

CHAPTER

3

ROLE-BASED GOAL MODELLING WITH REQUIREMENTS CLASSIFICATION MATRIX

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3.1 OVERVIEW OF ROLE-BASED GOAL MODELLING

Due to the different types of stakeholders' role, various goal and priority, the concept of goal is significant and useful in understanding and clarifying requirements in the early stages of system developments. Goals are implemented during requirements analysis and at the early stages of a system's development process. Huysegoms et al. (2014) describe goals as wishes, ideas and opinions from stakeholders that need to be realised in the system-to-be. Besides, the representation of goal could demonstrate the relationship between a system and its environment. Stakeholder role-oriented identification is used in this process to classify the stakeholder's requirement based on the functions required in the system. In addition, Pacheco and Garcia (2012) claimed that stakeholder's representation at this level is important in order to accomplish the goals of a system-to-be. With the existent of stakeholder's representation, all the stakeholder's needs that are engaged to the system could be organised wisely and would produce less conflict of unnecessary requirements from different stakeholders' point of view.

Goal-oriented has been applied by Boness et al. (2011) that address confidence from stakeholder requirement that being illustrate using goal sketching technique. The goal sketching technique that highlights the appearance of assumptions and establishes them to the system elements before it can be constructed. Each goal is evaluating based on four independent risk factors. In goal sketching, we need to set down the objectives and show how each objective is to be satisfied in the resulting system. However, the goal sketching that is currently being used does not describe the requirement from multiple stakeholders. Therefore, this study proposed a goal realisation technique with an enhancement of stakeholder requirement representation by including the stakeholder-oriented identification. An advantage of this technique is that it emphasises the importance of classifying stakeholder requirements according to their specific roles and functions.

3.2 DEVELOPMENT OF ROLE-BASED GOAL GRAPH

The development of a role-based goal graph serves as a systematic approach to model and represents the relationships between stakeholder roles, goals, and their corresponding sub-goals within a system. This section outlines the process of constructing the goal graph, beginning with the identification of key roles and their high-level goals, followed by the development of a hierarchical structure of sub-goals, and concluding with an explanation of the notations used. The role-based goal graph helps requirements engineers visualise stakeholder interactions and dependencies, ensuring that system objectives are aligned with stakeholder needs and priorities.

Figure 3.1 depicts the process of system analyst/requirement engineer with the respective work products involved in the developing role-based goal graph. The development of role-based goal graph begins with identifying the roles and respective high-level goal. Afterwards, the following section provides details of the steps to form the goal graph and notation used in development of role-based goal graph.

