ROADMAP: A NOVEL METHOD FOR ROLE-BASED AND DECENTRALIZED PROCESS MODELING

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ROADMap: A NOVEL METHOD FOR ROLE-BASED AND DECENTRALIZED PROCESS MODELING

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ABSTRACT

ROADMap: A NOVEL METHOD FOR ROLE-BASED AND DECENTRALIZED PROCESS MODELING

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Role-based and decentralized process modeling allows actors to focus on modeling their own role behaviors and requires them to communicate and negotiate with each other in order to form a consistent and integrated process model. Due to the collaborative nature of role-based and decentralized process modeling, negotiations among the actors who play different roles have a crucial impact on modeling activity of overall process. Based on the communication and negotiation time among the actors, these types of process modeling approaches vary. In this study, we propose a role-based and decentralized process modeling method, called ROADMap, that keeps the strengths and improves the weaknesses of current ones. The exploratory study results reflect that these strengths and weaknesses can be categorized under five aspects namely flexibility, conflict prevention, information awareness, overall view and latency. The proposed ROADMap method considers these aspects and it is supported with a web and cloud-based tool and a notation. A multiple case study is conducted in order to validate the proposed ROADMap method. Case study results indicate that ROADMap method is a successful role-based and decentralized process modeling method for process stakeholders in organizations.

Keywords: Role-based Process Modeling, Decentralized Process Modeling, Colaborative Process Modeling

ÖZ

ROADMap: ROL TABANLI VE DAĞITIK SÜREÇ MODELLEME İÇİN YENİ BİR YÖNTEM

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Rol tabanlı ve dağıtık süreç modelleme aktörlerin kendi rol davranışlarını modellemeye odaklanmalarını sağlar ve tutarlı ve bütünleşmiş bir süreç modeli oluşturmak için onların birbirleri ile iletişimlerini ve müzakere etmelerini gerektirir. Rol tabanlı ve dağıtık süreç modellemenin işbirlikçi doğası gereği, farklı rolleri icra eden aktörlerin arasındaki müzakerelerin tüm süreci modelleme faaliyeti üzerinde önemli bir etkisi vardır. Aktörler arasındaki iletişim ve müzakere zamanına göre, bu tür süreç modelleme yaklaşımları değişiklik gösterir. Bu çalışmada, mevcut rol tabanlı ve dağıtık süreç modelleme yöntemlerinin güçlü yönlerini içeren ve zayıf noklarını geliştiren ROADMap yöntemi önerilmektedir. Açınsayıcı çalışma, bu güçlü yönlerin ve zayıf noktaların esneklik, çakışma önleme, bilgi farkındalığı, genel görünüm ve gecikme olmak üzere beş kategori altında toplanabileceğini göstermektedir. Önerilen ROADMap yöntemi bu noktaları göz önünde bulundurmaktadır ve web ve bulut tabanlı bir araç ve bir notasyon tarafından desteklenmektedir. Önerilen ROADMap yöntemini doğrulamak amacıyla bir çoklu durum çalışması gerçekleştirilmiştir. Durum çalışması sonuçları göstermektedir ki ROADMap yöntemi kurumlardaki süreç paydaşları için başarılı bir rol tabanlı ve dağıtık süreç modelleme yöntemidir.

Anahtar Kelimeler: Rol Tabanlı Süreç Modelleme, Dağıtık Süreç Modelleme, İşbirlikçi Süreç Modelleme

To all beloved

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CHAPTER 1

INTRODUCTION

Business process modeling has become an important activity for a growing number of organizations during the last decade. Organizations use business process modeling as a way to represent the work knowledge [20] [32]. Moreover, it is used in many fields of organizational life such as explicit definition of processes, process execution and automation, assessment and identification of added value, comparison of workflows to be planned and realized, software requirements identification and quality manual establishment. Therefore, process models are significant assets for the organizations since they are utilized for different purposes in several organizational activities namely business process management, software process improvement, business process re-engineering and workflow management. As a result, process modeling can be put forth on as a crucial activity for the organizations.

Business process modeling can be seen as single person activity or multi person activity [71]. For the single person perspective, one person is accountable for all process modeling activities. In other words, that person should have the domain knowledge, create process model and verify and validate the created model. However, it is not likely that one person can have in-depth domain knowledge about all aspects of the process. On the other hand, for multi person perspective, a number of people are responsible for process modeling activities. Since domain knowledge may be distributed in the organization, capturing this distributed knowledge and turning it into models requires communication, coordination and decision making. This means that business process modeling has a collaborative nature so that multi person perspective should be followed.

Traditionally, business process modeling is performed using a top-down and centralized approach. It means that a group of experts apply modeling based on the knowledge gathered from the stakeholders who participate in process executions. However, in today's world, the process knowledge is distributed among many workers due to globalized business world. Therefore the acquisition of this domain knowledge for the process modeling is conducted by the process engineers via interviews and questionnaires. Since the process knowledge is spread out over the organization, acquisition of the knowledge is time and effort consuming. Therefore, modeling the processes can take months or even years especially for the large organizations. As a result, this leads to a disadvantage for the organizations to change and improve their business processes in order to adopt them to frequently and rapidly changing environment.

Demirors pointed out that the process stakeholders have much more information about process domain than the process engineers [10]. Therefore, how accurate the process model represents the actual work highly depends on the degree of stakeholder involvement during

process modeling [10] [69]. If each stakeholder in the organization is responsible for modeling its own contribution to the process, which is decentralized way, as the modeling can be performed concurrently by the different stakeholders, total time and effort for the process modeling will decrease significantly. Similarly, Antunes et al. stressed that expert modelers are needed to be avoided during the elicitation of information about work since they may not have sufficient knowledge about the actual work [1]. Instead, stakeholders who perform the actual work i.e. people who participated in execution of the process should themselves be involved in the process modeling.

1.1 The Problem Statement

In various studies, the importance of the fact that individuals who involve in process execution model their own business processes was declared. Also, this was preferred over employing process engineers who gather process knowledge from stakeholders and model accordingly. [2] [18] [29]. While some studies [23] [53] support individual involvement during process modeling with collaboration, only a few of them are role-based. In other words, stakeholders deal with the overall view of the whole business process and cannot focus on their individual roles in the organization. Since roles are the smallest units from which the concerns are separated in a business process, allowing each role to focus on its own work is meaningful and beneficial. Therefore, a role-based approach leads to reflection that best fits to actual work.

Among the collaborative and decentralized studies, only a few of them adopts a role-based business process modeling approach [67] [70] [42]. The idea of collaborative and decentralized approach is first suggested as Horizontal Change Approach (HOC-A) by Demirors [10] [11]. Following that approach, Turetken offered a method namely Plural [66] that provides a guideline for individuals to model their own work in a role-based and decentralized manner. Plural defines a third party participant called coordination team which may reduce the expected benefits of a decentralized process modeling. Also, the tool support for Plural method was not a comprehensive one and it was an add-on for ARIS Toolset, which is a part of ARIS Collaborative Suite [57]. Although tool support is a facilitator for life-cycle management of process modeling such as workspace awareness [54] and negotiation, the tool supporting Plural method had some limitations. Moreover, the notation used for Plural was a mix of eEPC [57] and UML notations [38] so that it could not be well suited to represent the interaction related behaviors of the roles in collaborative and role-based business process modeling. Lastly, the suggested notation was informal without formal syntax and semantics definitions.

Communication is a crucial aspect of role-based process modeling in order to form a consistent and integrated process model. In other words, due to collaborative nature of role-based process modeling, all roles in a process need to communicate and negotiate to create a sound process model. Although in all role-based approaches each role is responsible for modeling its own work, these approaches vary based on the time when message specifications among the roles happen. Oppl identified three different role-based process modeling approaches for distributed model elicitation namely ex-ante, ex-post and ongoing communication negotiation [42]. Ex-ante approach requires all roles to gather and determine all messages to be transferred among the roles before each of them starts to model its own contribution to the process. Since these roles stick to the agreement, they lose their flexibility during modeling their own work. Moreover, roles have to wait until consolidation step, even if they need a

small modification. In ex-post approach each role models its own work and when all roles finish their part, they discuss the messages to be transferred in a consolidation step. Thus, none of them are aware of each other during modeling their own works so that a large amount of conflicts may occur. Finally, in ongoing approach, while roles model their own contributions, they negotiate with each other. When a message to be transferred is defined, this message is discussed immediately between the pairs. Therefore, this brings a cognitive overload to the related roles and makes it difficult for them to concentrate on their own parts. As a result, none of these approaches is an ideal communication and negotiation approach, and each of them has drawbacks related to flexibility, conflict prevention, information awareness, overall view and latency.

There is a need for a method that enables roles in the organizations to model their own works in a role-based and decentralized manner. The method also should consider flexibility, conflict prevention, information awareness, overall view and latency aspects while the roles model their own work. Additionally, the method should be supported with an appropriate notation and a tool which are suitable for collaborative role-based business process modeling.

