	S9	5
E10	1	G10	2	S10	5

The table 1 represents the number of goals, events and supports regarding the software development company with limited number of goals namely 10 numbers. Now, the proposed approach is executed to optimize the number of goals with respect their association between event nodes and cost value

G0: [E11, E5, E20, E8, E17, E12, E18, E13, S10, S16, S3, S14, S4, S2, S9, S19]
G1: [E12, E7, E11, E19, E17, E14, E5, S3, S16, S6, S18, S1, S20, S13]
G2: [E8, E6, E7, E2, E1, E5, E11, E14, E10, S17, S16, S15, S3, S4, S19, S9, S18, S12]
G3: [E8, E3, E15, E18, E10, E7, E13, E1, E14, S20, S19, S12, S2, S11, S17, S5, S6]
G4: [E7, E12, E20, E8, E3, E4, S5, S2, S10, S6, S16, S18]
G5: [E20, E8, E13, E5, E10, S15, S4, S11, S6]
G6: [E1, E10, E5, E9, E4, E11, E6, E18, S7, S8, S19, S12, S16, S20, S14]
G9: [E19, E2, E12, E20, E7, E5, E11, S1, S10, S17, S3, S13, S14]
G10: [E13, E8, E18, E1, E10, S19, S16, S7, S20, S2]

Fig.4. Tree Structure For Different Goal Node

The figure 4 represents the tree structure generated for the different goal node. The tree structure represents the association of goal nodes with most frequent event nodes. The events in bold letters represent the most frequent events according to the proposed approach. So based on the most frequent events and association values, we can generate the most relevant goal nodes as,

[G1, G4, G5, G7, G8, G9, G10]

The nodes are selected based on the threshold value set for the assigned for the associations by the proposed approach. Since the goals [G2, G3 and G6] does not possess the relevant associations, we neglect them from the candidate solution generation. In order to check the performance of the proposed approach, an analysis based on time and memory is conducted.

Number of goal node	Tropos goal model with goal node optimization		Tropos goal model without goal node optimization	
	Time	Memory (MB)	Time	Memory
10	1204	2.02	2892	2.96
15	1656	2.84	3214	3.12
20	2609	3.04	4028	3.68

Table.2. time and memory

The table 2 represents the time and memory based evaluation over the proposed tropos goal model and goal model without goal optimization. The analysis can be represented as following graph,

Journal of Theoretical and Applied Information Technology
20th March 2014. Vol. 61 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

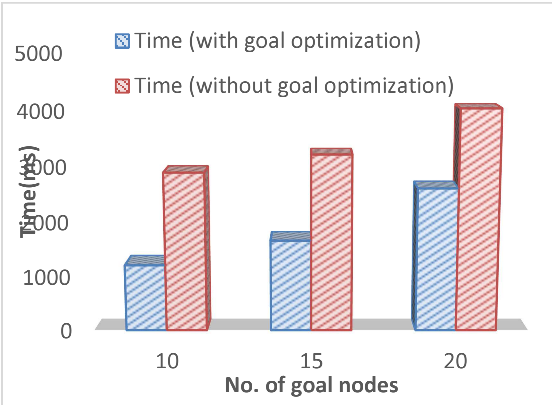

Fig.5. Time analysis

The figure 5 represents the time based analysis of the proposed approach. The analysis is conducted by selecting the goal nodes and three sets. A set of 10, 15 and 20 nodes per candidate solution. The analysis from the figure shows that, the model with goal optimization consumes less time as compared to the one without goal optimization. The responses of time for different set of goal nodes are sequential in nature, I.e. as the number of goals increase the time for execution also increases in both cases. The maximum time recoded for the model with goal optimization is 2069 ms, while that for without goal optimization is 4028.

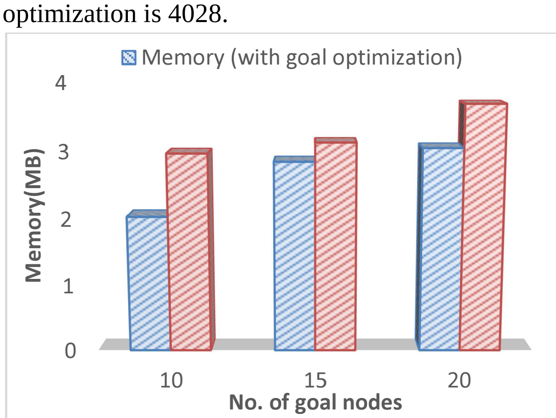

Fig.6. Memory analysis

The figure 6 shows the analysis based on memory regarding the proposed goal model and the existing goal model. The memory usage is comparably low for both methods, but the goal model with goal node optimization outperforms the existing method with a low memory utilization of 3.04 Mb. On the same scenario, the tropos goal model without goal optimization has utilized about 3.68 Mb of data. We can state that the proposed approach is efficient in limiting the memory and execute the process in fast pace. The proposed model has limited the number of goals but the cost to risk analysis is not much affected by the limitation. So, we can state the proposed approach is an enhancement to the Tropos goal model.