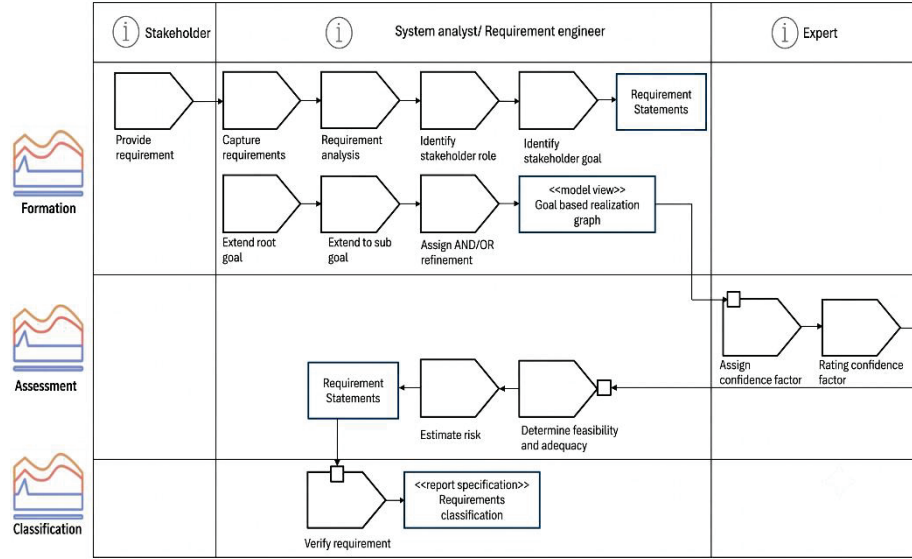


Figure 3.1 Summary of role-based goal graph

3.2.1 Identifying Role and Goal

Stakeholders may be classified under different viewpoints which represent the structuring of different stakeholder's perspectives. There will be many different stakeholders with their own role and objectives that need to be analysed by requirement engineer (Zhang et al., 2011). Sharp et al. (1999) has discovered that stakeholder identification usually focuses on identifying actors for use case development rather than interactions between stakeholders. Business workflow is another useful representation that can describe the business requirements of different stakeholders (Fan et al., 2012). Therefore, stakeholder role of the system-to-be can be identified and extracted from viewpoints, use case representation and business workflow representation. Meanwhile, Figure 3.2 depicts the process of requirement engineer identifying the stakeholders' role and their respective goal towards the system-to-be.

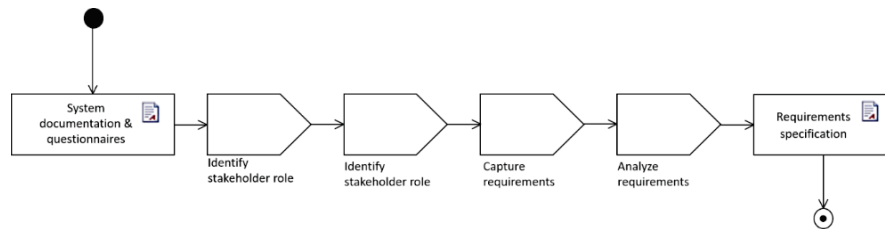


Figure 3.2 Diagram of detail activities in identifying stakeholders' role and goal

3.2.1 Formation of Goal Graph

The identified goals guide the subsequent activities that influence decisions that must be taken during the requirement refinement. Goal graph allows hierarchical decompositions of goals. Figure 3.3 explains the steps that are required to develop the goal graph. The main root of the goal represents the hard goal to be achieved by the system. Next, the goals are refined into sub goals that elaborate how the main root goal is accomplished. The sub goals are identified together with labeling its stakeholder role to show the importance and commitment of each stakeholder.

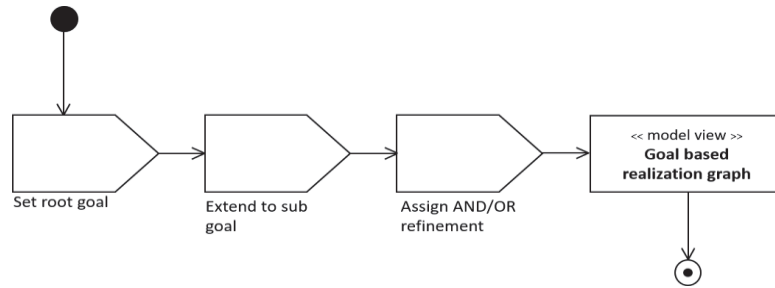
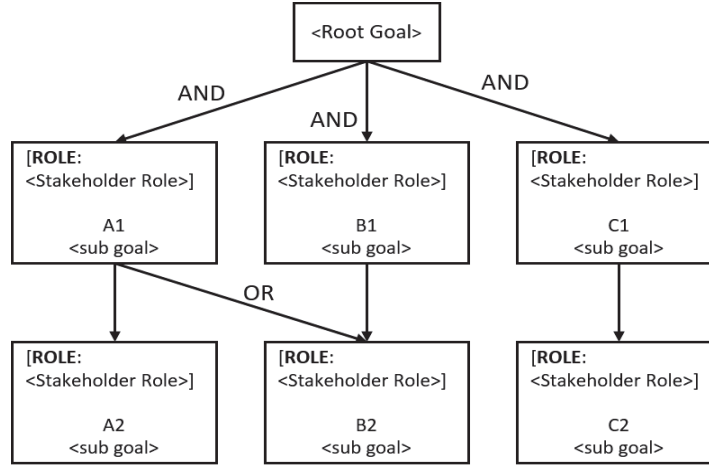


Figure 3.3 Steps in formation of goal graph

Table 3.1 summarises the notation used in developing the goal graph. Subsequently, Figure 3.4 illustrates the representation of goal graph used in this study in a top-bottom manner.