1.2 The Solution Approach

The participation of the process stakeholders into process modeling is very significant [68] [2] [18] since they have much more information about their process than the other people in the organization. The accuracy of the model that represents the executed process increases directly proportional to the involvement of the process stakeholders in process modeling. As a result, if representative model is more accurate, controlling and improvement of the process both takes far less time and needs far less effort. Therefore, in this study we propose ROADMap method, ROle-based And Decentralized process Modeling method, that follows a stakeholder driven and decentralized process modeling.

Beside being stakeholder driven and decentralized, the ROADMap method needs to pursue a role-based modeling approach in which each role concentrates on its own part of work. Rather than participating in an overall view of the whole business process, each role deals with only its own internal work and its own interactions. As a result, a purer and more detailed models which reflect the actual perception of work are obtained [43]. Also, since concerns are separated in role granularity, both overlaps among the models are avoided and communications among the roles are identified more clearly and explicitly. As a result, the ROADMap method adopts a role-based process modeling approach.

Since a decentralized and role-based modeling approach constitutes collaborative nature, the communication and negotiation among the roles are inevitable. Therefore, the aspects that vary with time, when message specifications among the roles happen, should be clearly examined in order to form a consistent and integrated process model. As stated in Section 1.1 current role-based process modeling approaches namely ex-ante, ex-post and ongoing communication negotiation have some drawbacks in terms of the given aspects. However, the ROADMap method satisfies all of these aspects. In other words, it is flexible meaning that the roles are not restricted while they are modeling their own parts of work. Moreover, the ROADMap method includes a conflict prevention mechanism in order to provide consistency among roles in the whole process. Additionally, information awareness is a necessary aspect so that our method provides this aspect based on the demands of roles. Also, roles are aware

of the overall process view anytime in order to follow the current state of the overall process. Finally, none of the roles faces with a latency resulted from cognitive overload, any restrictions or resolution of excessive amount of conflicts at the end of the modeling session with ROADMap method.

Our method is supported by a notation and a tool. Firstly, the notation is simple enough for people who have little or no experience and knowledge about business process modeling. Assuming that stakeholders may be inexperienced, we use an extended version of S-BPM [16] as the notation for ROADMap method due to its simplicity. Secondly, the method requires a tool support because of its collaborative nature. In order to automate the integration of individual models, manage negotiations among roles and provide instant information awareness, we provide a web and cloud-based tool support as part of the ROADMap method.

1.3 Research Questions

The following questions are explored in this study:

RQ 1: To what extend does ROADMap method cover the aspects that are identified in the exploratory study?

RQ 1.1: Does ROADMap method cause restrictions about definition or transfer of messages during modeling role behaviors?

RQ 1.2: Does ROADMap method have a mechanism to prevent conflicts?

RQ 1.3: Does ROADMap method provide current changes related to the roles themselves whenever they demand?

RQ 1.4: Does ROADMap method provide an informative overall view of the process including the roles and interactions among them?

RQ 1.5: Does ROADMap method cause to a significant latency to finish modeling?

RQ 2: What are the drawbacks and additional benefits of the ROADMap method?

1.4 Organization of the Thesis

Chapter 2 presents the literature review and discussion about collaborative process modeling tools, role-based and decentralized process modeling approaches and process modeling notations for role-based modeling.

Chapter 3 gives our proposed ROADMap method in terms of the approach it drives. In other words, this section explains in detail its application process in the organizations, its notation and its tool support.

Chapter 4 presents details of the exploratory study to discover ROADMap method and multiple case study we conducted to validate it.

Chapter 5 explains the results of the case studies we conducted to validate our ROADMap

method and also gives a brief discussion about these results.

The final chapter, Chapter 6, discuses the outcomes of the overall study and points out the possible future directions of this work.

CHAPTER 2

LITERATURE REVIEW

In this chapter, the summary of the literature is given in order to increase understandability of the study. In Section 2.1 current collaborative business process modeling tools are analyzed. Therefore, the approaches they use for the collaboration are identified. Section 2.2 describes the current decentralized process modeling approaches and gives a detailed analysis on them. Moreover, the notations which can be used for the role-based process modeling are given in Section 2.3. The advantages and disadvantages of these notations are discussed. Finally, a brief discussion on literature review is given in Section 2.4.

2.1 Collaborative Process Modeling Tools

Business processes have a high degree of collaboration since a number of participants are involved within different parts of the process [47]. Thus, modeling such a collaborative process can also be in collaboration. There exists a number of collaborative business process modeling tools in the literature.

Cooperative Editor for Process Elicitation (CEPE) [56] was one of the first collaborative business process modeling applications and it was developed in order to enable the employees of the organizations to participate in process modeling. CEPE was implemented based on the second stage of the PAWS [3] business process re-engineering method which is elicitation of the process and identifying problems. Moreover, CEPE provides an interactive platform on which users perform modeling activities on the same shared model. Basically, users start with defining the places where the activities are performed in the organization. The places consist of the stages which are the tasks conducted by the roles. After specification of the places and the stages, exits of the stages are determined which are called options and the information flows among the stages are established by the events. CEPE also supports several functionalities that facilitate process modeling like commenting, making suggestions and etc.

The Collaborative Modeling Architecture (COMA) [49] was offered as a collaborative modeling support system by Rittgen. COMA has four main activities for negotiation which are propose, support, challenge and accept. Basically, each group member creates a model and proposes that model to others. The acceptance of the proposals is decided based on either rule of seniority or rule of majority [50]. The motivation behind the implementation of COMA was to support active participation of the process stakeholders unlike traditional process modeling in order to make models more understandable and more agreeable [52]. Although COMA provided some advantages such as a better shared view, more insight and focus on processes

ability to evaluate alternative models and good perceived usefulness [51], experiments showed that a group-ware functionality for better communication and negotiation was needed.

Metasonic Suite [35] is a commercial business process modeling tool which adopts subject-oriented approach and it was implemented by Metasonic AG [34]. Metasonic Suite is composed of three essential modules which are Metasonic Build, Metasonic Proof and Metasonic Flow. While the Metasonic Build enables the users to model business processes of the organization, Metasonic Proof validates these generated models and Metasonic Flow executes them in pursuit of validation. Since Metasonic Suite employs subject-oriented process modeling approach, it provides active involvement of the employees who perform the actual works in process modeling activities. Moreover, in order to model business processes with the help of modeler module, firstly a process group is created. A process group mainly consists of processes, roles, and process overviews. Process overviews show the interaction of the processes within the process group. Also, each process includes subject behavior and subject interaction diagrams. The messages to be transferred among the subjects are defined on the subject interaction diagram. Therefore, each subject models its own contribution on subject behavior diagram based on the messages defined on the subject interaction diagram. Moreover, roles in the organization are mounted to the tool and these roles are assigned to subjects in order to determine which role is responsible for both modeling and execution of assigned subject. Lastly, the new version of the Metasonic Suite a collaboration environment is provided for modeling via design repository system [35].

ARIS Cloud [61] is a commercial, web-based and new generation collaborative business process modeling tool developed by Software AG [63]. The company has also other process modeling tools namely ARIS Express [62] and ARIS Align. ARIS Cloud runs on the cloud meaning that the application servers and central repositories are located in the cloud. It mainly consists of two views which are collaboration view and portal view. In collaboration view, the tool allows modelers to display the feeds posted by the other modelers, which are related to processes or groups they follow. These feeds can be manipulated with some operations such as "like", "comment", "share", "bookmark", which are similar to ones of social media. The other view is portal view and it is used to carry out modeling activities. With the help of this view, business processes can be created and edited. Also, for any process, its feeds are listed while editing that process. Therefore, the modelers can discuss the process via this social collaboration capability of the tool. ARIS Cloud provides a shared overall view of the process so that the modelers work on the same shared model. Finally, it supports a number of notations for modeling namely application system type diagram, EPC, organizational chart and value-added chain diagram.

The Signavio Process Editor [59] is another commercial web-based collaborative business process modeling tool and was originated from Oryx [9] which is also a process modeling tool. The created process models with this tool are kept in a central repository similar to the other tools. Multiple modelers can work on the same shared process models, however, it is not possible to edit models synchronously. There is also a version management system so that change history of the models are stored. Moreover, information awareness is provided via e-mail notification system meaning that when a change occurs on the model, other associated modelers are informed via e-mail based on the publish/subscribe pattern [13]. One of the collaboration aspects of tool is to support commenting feature. Therefore, multiple users can discuss on process models. Another collaboration aspect is the model publishing which allows the users to publish process models on different web-based systems. Finally, it also provides several APIs in order to configure user specific editors.

The high level comparison of the collaborative process modeling tools mentioned above is given in Table 2.1.