6. CONCLUSION

The proposed requirement engineering model is based on the Tropos goal model. A modified Tropos goal model is used in the proposed goal risk model. The goal risk model consists of three layers, and in the top level goals to be achieved by the process is plotted and in the second level, the events that triggers the goals and in the bottom level, the supporting parameters for the goal and events are plotted. The proposed approach also adds an optimization on the goal layer with the proposed approach. The goal node in the goal layer is limited by considering the association values and event layer. The risk analysis of the proposed GR model is conducted based on Three analyses, the cost analysis, risk priority calculation and the cost to risk analysis. The experimental evaluation is carried out on a case study considering a software development company. The results showed that the proposed goal risk model has enhanced the Tropos goal model in terms of time and memory. The proposed goal model only consumed 3.04MB of memory in a 2064 MS of time for executing the software under test.

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Journal of Theoretical and Applied Information Technology
20th March 2014. Vol. 61 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

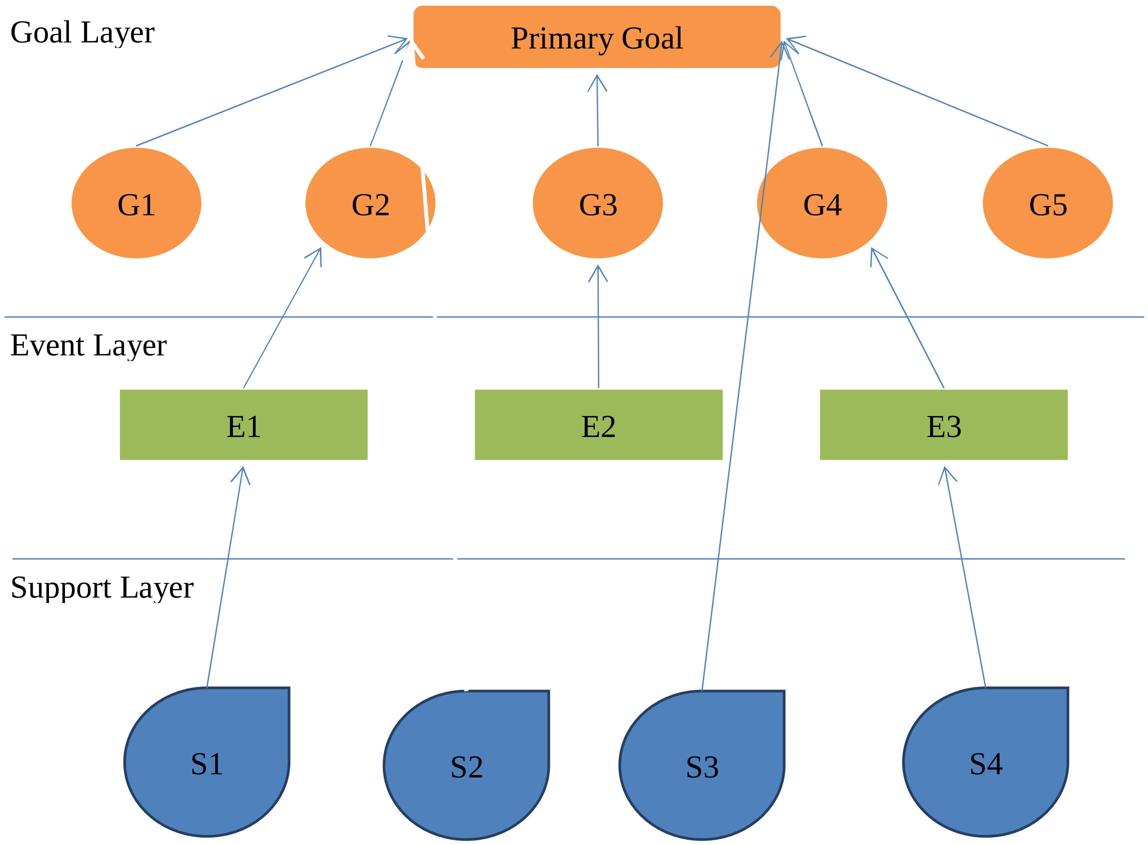

Fig.1. Tropos Goal Model