Table 3.1 Notation of goal graph

Notation	Description	Example
<Root Goal>	A root goal to be achieved by the stakeholders	Demonstrate a success labour information system
[ROLE: <Stakeholder Role> Ai <sub goal>]	[Role: <Stakeholder Role>] Represent the stakeholder's role that execute the goal <sub goal> refers to the name of sub goal (A3) shows the sequence number of goals	[ROLE: Assist. Exec. Dep. of Labour] (A1) Manage quota requisition
AND OR AND means the lower sub goal MUST be executed by stakeholder in order to satisfy the higher goal/sub goal OR means the execution of the lower goal by the stakeholder in order to satisfy the higher/sub goal is OPTIONAL		<pre> graph TD Root[Manage labour requisition] -- OR --> A1["(A1) Manage quota requisition"] Root -- AND --> A2["(A2) Prepare labour requisition"] A2 --> A21["(A2.1) Verify labour requisition"] style Root fill:#fff,stroke:#000 style A1 fill:#fff,stroke:#000 style A2 fill:#fff,stroke:#000 style A21 fill:#fff,stroke:#000 </pre>

**Figure 3.4** A goal graph

3.3 ASSESSMENT OF ROLE-BASED GOAL GRAPH

The goals assessment aims to evaluate the confidence and reliability of stakeholder goals represented within the model. This section describes the process used to assess each goal according to defined confidence factors—such as assumptions, achievability, stakeholder mandate, and refinement. Through this assessment, requirement engineers can determine the feasibility and adequacy of the modelled goals, helping to identify potential risks and areas requiring further validation before system implementation.

Figure 3.5 illustrates the steps involved in assessing the goal graph. The focus is to assess stakeholders' representation based on the **ROLE** involved in the system-to-be. Therefore, in this study, four confidence factors are adapted from Boness et al. (2011) and Boness et al. (2008) which are: (1) Assumptions (**ASSUME**), (2) Achievability (**ACHIEVE**), (3) Stakeholder's mandate (**MANDATE**), and (4) Refinement (**REFINE**). This study requires an expert's rating of the confidence factors in order to obtain the feasibility and the adequacy attach for each goal.

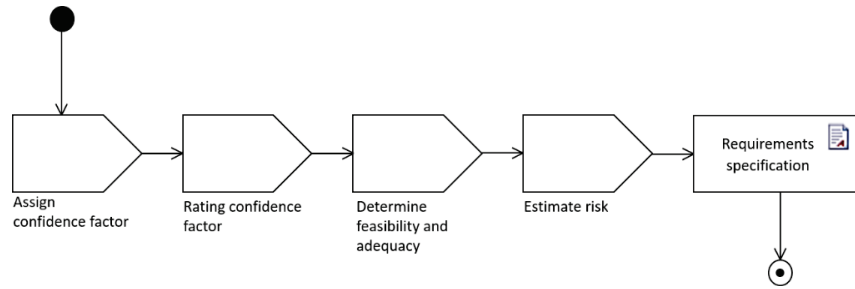


Figure 3.5 Steps in assessment of goal graph

3.3.1 Confidence Factor Assessment

The definition of chosen confidence factors is summarised in Table 3.2. Each sub goal will be assigned with the confidence factor; either ASSUME or ACHIEVE and must be assigned with MANDATE and REFINE. Once each sub goal has been assigned with the confidence factors, next each sub goal will be rated by an expert using 4-point ordinal scale (NONE (N), LOW (L), MEDIUM (M) and HIGH (H) as proposed by Boness et al. (2011). The default rating for each confidence factor is Low.