Table2.1: Comparison of Current Collaborative Process Modeling Tools

	Model Perspective	**Architecture**	**Information Awareness**	**Central Repository**	**Concurrent Modeling**
CEPE	Shared View	Desktop App.	No	Yes	Yes
COMA	Shared View	Desktop App.	No	Yes	Yes (Not on the same model)
Metasonic Suite	Subject View	Desktop App.	On Demand	Yes	Yes
ARIS Cloud	Shared View	Web-based	For Collaboration View	Yes	Yes
Signavio Process Editor	Shared View	Web-based	Via e-mail	Yes	Yes (Not Sync.)

Reimer et al. [47] analyzed eleven business process modeling tools after a systematic tool selection process where each selected tool was expected to support at least one of the notations which are EPC [57], BPMN [39], IDEF [30] and UML [38]. ARIS Design Platform 7 [8], Enterprise Architect 8 [65], Bonapart Collaborative [45] and iGrafix Process Modeler 2011 [27] were some of the analyzed tools. These tools were examined in terms of three criteria namely process modeling, collaboration and technical criteria. For the collaboration aspect, strong negotiation support on process models and chat communication for real time communication were specified as missing features for most of the analyzed tools. Also it was stated that none of these tools has a comprehensive information awareness support. Finally, the study suggested a very high-level architecture for supporting collaborative process modeling in terms of workflow management, awareness, conflict resolution and communication.

2.2 Decentralized Process Modeling Approaches

Work is a cooperative event [64] including activities that are distributed to different actors in the organizations. These actors contribute their works and use the work results of other related actors by communication [58]. Business process modeling is also a work and each actor in a process have much more information than the process engineers or the other actors for its contribution to the process [68] [69] [1]. Therefore, there are a number of studies working on decentralized process modeling in which each actor models its own part of work in the process [10] [66] [42] [70]. While some of these studies directly concern the approaches for decentralized process modeling itself, the others examine its communication and negotiation aspects.

Horizontal Change Approach (HOC-A) was proposed by Demirors [10] and is prior and one of the most important studies related to decentralized process modeling. The main idea of the approach is that each agent models their own activities concurrently in a decentralized way

in order to perform change management in the organizations. Firstly, Demirors discussed the methods for software process improvement supporting the assumptions below:

- Quality management principles in manufacturing can be directly employed to software development process. [26]
- The core of software development process can be defined explicitly and the enactment of the model can be applied in the real world.
- The process modeling activities can be performed vertically. In other words, a top-down and centralized approach can be followed by an expert group while modeling the processes [5].

Based on these assumptions, Demirors specified the problems related to software quality management and offered HOC-A. The focus of the approach is establishing a change environment using the expertises of all knowledge workers in the organization. Demirors stated that the process of process modeling is more crucial than the process model itself since focus on process of process modeling helps to identify problems related to process and to resolve them instead of monitoring and controlling. Moreover, he pointed out that the process knowledge is created by the knowledge workers and this knowledge is distributed over the organization. Also, Demirors stressed that since knowledge workers have the process knowledge, they should be encouraged to take responsibility in modeling their own activities, identification of the problems, and improvement of their process [11].

In HOC-A, each agent has three different roles which are modeling, change and enactment. Initially, in the modeling role, agents model their own individual processes concurrently and in a decentralized manner instead of a centralized and top-down approach. After that, in the change role, agents communicate with each other in order to detect and resolve inconsistencies among their personal process models. Finally, agents execute their own processes based on the models they created in the enactment role.

In order to apply HOC-A in the organizations, Demirors proposed a notation for that approach namely Horizontal Change Notation (HOC-N) [10]. This notation not only helps to model individual process models and integrate them but also supports communication among agents. With the help of this notation, agents are enable to perform their behavioral representations concurrently.

When HOC-A is applied with a disciplined guideline in the organizations, it brings advantages in terms of knowledge elicitation, process improvement and execution. However, absence of a tool support for the given approach does not allow applying HOC-A in an efficient and effective way although it is supported by HOC-N for process modeling. Also, HOC-N is a text-based notation which does not provide a visual representation so that learning its semantics is difficult for the process participants.

Plural method is another decentralized process modeling method and it was proposed by Turetken [66]. This method is based on the idea that all individuals in the organization model their own activities, resolve their conflicts among them and integrate partial models in order to obtain a consistent and integrated business process model. However, the communications and relationships between agents depend on the roles of the agents. Therefore, Plural is a role-based process modeling method.

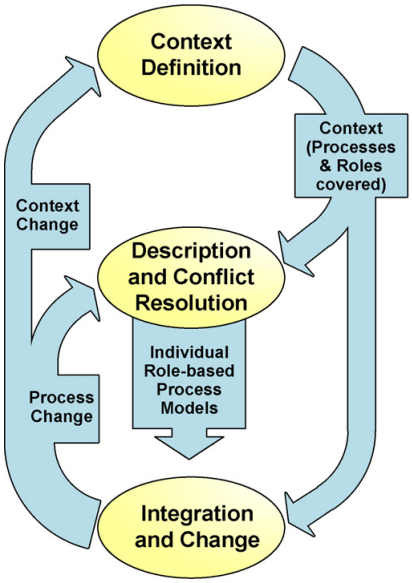


Figure 2.1: The Plural Phases [69]

Plural method consists of three main phases namely context definition, description and conflict resolution, and integration and change phases [69]. In the context definition phase, the scope and the purpose of the initiative are determined, the process which will be modeled is identified, the agents and roles which take in the scope of the process are decided. In the description and conflict resolution phase, all roles in the process model their own parts of works, identify conflicts between other roles in the process and resolve these conflicts. After that, partial role-based models are verified and validated in order to meet the goals of the process and these models represent behaviors of the roles correctly and entirely. Finally, the verified and validated partial models are integrated in the integration and change phase. Moreover, if there is a problem due to the context or the model description, changes to handle these problems are performed in this phase. The Figure 2.1 depicts the phases of Plural and information flow among them.

In order to apply Plural in the organizations effectively, efficiently and systematically a tool support was provided. Also, Plural has a notation which is a modified version of eEPC notation. However, the tool is an add-on for ARIS Toolset [57] and it has some limitations. Beside that, the eEPC notation is not well suited for the decentralized process modeling so that process models may lack all advantages of decentralized modeling. Moreover, case studies were conducted in order to analyze the effects and implications of Plural Method on the organizations and individuals. According the results, the Plural decreased the total effort of process modeling and it helps the organization gather more accurate process knowledge. However, the negotiation aspects of the role-based process modeling to form an consistent and integrated model were not examined in detail. Furthermore, Plural defines a third party participant which is called coordination team, which manages execution of modeling, provides guidance to participants, verifies individual diagrams, and integrates generated models. Incorporating a central third party into modeling activity may reduce the expected benefits of a decentralized process modeling.

Generally, business processes are specified in terms of roles rather than actors [43]. Roles are the smallest units in which concerns are separated in business processes. Therefore, modeling

parts of business processes in role granularity is meaningful and beneficial. Since role-based process modeling relies mainly on self-modeling of each role, due to its collaborative nature, communication among roles is substantial. Rittgen emphasized that modeling is a special type of conversation namely negotiation [48]. Therefore, negotiations among the roles have a crucial impact on the overall process in order to identify and resolve inconsistencies and to form a sound overall process model. Oppl identified three different role-based model elicitation approaches which are ex-ante, ex-post and ongoing communication negotiation [42].

In ex-ante communication negotiation approach, all messages, which are sent and received, among the roles in the process should be determined collaboratively before each role starts to model its own part of work. Therefore, the roles should comply with the predefined messages while modeling their own parts. Although this brings an overall process view perspective to all roles in the process, it also leads to an inflexibility to roles when they need to define a new message to be transferred. Moreover, if communication problems arise among the roles while they model their contributions, the roles should wait until a subsequent phase in order to handle these problems [42].

In ex-post communication negotiation approach, firstly, all roles are expected to create separately their own part of works including the messages to be transferred from their point of views. Therefore, focusing on the individual work is more prior than the interaction aspect among the roles. After all roles models their own contributions, a negotiation step is needed in order to resolve the inconsistencies among them in terms of the messages. Although this approach provides flexibility for roles to model their own parts of works as they want, a huge amount of conflicts may pile up at the end of the individual modeling sessions [42].

In ongoing communication negotiation approach, the negotiation in terms of the messages to be transferred among the roles should be handled instantly when they are identified although each role in the process focuses on its own contribution. Firstly, the roles start with modeling their own part of work. Whenever, a message is identified, the corresponded role should be informed and if there exists an inconsistency between the pairs, it should be simultaneously resolved. Although this approach prevents crowd of inconsistencies due to instant resolution of conflicts via immediate communications and negotiations, this situation distracts focus of the roles on their role behaviors and leads to cognitive overload [42].

All three approaches differ in time when the message specifications are defined. However, all of them have several disadvantages in terms of different aspects while modeling processes as mentioned above.

Some of the recent researches in the area of distributed process modeling develop decentralized process modeling approaches on tangible modeling elements [70] [43] [21] [41]. Generally in these studies, the actors place physically placeable elements on the tabletop surface and specify the messages to be transferred to other actors in order to create business processes. The system recognizes these elements and their information such as type of the activity, its position, its rotation and etc.

Comprehand [70] is one of these studies and it is a computer-supported modeling environment that enables the stakeholders to model their works in the process in a subject-oriented manner. A tabletop surface and physically placeable elements are provided to facilitate modeling in this environment. Also, Comprehand uses S-BPM notation to make gathering process knowledge from individuals easy.

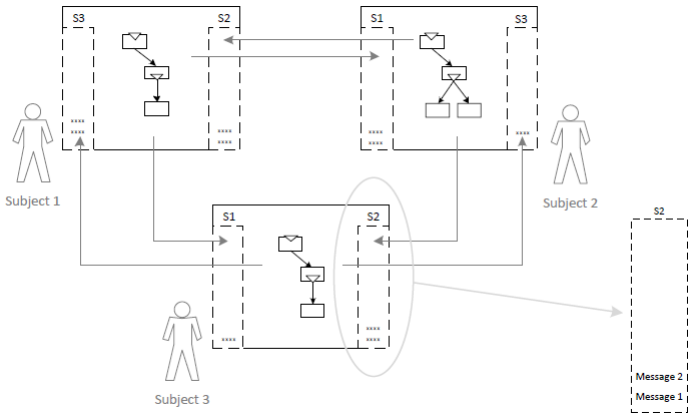


Figure 2.2: The overview of Comprehand [70]

The main idea of the approach is to integrate subject-oriented business process modeling approach with the tabletop surfaces. In other words, each tabletop surface represents a subject. These surfaces can be placed as co-located or spatially distributed that means subjects do not have to locate at the same place. Therefore, information awareness is a crucial aspect for Comprehand since spatially distributed subjects should be aware of the changes in terms of the interactions among them. In order to achieve that, each tabletop surface has notification trays for all of the other subjects to keep messages received them. The Figure 2.2 shows an overview of Comprehand.

In order to analyze the acceptance and usability of the given system, an exploratory user study was conducted on a vacation process. According to results of this study, it was hard to choose right tangible element for modeling. Moreover, Comprehand suffered from the overview of global process meaning that there was no common view that shows the entire and integrated process model. Also, the system did not have enough modeling space to model complex business processes. Finally, although the possible solution were suggested to given drawbacks of Comprehand, none of them was implemented.

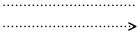
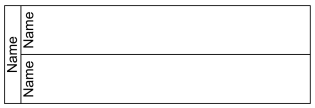
2.3 Process Modeling Notations for Role-based Modeling

In this section, process modeling notations that support role-based process modeling namely Business Process Modeling Notation [39], Role Activity Diagram [25] and Subject-oriented Business Process Management notation [16] are explained. Moreover, a sample business trip application process is modeled with each of given process modeling notations.

2.3.1 Business Process Model and Notation

The Business Process Model and Notation (BPMN) [39] is a graphical notation which was standardized by Object Management Group (OMG) [40] for articulating the business processes. The main purpose of BPMN is to provide a business process model and notation for supporting business users range from the technical users to the business users. The other objective of BPMN is to map graphical notation to XML execution languages, especially WSBPEL (Web Service Business Process Execution Language). Moreover, BPMN conducts

Table2.2: The core elements of BMPN

Notation	Description
	**An Event** is something that "happens" during the course of a process. It is usually a trigger or a result of an activity.
	**An Activity** is a generic form for work that companies perform. Also, tasks and subprocesses are the types of the activities.
	**A Gateway** is responsible for branching, forking, merging and joining of the paths.
	A Sequence Flow shows the order of the activities performed in the process.
	A Message Flow shows the direction of the messages transferred between two participants in the process.
	**An Association** links the information and notation elements so that it shows the relation between them.
	**A Pool** is used to both represent a participant in a collaboration and a graphical container that separates a set of activities form other pools.
	**A Lane** is used to organize and categorize the activities. It extends the length of the process.
	**A Data Object** is used to provide information about the requirements to perform an activity or the productions of it.
	**A Message** is used to show the content of a communication between two participants.
	**A Group** is used to bring together the graphical elements which have the same category.
	**A Text Annotation** is used to provide additional text information for the reader of a BPMN diagram.

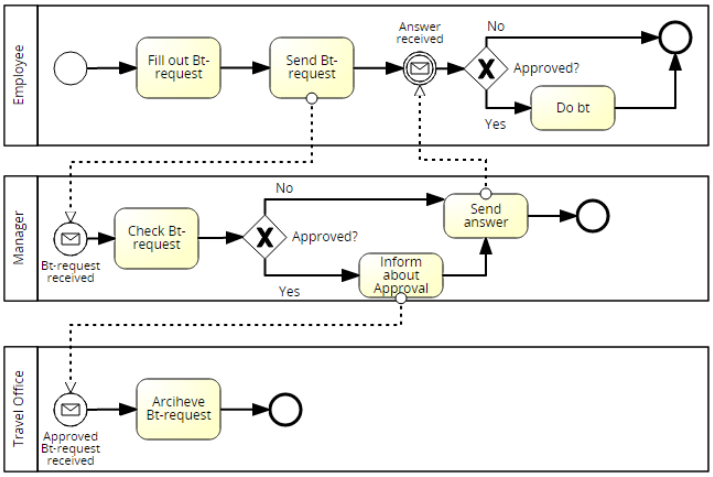


Figure 2.3: Process Model of Business Trip Application Process using BPMN 2.0

specifications of some other methodologies and notations like EPC, UML Activity Diagram, and IDEF.

While using BPMN, the activities, events, flows, and flow controls are modeled on Business Process Diagram (BPD). In Table 2.2 the core modeling elements of BPMN is given. However, with the existence of the execution support and new choreography and collaboration diagrams in BPMN 2.0 these elements are not limited to the given list, there is also a complete set of modeling elements [39].

Since BPMN provides strong execution support, it has many constructs in terms of the behavioral and functional perspectives. However, in the earlier versions of BPMN, the support for informational and organizational perspectives was weak [33]. In addition to that, its metamodel was not well-defined. Therefore, converting BPMN to other modeling languages was not easy. In order to handle these problems, BPMN was improved with the addition of collaboration and choreography in the version BPMN 2.0. However, the process modeling in role-granularity is not explicitly implemented for BPMN. Moreover, increase of the complete set of elements in BPMN 2.0 results in high complexity although it makes BPMN more expressive [46]. Therefore, it may not be a simple notation for the inexperienced modelers. The Figure 2.3 depicts the process model of a sample business trip application process modeled using BPMN 2.0.

2.3.2 Role Activity Diagram

Role Activity Diagram (RAD) [25] is a flowchart type notation, which is based on the role modeling. In other words, processes are modeled from the perspective of roles which performs tasks and communicate with each other in order to achieve some particular goals in the organizations. Roles represent not only organizational job titles, but also people and computer systems.

Role activity diagrams are the state diagrams. They basically include activities, decisions and transactions. The activities are encapsulated by the roles and they are ordered vertically most of the time. RAD concept firstly defined by Hot et al. [25] and then enhanced by Ould [44].

Table2.3: The elements of RAD

Notation	Description
	**A Role** is a set of activities which are taken together to achieve some particular goals.
	**An Activity** is a generic form for work that companies perform.
	**A Trigger** is used to trigger an activity.
	A State is used to show states. These states are the lines between the activities.
	A State Description is used to explain the states. They are similar to events in the BPMN.
	**An End of Thread** is used to show the end of the threads and it is optional.
	**A Decision** is used to show the alternative paths that branch from the activities.
	**A Concurrent Part-refinement** is used to show the concurrent paths branched from the activities.
	**An Iterative Part-refinement** is used to show that the given path is an iterative path.
	**An Interaction** is used to represent the role collaboration like passing information, approving something and etc.

The basic notation elements of RAD are given in the Table 2.3.

Since RAD includes interactions among the roles and their relationships, it is a good alternative for the role based modeling. Nonetheless, the informational perspective of the processes is not well represented in RAD. Also, it does have an execution language [33]. Finally, RAD does not provide a decomposition of process to the subprocesses. Therefore, it brings disadvantages and restrictions for the complex and larger processes while modeling or reading such a process with RAD. The Figure 2.4 shows the process model of a sample business trip application process modeled using RAD.