Table 3.2 Definition of confidence factor (Source: Boness et al., 2011)

Confidence Factor	Description
ASSUME	The sub goal and its environment are trusted and satisfied even though the stakeholder has inadequate grounds for believing this is reliable.
ACHIEVE	The acceptance criteria of the sub goal are achievable even though the stakeholder has inadequate grounds for believing the implementation is realizable.
MANDATE	The sub goal is trusted and satisfied to have adequate scrutiny from the stakeholder.
REFINE	The sub goal is still uncertain and incomplete, thus is open to refinement from the stakeholder.

3.3.2 Determination of Feasibility and Adequacy

According to Boness et al. (2011), assessing the work or task is essential during requirements analysis to determine whether it is feasible and adequate to be implemented. ASSUME and ACHIEVE confidence factors are used to estimate the feasibility of each sub goal in the goal graph. Meanwhile MANDATE and REFINE confidence factors are used to determine the degree of adequacy of each sub goal in the goal graph.

As illustrated in Figure 3.6, the goal graph was assessed from the leaves towards the root. The Feasibility (FEASIBLE) assessment is based on the weakest link technique that propagates the goal towards the root from the leaves. The FEASIBLE is then determined using both the ASSUME and ACHIEVE ratings. For instance, if the lowest sub goal is rated as ASSUME = HIGH, ACHIEVE = MEDIUM, then the upper sub goal is determined as FEASIBLE = MEDIUM, may supplement using the following rules:

- (1) If lower sub goal has ASSUME = LOW and ACHIEVE = HIGH then Upper sub goal/root goal has FEASIBLE = LOW.
- (2) If lower sub goal has ASSUME = HIGH and ACHIEVE = MEDIUM then Upper sub goal or root goal has FEASIBLE = MEDIUM.
- (3) If lower sub goal has ASSUME = HIGH and ACHIEVE = HIGH then Upper sub goal/root goal has FEASIBLE = HIGH.

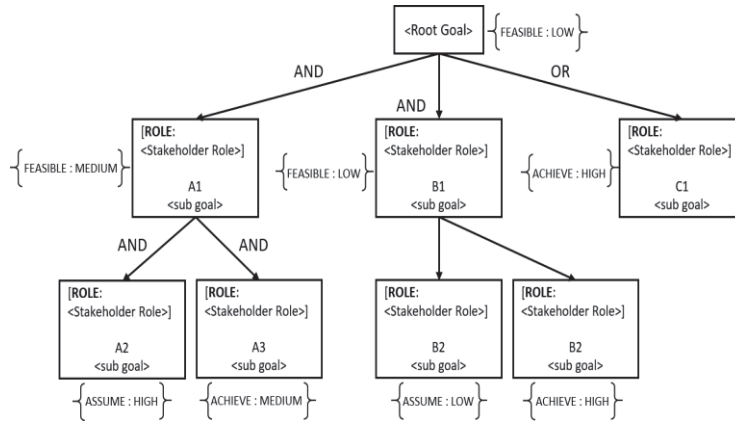


Figure 3.6 The determination of FEASIBLE of goal graph

As illustrated in Figure 3.7, the Adequacy (ADEQUATE) assessment is calculated based on parent goal (root) towards their leaves. In Boness et al. (2011), ADEQUATE assessment cannot be based on the combination of one single REFINE rating and one single MANDATE and should traverse from the root towards the leaves with the assumption that there is a possible lack of confidence in the ratings of REFINE and MANDATE. In this study, each of the sub goal has been given value of REFINE and MANDATE by expert using value of NONE, LOW, MEDIUM, and HIGH.

Subsequently, each sub goal is given a rating based on REFINE and MANDATE profile matrix as tabulated in Figure 3.8. For example, if the lowest sub goal is rated as REFINE = HIGH, MANDATE = MEDIUM, then the upper sub goal is determined as RA = MEDIUM.