2.3.3 Subject-oriented Business Process Management Notation

Subject-oriented Business Process Management (S-BPM) is a new process management paradigm and was developed by Fleischmann [16]. It supports both modeling and execution of the business processes. S-BPM and natural language have the similar structure. Fleischmann pointed out that, the activities are driven by the subjects in S-BPM similar to the natural

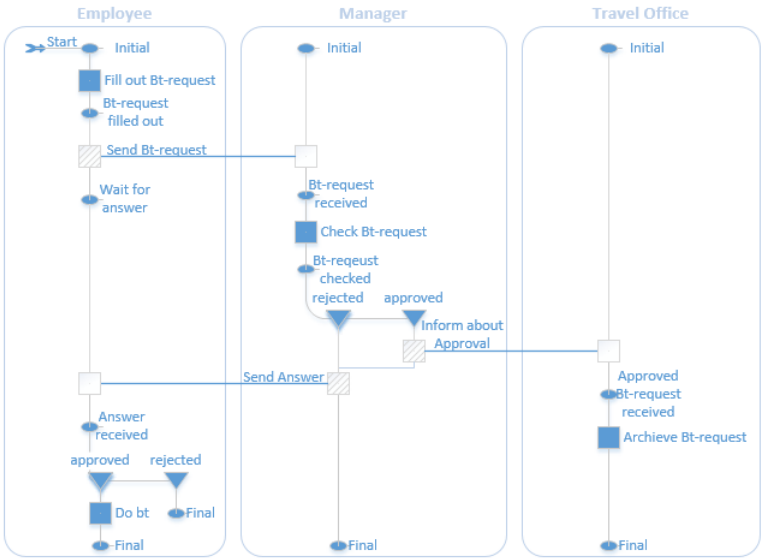


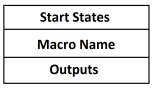
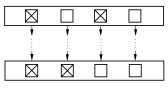
Figure 2.4: Process Model of Business Trip Application Process using RAD

language sentences [14]. They both have subjects, which are the active elements, predicates (actions in S-BPM) and the objects, which are the targets of the activities. Also, the subjects are the initial points of the activities. Therefore, the main idea of S-BPM is to model and execute business process from the subject point of view.

In S-BPM, firstly the responsibilities of the actors in the process are identified and based on these responsibilities, the subjects are created. After the creation of the subjects, the interaction relationships between them is needed to be represented. These relationships are the messages transferred among the subjects. Also, these messages may carry a structured information which is a business object [16]. In S-BPM, there are two types of diagrams. The first one is the subject interaction diagram (SID). SID shows the subjects and the messages transferred among them. It does not take care of the internal works of the subjects. The second diagram type is the subject behavior diagram (SBD). Each subject in a specific process has its own SBD. Thus, the internal works of each subject are defined in its own SBD. The core elements of the S-BPM notation is given in the Table 2.4.

Since structure of S-BPM notation is similar to the natural languages and it has simple and few number of elements, it is very easy to learn for the inexperienced people. Therefore, process stakeholders can easily participate in process modeling activities despite inadequate knowledge about process modeling [15]. Moreover, Cakar [4] stressed that visualization of message exchange among the subjects and behavior of the communication partners are very-well defined in S-BPM. In addition to that, Singer et al. [60] , pointed out that S-BPM has a competitive advantage among the other process modeling approaches since it has an IT support and it is a behavior oriented modeling approach. Also, it is very easy to execute the models in S-BPM since process models are defined strictly formal. Finally, although its support for behavioral perspective of the processes needs to be enhanced, informational perspective is well-defined. The Figure 2.5 and Figure 2.6 depict the subject interaction diagram and subject behaviors diagrams of a sample business trip application process respectively.

Table2.4: The elements of S-BPM notation

Notation	Description
	**A Subject** is an active element and performs the actions in the process.
	**A Message** is a communication act between two subjects. It shows the interaction relationship.
	**A Business Object** is used to show a structured information carried by a message.
	**A Function State** is used to show an internal action of a subject.
	**A Receive State** is used to show that a subject is waiting for or receiving a message from other subjects.
	**A Send State** is used to show that a subject is sending a message to other subjects.
	**A Start Node** is used to show the start point of the subject's internal behavior.
	**An End Node** is used to show the end points of the subject's internal behavior.
	A Control Flow is used to show the flow of the actions.
	**A Macro Class** supports multiple use of the description of similar sequences of a subject behavior.
	**A Choice Operator** is used to show parallel paths branching from an action in a subject behavior. The order of the finishing time of these paths is not specified.

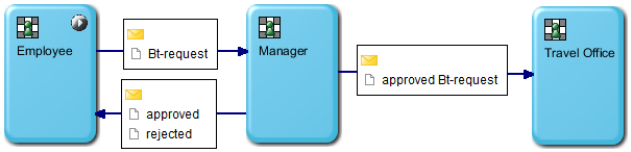
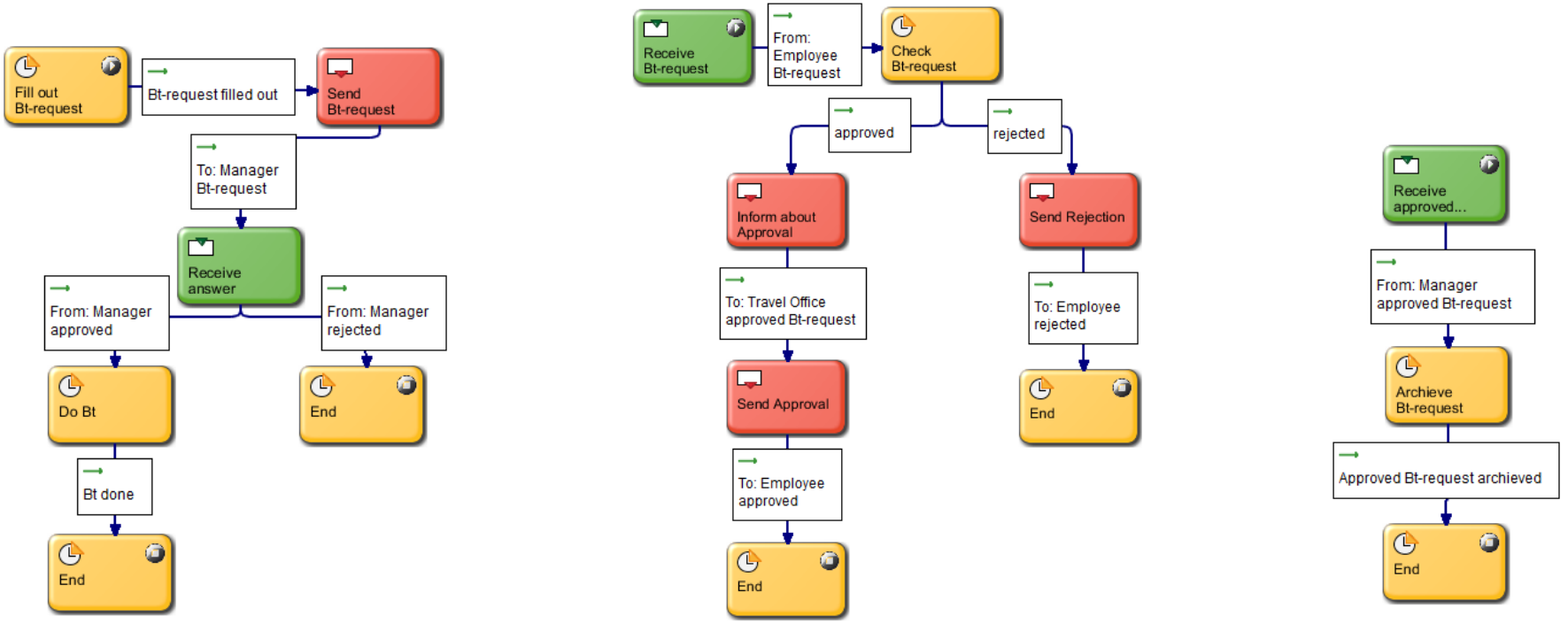


Figure 2.5: Subject Interaction Diagram of Business Trip Application Process



(a) Employee SBD

(b) Manager SBD

(c) Travel Office SBD

Figure 2.6: Subject Behavior Diagrams of Business Trip Application Process

2.4 Discussion on Literature Review

In the literature, there are a number of collaborative business process modeling tools. Most of them provide a shared view of the entire process so that the users work on that same shared process. However, working on the same view might cause cognitive overload during process modeling [6]. Contrary to working on the same view, if each user is allowed to focus on its own contribution to the process and its communication with other users, a more clear and more reflective process models are obtained. The only tool that provides this approach is Metasonic Suite. However, it uses a top-down approach meaning that all messages among the process stakeholders are defined as a first step. After that, each subject starts to model its own internal behavior. Furthermore, in order to stay up-to-date about the changes on process models, information awareness is a crucial aspect for collaborative process modeling. Nonetheless, Raimer et al.[47] stressed that none of the tools they analyzed offered a comprehensive and holistic information awareness support. Thus, they suggested that an information awareness mechanism should be taken into consideration while designing a collaborative process modeling tool. Finally, using a central database to keep process models and role management implementation to access to them is a facilitator for collaborative process modeling.