Once the FEASIBLE and ADEQUATE ratings have been propagated through the goal graph, the risk of each sub goal is identified. According to Boness et al. (2011), the higher the fraction of sub goals in the PROCEED zone; the lower is the risk in the requirement of the project. The CAUTION zone would be a cause for great concern because the sub goal could be inadequate or infeasible to be implemented. A higher number of leaf goals in the DO NOT PROCEED zone would indicate that further requirements work is required by the requirement engineer to get more information about the mandate and to re-examine the requirements. Figure 3.9 shows the risk identification as a result of value of FEASIBLE and ADEQUATE in the goal graph.

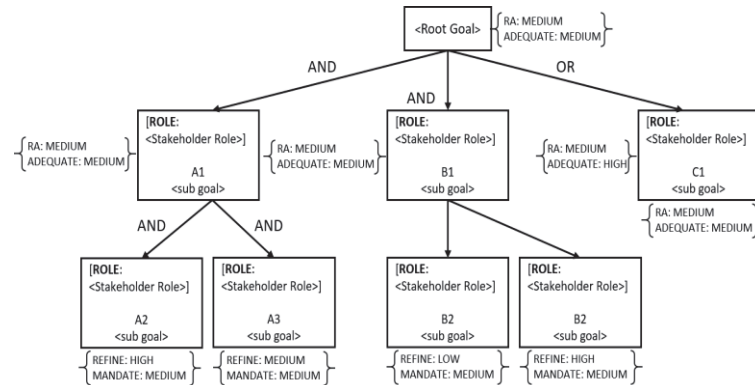


Figure 3.7 The determination of ADEQUATE of goal graph

MANDATE	H	N	L	M	H
	M	N	L	L	M
	L	N	L	M	M
	N	N	N	N	N
		N	L	M	H
REFINE					
Key: N: NONE; L: LOW; M: MEDIUM; H: HIGH					

Figure 3.8 REFINE and MANDATE profile matrix (Source: Boness et al., 2011)

ADEQUATE	H				
	M				
	L				
	N				
		N	L	M	H
FEASIBLE					
Key:					
		PROCEED (ADEQUATE = M ∨ H) ∧ (FEASIBLE = M ∨ H)			
		CAUTION ((ADEQUATE = L) ∧ (FEASIBLE = M ∨ H)) ∨ ((FEASIBLE = L) ∧ (ADEQUATE = M ∨ H))			
		DO NOT PROCEED (ADEQUATE = N ∨ L) ∧ (FEASIBLE = N ∨ L)			

Figure 3.9 The risk identification based on the FEASIBLE and ADEQUATE of goal graph (Source: Boness et al., 2011)

3.4 EXTENDING ROLE-BASED GOAL MODELLING FOR REQUIREMENTS CLASSIFICATION

This section extends the role-based goal modelling technique by introducing a requirements classification matrix that links stakeholder roles to their corresponding goals, feasibility levels, adequacy ratings, and risk zones. The extended model enables clearer traceability between goals and specific system requirements, assisting requirement engineers and project managers in prioritising, evaluating, and managing requirements more effectively throughout the development lifecycle.

Goal modelling should be traceable to detailed requirements and specifications. This traceability provides assurance that the engineered system satisfies requirements in the application domain (Habli et al., 2007). Role-based driven requirements classification matrix that characterises the following attributes:

- (1) **ROLE:** Describes stakeholder roles as $R_i, R_{i+1}, R_{i+2}, R_{i+3}$ until R_n where “i” is index and “n” is the maximum number of stakeholder roles.
- (2) Priority decision is based on findings, which is either:
 - (a) **FEASIBLE/ADEQUATE:** Describes the degree of goal feasibility and adequacy based on confidence factors assessment as elaborated in Section 3.1. The degree is represented using NONE, LOW, MEDIUM or HIGH.
 - (b) **RISK:** Describes the degree of risk for each sub goal either PROCEED, CAUTION or DO NOT PROCEED.
- (3) **G:** Describes the ID of sub goal.
- (4) **Requirements:** Describes requirements ID together with requirements description that attach to its sub goal.
- (5) **Count:** Number of requirements that are attached to its sub goal.

The advantages of having this role-based driven requirements classification is:

- (1) It facilitates requirement engineer, project manager or relevant stakeholders with visible number of feasible and non-feasible requirements.
- (2) It facilitates requirement engineer, project manager, or relevant stakeholders with visible number of adequate and inadequate requirements.
- (3) It facilitates requirement engineer, project manager, or relevant stakeholders with visible number of requirements in the Proceed, Caution, and Do Not Proceed zones.

3.5 IMPLEMENTATION TO THE CASE STUDY AND DISCUSSION

This section demonstrates the application of the proposed role-based goal modelling approach using a real-world case study. The case focuses on a labour management system to illustrate how stakeholder roles, goals, and confidence factors are integrated into the goal graph. Through this implementation, the effectiveness of the model is assessed in identifying feasible, adequate, and high-risk requirements. The discussion highlights key findings, insights, and implications derived from the analysis, providing a foundation for future refinement of the model.

Figure 3.10 demonstrates a segment of business workflow in Labour system that focuses in managing labour requisition. There are five direct stakeholders (those who use the system) identified in Figure 3.10. Each role has their own goal in realizing the process of labour requisition. From this business workflow representation, the role-based goal can be modelled. All stakeholders and processes in Figure 3.10 are extracted and transformed into goal graph as illustrated in Figure 3.11 using the formation guideline described in Section 3.2 and notation guideline tabulated in Table 3.1.

Figure 3.11 presents in detail the level of goal realisation graph for “Manage Labour Requisition”. To make the root goal more concrete, the goal is split-up into GOAL A1 and GOAL A2. GOAL A2 is refined into GOAL A2.1 and GOAL A2.1.1 in order to construct more

feasibility to accomplish the root goal. Besides, GOAL A2.1.1 is made more sufficiently concrete by adding two more sub goals which are GOAL A2.1.1.1 and GOAL A2.1.1.2. For each sub goal, the role of stakeholder is attached.

Once the goal graph design is completed, experts rate each sub goal using the confidence factors (ASSUME, ACHIEVE, REFINE, MANDATE) as described in Section 3.3.1. In this case, the experts consisted of system developers, testers and system analysts and they rated each sub goal. The assessment result is tabulated in Table 3.3. Next, the representation of role-based goal model is enhanced with confidence factor ratings as illustrated in Figure 3.12. Based on Figure 3.12, the FEASIBLE and ADEQUATE of each sub goal can be determined by observing the traversal pattern as described in Section 3.3.2.