Decentralized process modeling leads to reduce effort and time for processing models in the organizations [22] [68] Also, it is a better way to reflect actual works [69] compared to traditional centralized modeling approaches. Applying decentralized process modeling in a role-based manner separates the concerns properly so that it enables the actors to focus on their own roles [43]. However, there are a few number of role-based process modeling approaches in the literature. Most of these approaches lack of tool or method support for efficient and effective collaboration. Moreover, the communication and negotiation for the message specifications among the roles is very crucial to create integrated and sound process models [42]. It also shapes the structure of the process modeling approach. Though, most of the role-based process modeling approaches either do not analyze this aspect in detail or have important drawbacks resulted from the way of how the specifications of the messages among the roles are handled.

BPMN, RAD and S-BPM notations are the suitable notations that support role-based process modeling. Among them, BPMN and RAD are not well-defined in terms of the informational perspective of the business processes [33]. Also, it is not possible to decompose processes to subprocesses with RAD, so it is not suitable for the complex processes. In BPMN, a "pool" element can be used for the roles. However, interactions among the roles and their internal behaviors are represented on the same model. This brings a cognitive overload to look at overview of the entire process. Moreover, it is not suitable for inexperienced people since it is complex and has many elements for modeling although BPMN has a strong execution support. On the other hand, S-BPM notation is simple and it has a few elements for modeling so that inexperienced people can easily learn modeling with S-BPM [15]. Subject elements can be directly mapped to the roles. Moreover, it is well-defined with respect to informational perspective of business processes and has formally strong execution support. However, the functional and the behavioral perspectives of S-BPM is needed to be developed. Finally, it allows bottom-up and decentralized process modeling contrary to traditional top-down centralized modeling approaches.

CHAPTER 3

ROADMAP METHOD

Decentralized business process modeling allows participants to focus on modeling their own parts of work and requires them to interact with each other in order to form a consistent and integrated process model. Due to the collaborative nature of decentralized process modeling, interactions among the roles have a significant impact on the overall process. Based on the findings gathered from the literature survey, we observed that decentralized process modeling has advantages over centralized one in terms of time and representation accuracy of the actual work. Additionally, when separation of concerns in business processes are considered, the smallest unit of a business process is role. Therefore, we proposed a decentralized and role-based process modeling method, called ROADMap method, considering the results of the exploratory study we conducted (see Section 4.1). This section presents the application process of ROADMap method in organizations, the notation it drives and the tool support.

3.1 Process of Method Application

The application process of ROADMap method is divided into two main phases namely preparation and modeling. The preparation phase includes all activities before starting modeling session. On the other hand, modeling phase constitutes the larger part of the method in which roles model their own parts of work in order to obtain an integrated and sound process model.

3.1.1 Preparation Phase

In preparation phase, the purpose is to make process stakeholders ready to model their own parts of work. In order to do that, after the process to be modeled is determined, the process owner gathers the individuals who take part in the execution of the process. In this meeting, the aim is to clearly identify the roles in the process since the proposed method drives a role-based process modeling approach. The role is a special type of organizational element which includes a set of activities and interactions with other roles. Actors, on the other hand, are the people or software that perform the activities of the roles they play.

After all roles are specified collaboratively, each actor, in other words each process stakeholder, is assigned to corresponding role(s) who actually plays in the process. Since each actor may play more than one role or each role may include more than one actor, there is a many-to-many relation between the actor and the role concepts. For example, actor Mert, who is participated in the execution of "software integration process", can perform the roles both

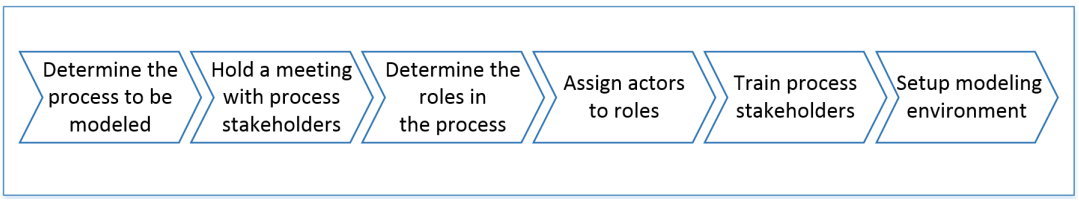


Figure 3.1: Preparation Phase

"integration engineer" and "configuration management engineer". Similarly, "software development engineer" role in the same process may consist of more than one actors such as actor Murat and actor Zeynep. After the assignment of the actors to the roles, a training session is held to introduce participants to the process modeling concept and the ROADMap method. Therefore, if there exists ones who have little or no knowledge about these topics, they are trained before modeling activity. Also, sample processes can be modeled with the ROADMap method in order to make individuals more familiar with it during the training session.

Finally, the process owner establishes the process modeling environment. In other words, s/he describes the process to be modeled, its roles and its actors on the tool. Also, s/he assigns the actors to the roles and gives access rights to the actors on the software. As a result, process stakeholders are ready to model their own roles they are assigned. Finally, the high level process map of the preparation phase is shown in Figure 3.1.

3.1.2 Modeling Phase

After preparation phase is completed, each role is ready to model its own part of work. Since the interactions among the roles in terms of the messages are not identified during the preparation phase, the ROADMap method can be described as a bottom-up method. In other words, the overall process model is formed progressively as long as the roles model their own internal behaviors and identify their interactions from their own perspectives. Furthermore, roles model their own works using a specific notation, which is extended S-BPM notation. Additionally, there is a process for the identification of the interactions among the roles. In that process, the roles define and transfer messages from their own perspectives during modeling. If inconsistencies occur, the roles identify and resolve them in an ongoing way. Finally, the modeling phase is applied using the tool support of ROADMap method.

Modeling phase of the ROADMap method can be analyzed in terms of five main aspects namely flexibility, conflict prevention, information awareness, overall view and latency. These five aspects are identified as a result of an exploratory study we conducted. In that study, three current role-based process modeling approaches, namely ex-ante, ex-post and ongoing communication negotiation [42] are compared (see Section 4.1).

3.1.2.1 Flexibility

Flexibility is defined as the ability of a role to define a message, send a message to or receive a message from another role during modeling its own internal behavior. Based on the findings from the exploratory study, we observe that inflexible approaches provide more well-defined

structure for modeling since all interactions among the roles are specified at the beginning of the modeling session. However, they suffer from easy and quick adaption to required changes in the model. Also, they result in restrictive modeling for the roles. Therefore, handling even a small mistake made at the beginning has to wait until a next consolidation step. Therefore, in the ROADMap method, the roles are free to define new messages and business objects. Moreover, they are able to send any message to, or receive any message from the other roles any time during modeling.

3.1.3 Conflict Prevention

Conflict prevention is a mechanism which helps to modelers to avoid conflicts in terms of messages and business objects they define or transfer to each other. Our study shows that the approaches that do not include such a mechanism causes excessive amount of conflicts at the end of the modeling session. Therefore, ROADMap method includes a conflict prevention mechanism. Hence, all roles can check inconsistent interactions with the other roles any time during modeling automatically. They are able to see missing or redundant messages they send or receive whenever they demand during modeling. Moreover, all roles are able to view pairwise interactions with the other roles before transferring a message. It means that, when a role wants to send a message to another role, it can see the messages previously received by the corresponding role from itself. Similarly, when a role needs to receive a message from another role, it can see the messages already sent to itself by the corresponding role. Therefore, each role in the process ensures that it has no pairwise conflicts. This results in a consistent and sound overall process model. Moreover, the ability of viewing all previously defined messages prevents defining a new message targeting the same meaning with different names.

3.1.4 Information Awareness

Information awareness is defined as the ability of that a role is aware of the changes related to itself during modeling. For any collaborative work, information awareness is very important since it keeps the roles aware of the current state of the work. Based on the findings gathered from the exploratory study, the modeling approaches in which roles are not aware of each other until end of the modeling session, are likely to cause large amount of conflicts. Therefore, in the ROADMap method, a special type of information awareness is used as in social network applications. Whenever a message is defined or transferred to a specific role, a small and non-distractive information is sent to that role. However, this small information does not include details of the changes. Rather, it just makes the role aware of the changes related to it. Also, the details of the changes are presented to the role whenever it demands. The reason why this type of information awareness is used is to prevent distracting the focus of the roles on their internal behaviors.

3.1.5 Overall View

Overall view is a way to see the roles and all interactions among them in a process. It is crucial since seeing the other roles and interactions among them gives a high level idea about

the current state of the process. Moreover, by looking at the overall view, a role can decide what roles are related to itself and what messages among the other roles are possibly used by itself. Our study shows that while overall view provides a high level abstraction of the process, it could also have some restrictions on the modeling activities for the roles. Some process modeling approaches, in which communication acts are defined as a first step, provide a static and clear road-map for modeling. However, they prevent defining mew messages or transferring them during modeling. Therefore, that kind of overall view presentation puts a barrier on modifications of communication acts. On the contrary, the ROADMap method provides a dynamic and informative overall view instead of a static and restrictive one. In other words, the roles are able to see the current state of the process in terms of the roles and the interactions among them whenever they require.