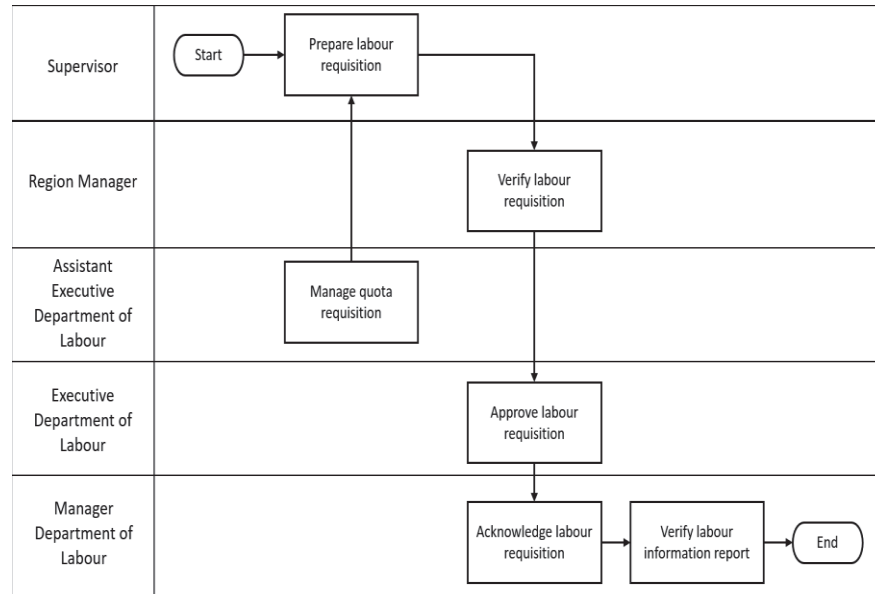


Figure 3.10 A segment of business workflow in labour system

Table 3.3 The confidence factor rating

Goal ID	Goal	Confidence Factor				FEASIBLE	ADEQUATE
		ASSUME	ACHIEVE	REFINE	MANDATE		
A	Manage labour requisition		HIGH	HIGH	HIGH	HIGH	HIGH
A1	Manage quota requisition	MEDIUM		MEDIUM	MEDIUM	MEDIUM	MEDIUM
A2	Prepare labour requisition	HIGH		MEDIUM	HIGH	HIGH	MEDIUM
A2.1	Verify labour requisition		HIGH	HIGH	HIGH	HIGH	MEDIUM
A2.1.1	Approve labour requisition		HIGH	MEDIUM	MEDIUM	HIGH	MEDIUM
A2.1.1.1	Acknowledge labour requisition	HIGH		MEDIUM	MEDIUM	HIGH	MEDIUM
A2.1.1.2	Verify labour information report	MEDIUM		MEDIUM	MEDIUM	MEDIUM	MEDIUM

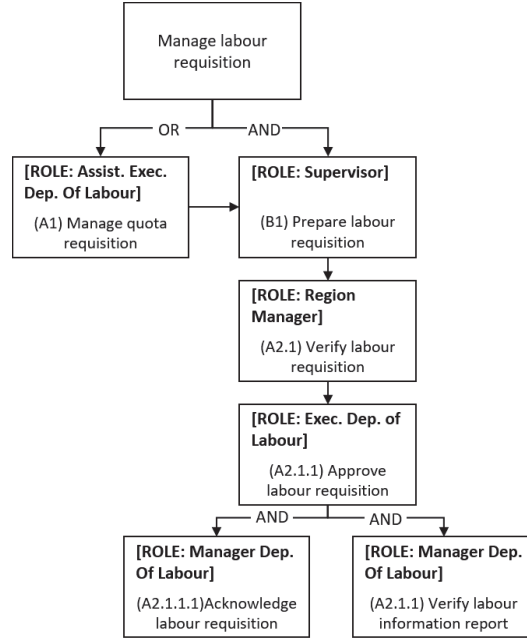


Figure 3.11 The role-based goal graph of manage labour requisition

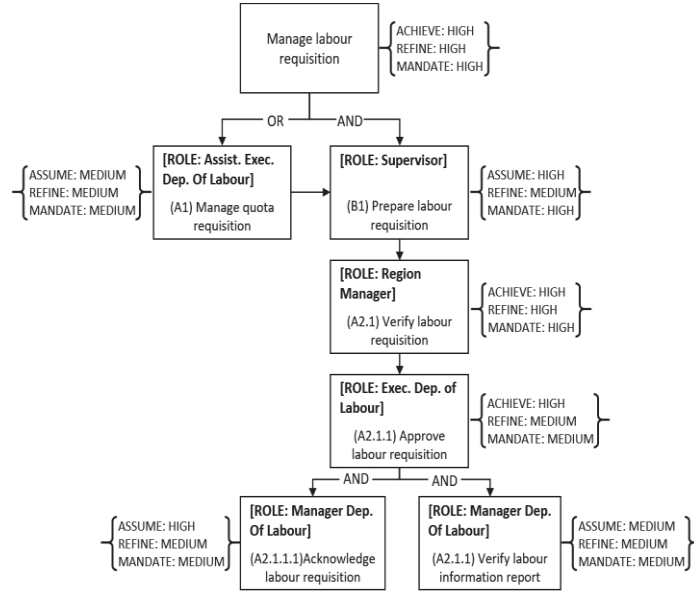


Figure 3.12 The role-based goal graph with confidence factor rating of manage labour requisition

3.5.1 Evaluation and Findings

Finally, the propagated FEASIBLE and ADEQUATE, the risk of each sub goal can be identified as tabulated in Figure 3.13 that indicates that five goals demonstrated the PROCEED zone and two goals demonstrated CAUTION zone. It shows that for the “Manage labour requisition” goal, there is minimum potential risks that could be attached to the requirement stated by stakeholders. If there is appearance of risk prediction, requirement engineer could re-examine the requirement before it can be proceeded to the other stage of development.

In addition, this role-based goal modelling gives straightforward means to deriving the number of requirements which are feasible or non-feasible and adequate or inadequate as summarised in Table 3.4. Besides, in Table 3.4 also presents the risk assessment for managing labour requisition. From Table 3.4, we can summarise that requirement under goal GOAL A1 and GOAL 2.1.1.2 are in danger since it has been labelled under the Caution zone. The requirement engineers or project manager has to further consult the stakeholders involved before they can proceed to the other stage of development.

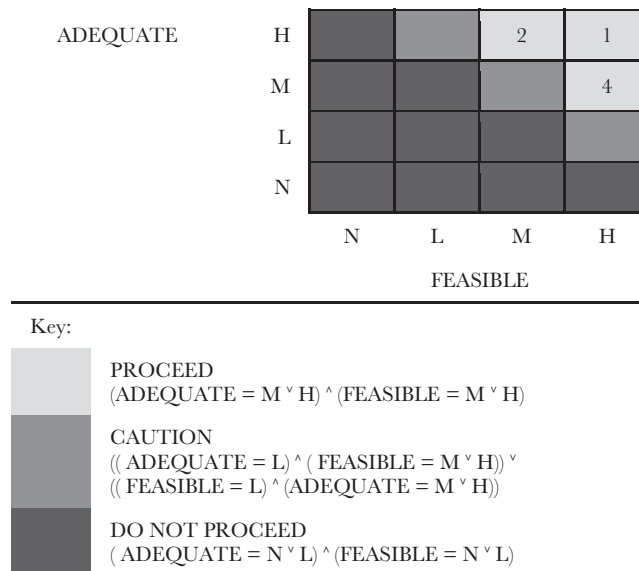


Figure 3.13 The goal count for Figure 3.12

Table 3.4 (Continued)

ROLE				FEASIBLE		ADEQUATE		RISK		G	Requirements
R _i	R _{i+1}	R _{i+2}	R _{i+3}	R _n	Degree	Count	Degree	Count	Degree		
/					MEDIUM	2	HIGH	2	PROCEED	2	G3
G3R1: The system shall be able to display the current number of total labour that is available. G3R2: Users are add requisition summary details.											
/					MEDIUM	2	HIGH	2	PROCEED	2	G4
G4R1: The system should allow users to view all labour information details. G4R3: The system shall be able to print the labour information details that have been selected from the list.											

continue

Table 3.4 (Continued)

ROLE				FEASIBLE		ADEQUATE		RISK		G	Requirements
R _i	R _{i+1}	R _{i+2}	R _{i+3}	R _n	Degree	Count	Degree	Count	Degree	Count	
/					MEDIUM	1	HIGH	1	PROCEED	1	G5 G5R1: The system must be able to change the labour requisition status from “Prepared” to “Approve” by clicking the approve button.
/					MEDIUM	1	HIGH	1	PROCEED	1	G6 G6R1: The system should allow users to view all labour information details.
/	/				HIGH	2	MEDIUM	2	CAUTION	2	G7 G7R1: The system should allow users to view all labour information details. G7R2: Users are able to select from the labour information list.

3.6 CONCLUSION

In a nutshell, this chapter has described an innovated role-based goal model by adding the role of stakeholder element for better goal representation of system-to-be. This chapter has demonstrated how to develop the role-based goal realisation graph and followed by on how to assess the model from the aspect feasibility, adequacy, and risky. The role-based goal modelling is then extended and used in requirements prioritisation matrix to facilitate the requirement engineer and project manager to analyse or estimate the severity of any requirements.

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