3.1.6 Latency

Latency is defined as the reasons for delay in finishing the modeling activities that can be avoided by performing some precautions. Based on the findings gathered from the exploratory study, we observe that all analyzed current approaches have a latency resulted from various reasons. These reasons are inflexibility, loss of conflict prevention mechanism and cognitive overload due to excessive information awareness. In order to get rid of those kinds of latencies, our proposed method is flexible and has a conflict prevention mechanism. Additionally, it provides information awareness without distracting the focus of roles on their internal behaviors.

Besides these five aspects, a conflict resolution mechanism is also a necessary feature to obtain a final consistent model. Decentralized process modeling is likely to cause conflicts among the roles due to its collaborative nature. Some analyzed approaches do not consider conflict preventive actions and prefer resolving conflicts at the end of the modeling session. Therefore, resolving these conflicts may require rework and be very time consuming. On the other hand, in ROADMap method, the roles first identify the inconsistencies among the roles they interact with during modeling. If these inconsistencies are not resolved intuitively by one of the peers, in other words both pairs insist on their own notion, this situation turns the inconsistencies into conflicts. Hence, pair roles should communicate and negotiate in order to handle inconsistencies. ROADMap method provides functionalities for identification of inconsistencies. However, it does not include features that facilitate resolving the conflicts such as instant messaging, video conference, discussion board and etc. These facilities are left as future work.

3.2 The Notation

A business process modeling method needs a notation in order to define processes. Since we propose a role-based and decentralized process modeling method, we analyzed three different role-based process modeling notations, namely BPMN, RAD and S-BPM notation in Section 2.3.

As the aim of ROADMap method is to enable process stakeholders to model their own processes in a role-based manner, the simplicity of S-BPM Notation has an advantage over the other ones. It has a few modeling elements so that it is very easy to learn for inexperienced

people. Therefore, with a less time training period, process stakeholders are ready to model their own parts of work. Similarly, Fleischmann et al. stated that insufficient knowledge about process modeling is not an obstacle to participate modeling activities with S-BPM [15]. Moreover, executing the models in S-BPM is very easy since process models are defined strictly formal.

Process modeling notations/languages may support one or more perspectives of business processes that Curtis et al.[7] identified namely behavioral, functional, informational and organizational. Functional perspective represents the activities and their decomposition into smaller units and information flows. Behavioral perspective views the conditions under which activities are performed and the way of performance of them in terms of complex decision making conditions, iteration and etc. Moreover, organizational perspective is interested in where and by whom process elements are performed such as actors, roles and departments. Finally, informational perspective represents which information entities are created and manipulated in the process and what relationships and structures they have.

In ROADMap method, subject element of S-BPM notation is mapped to role element so that the organizational perspective is supported. Furthermore, S-BPM has business objects, which are all objects or tools a subject needs to execute a process. While specifying business objects, physical and electronic documents or forms are specified and their relationships and structures are identified. Therefore, S-BPM notation also supports informational perspective of business processes. However, we did not implement the business object concept in our method and we left it as a future work. From the functional perspective, although S-BPM notation represents the activities performed in the process and information flows among the subjects (roles in our method), the decomposition of the activities into sub-activities is not considered. Thus, we can say that it partially supports functional perspective. Finally, for S-BPM notation, the conditions under which process elements are performed in terms of decision making are not clearly identified. Therefore, it has drawbacks in behavioral perspective of business processes.

Krogstie et al. pointed out that representation of both behavioral and functional perspectives of a business process improves human sense-making, communication between process stakeholders and model deployment [31]. Therefore, in order to represent work knowledge more accurately, the notation we used in ROADMap method should support these two perspectives at least partially. Although S-BPM notation already supports functional perspective partially, we need to improve its behavioral perspective in terms of decision making conditions. *Freedom of Choice* operator has already identified as a set of alternative clauses in S-BPM notation, which shows a number of parallel paths. However, it is not enough to give a specific information about the control flows.

Table3.1: Truth Table

$\mathbf{p}$	$\mathbf{q}$	$\mathbf{p} \wedge \mathbf{q}$	$\mathbf{p} \oplus \mathbf{q}$	$(\mathbf{p} \wedge \mathbf{q}) \oplus (\mathbf{p} \oplus \mathbf{q})$	$\mathbf{p} \vee \mathbf{q}$
0	0	0	0	0	0
0	1	0	1	1	1
1	0	0	1	1	1
1	1	1	0	1	1

The S-BPM methodology in its essential is based on Calculus of Communicating Systems (CCS)[37] which was proposed by Milner. Its purpose is to provide a mathematical frame-

work in order to define communicating systems formally. To improve behavioral perspective of S-BPM, i.e to explicitly describe the control flows, we define *choice (XOR)*, *parallel composition (AND)* and *at least one (OR)* gates for S-BPM notation. CCS already supports the actions choice and parallel composition. Therefore, this situation provides a baseline for *AND* and *XOR* gates. Moreover, *OR* gate can be obtained from *AND* and *XOR* gates. The Table 3.1 shows how the *OR* gate can be obtained from 1 *AND* and 2 *XOR* gates. Based on this information, we extend the S-BPM notation with three logical operators.

The modeling elements used in the notation that ROADMap method supports are given in Table 3.2.

Table3.2: The core elements of the notation that ROADMap method supports

Notation	Description
	**A Role** is a set of activities which are taken together to achieve some particular goals by the same organizational elements.
	A Message is a communication act between two roles. It shows the interaction relationship.
	**A Function State** is used to show an internal action of a role.
	**A Send State** is used to show that a role is sending a message to other roles.
	**A Receive State** is used to show that a role is waiting for or receiving a message from other roles.
	**A Gate** is a logical operator which links states in the process.
	A Control Flow is used to show the flow of the actions.
	A Missing Flow is used to show the messages sent or received by the other roles but not sent or received by the role itself.
	An Extra Flow is used to show the messages sent or received by the role itself but not sent or received by the other roles.

After extending the S-BPM notation with logical operators, splits and joins arises naturally. The inputs and outputs of these splits and joins are always control flow elements. Moreover, any type of states can connect to any type of logical operators via control flows. The example use of logical operators in extended S-BPM notation is given in Figure 3.2.

The notation is composed of three types of diagrams namely role behavior diagram, role interaction diagram and consistency check diagram. The role interaction diagram is the same as the subject interaction diagram (SID) in S-BPM since we map subjects to roles in our method. Similarly, role behavior diagram is equivalent to the subject behavior diagram (SBD) in S-BPM as well. Subject interaction and subject behavior diagrams are explained in Section

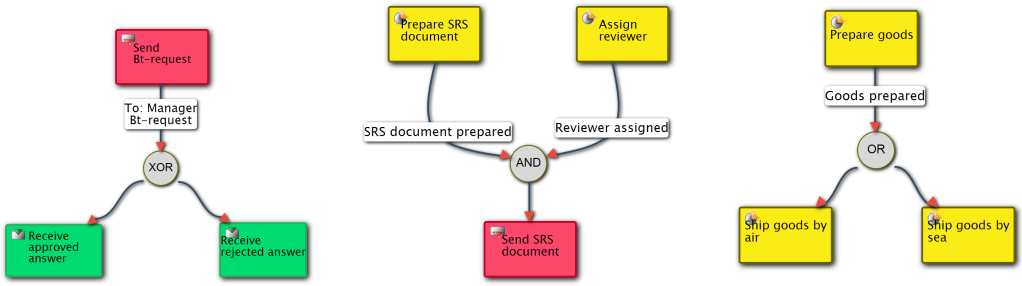


Figure 3.2: Logical Operators in Extended S-BPM Notation

2.3.3. Also, the consistency check diagram is explained in Section 3.3.3.

3.3 The Tool Support

Due to collaborative nature of decentralized process modeling, the ROADMap method should include a tool support to facilitate the creation of integrated process models. Basically, roles can model their own parts of work, identify inconsistencies among them and form integrated models using this tool. This section firstly describes the architecture of the tool. After that, the section continues with its requirements and an example its utilization.

3.3.1 Architecture of the Tool

Firstly, the architecture of a process modeling tool is an important technical criterion. The process modeling tools in the literature are constituted either desktop-based or web-based architecture. Riemer et al. stated that process modelers need to install some software components on their local working environments when they use desktop-based modeling tools [47]. Also, when a new version of the tool is available, all old versions should be replaced with the new one. On the other hand, a web-based architecture can easily include a wide range of modeling participants and it is enough to fix the software running on the web when a problem arises. Since our ROADMap method offers that all roles in the organization model their own works, the number of the modeling participants depends on the complexity of the processes and organizations. Therefore, we implemented a cloud-based process modeling tool in order to handle these scalability and maintainability issues. The very basic architecture of a cloud-based system is given in Figure 3.3.

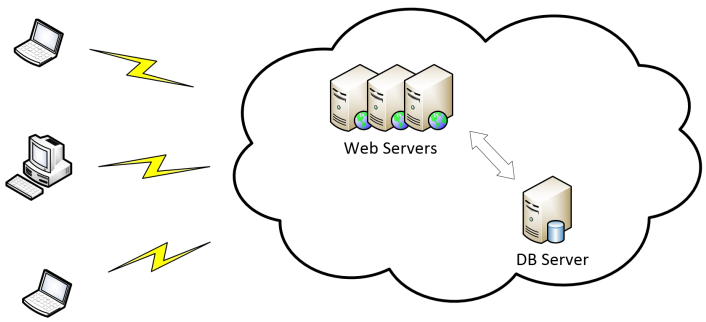


Figure 3.3: Basic Architecture of a Cloud-based System

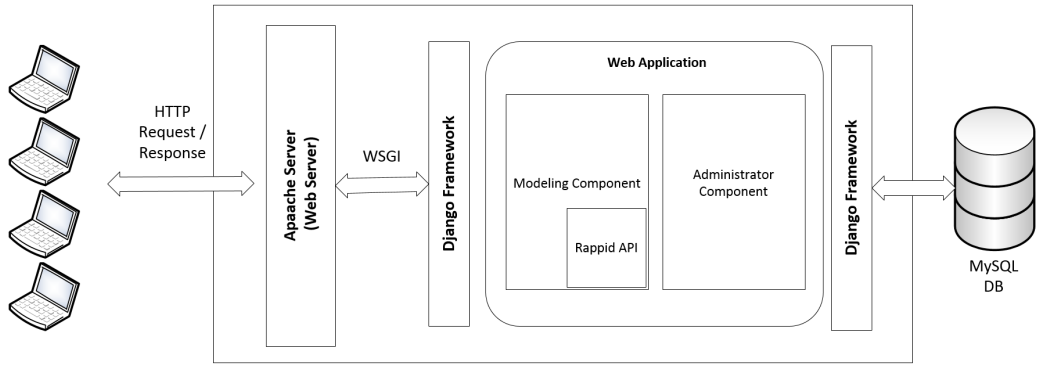


Figure 3.4: High Level System Architecture of Tool Support

In order to implement a cloud-based process modeling tool, the programming language was first decided as Python for the back-end development since its usage grows for server-side development in the industry. Then, the operating system was chosen as Linux in which our development environment takes place. To develop a complex and database-driven web application written in Python, Django[17] was used, which is a free and open source web application framework. On the other hand, javascript, css and html languages was preferred for the front-end development. Moreover, MySQL database server was our choice for storing the necessary information such as process models, interactions, user information and etc. After implementation of the tool, a domain was obtained on Microsoft Azure[36] and our web application was deployed on it. Microsoft Azure provides a cloud computing platform and infrastructure in order to deploy and manage the web applications. After deployment of the application on cloud, a simple browser is enough to model processes on the tool regardless of browser type. The high level system architecture of the tool is given in Figure 3.4.

For a scenario where a user wants to save his/her model, basically, an HTTP request comes from the modeler to the web server called Apache Server. Next, WSGI transmits this request to the web application from the web server. WSGI is a universal interface between web applications or frameworks and web server for Python. Modeling component processes request and stores the model data into MySQL database via Python DB API. Afterwards, a response message is created and sent to the user from web application in a similar manner via HTTP response.

The web application is composed of two main components, which are administrator component and modeling component. Administrator component is basically responsible for managing the actors, roles, messages, processes and access rights. The activities for setup of process modeling environment in Section 3.1.1 are performed using this component. On the other hand, modeling component accounts all modeling activities during process modeling as given in Section 3.1.2. It includes Rappid API[28], which is a javascript library consisting of modules like user interface, to facilitate implementation of advanced visual tools on the web.

3.3.2 Requirements of the Tool

This section identifies the high level functional requirements of the tool. In order to elicit these functional requirements, we combine the ones which are necessary for creating a process

model diagram and the ones which are essential for the application of ROADMap method given in Section 3.1. Therefore, we first give the high level general modeling requirements and then explain method specific requirements.

3.3.2.1 General Modeling Requirements

In this section, we basically describe the high level functional requirements for a platform in which process models are created.

Table3.3: Requirement 1.1

Identification	Req 1.1
Requirement	The tool shall enable actors to model behavior diagrams of the roles they are assigned to.
Description	The tool shall have features to define process models. In order to do that, there should be a diagram space in which modeling elements are interconnected to form a role behavior diagram. Also, these modeling elements can be edited via commands such as move, resize, and delete. Moreover, the tool shall provide a drag-and-drop feature for modeling elements of the notation it supports. Beside that, the actors shall be able to save and load the role behavior models they are assigned to.
Priority	High

Table3.4: Requirement 1.2

Identification	Req 1.2
Requirement	The tool shall allow actors to define their role behaviors concurrently and separately.
Description	The processes are more likely to consist of more than one role so that all actors need to model their role behavior models to form an integrated process model. Therefore, the tool shall enable more than one role to model their role diagrams at a time.
Priority	High

Table3.5: Requirement 1.3

Identification	Req 1.3
Requirement	The tool shall provide a semantic verification mechanism based on the semantic rules of the notation it supports.
Description	Every process modeling notation has its own semantic rules. Therefore, the tool shall have an automated semantic verification mechanism based on the notation it drives in order to prevent breaking the semantic rules. As a result, the actors ensures their role diagrams are consistent with the semantic rules.
Priority	High

Table3.6: Requirement 1.4

Identification	Req 1.4
Requirement	The tool shall provide an authentication and authorization management which enables to actors login to tool and regulates their access rights for the process models.
Description	After actors login to tool, they shall edit only the role behavior diagrams they are assign to. Although actors are given permissions to "read" any role behavior diagrams of other roles, they can only create and modify the diagrams they have "write" access right.
Priority	High

Table3.7: Requirement 1.5

Identification	Req 1.5
Requirement	The tool should provide a communication and negotiation platform in which the actors can resolve inconsistencies and conflicts among them.
Description	When the actors disagree with a message which is transferred among the roles they are responsible for, they need a communication and negotiation platform to resolve this uncertainty. The tool might support that kind of platform such as instant messaging, video conference, discussion board and etc.
Priority	Low

3.3.2.2 Method Specific Requirements

This section presents the method specific high level functional requirements of the tool which are generated from the 3.1.1 and 3.1.2. We can divide these requirements into 5 categories according to their relations namely flexibility, conflict prevention related, information awareness, overall view and process setup.

Table3.8: Requirement 2.1

Identification	Req 2.1
Requirement	The actors shall be able to define new messages and transfer them to other roles while they model the roles they are assigned.
Description	The tool shall enable the actors to define new local or global messages whenever they want during modeling. Moreover, the actors shall be free to sent messages to or receive them from another roles any time. These messages can be previously defined by the other actors or newly defined by the relevant actor.
Priority	High
Category	Flexibility

Table3.9: Requirement 2.2

Identification	Req 2.2
Requirement	The actors shall be able to check whether there is an inconsistency between the roles they model and the other roles.
Description	The tool shall detect and display the inconsistencies among the roles. To form a consistent and integrated overall process diagram, all roles should be consistent in terms of the messages to be sent or received. Therefore, the tool shall provide a functionality to show inconsistencies, i.e. missing and redundant messages, among the corresponding role and the other roles it interacts with.
Priority	High
Category	Conflict Prevention

Table3.10: Requirement 2.3

Identification	Req 2.3
Requirement	The actors shall be able to see the all previously defined and transferred messages relevant to the process.
Description	To be able to see previously defined local and global messages in the process, prevents definition of duplicate messages. In other words, defining the messages with different names which targets the same meaning can be eliminated. In addition to that, the roles shall be able to see the pairwise messages to be sent to or received by the corresponding role before they send or receive a message. Thus, they can avoid transferring messages which result in inconsistencies.
Priority	High
Category	Conflict Prevention

Table3.11: Requirement 2.4

Identification	Req 2.4
Requirement	The tool shall inform the actors whenever a change occurs in the process related to the roles they are assigned to.
Description	Firstly, the tool shall keep the changes immediately whenever they occur. These changes are either definition of a new local or global message, or transfer of a message between the related and other roles. In order to make actors aware of these changes, the tool shall send a notification about the change to the related role. Therefore, actors of the related role is aware of these changes. Moreover, the actors shall be able to see the details of the changes on-demand when they get the notifications.
Priority	High
Category	Information Awareness

Table3.12: Requirement 2.5

Identification	Req 2.5
Requirement	The actors shall be able to see the roles and all interactions among them in the process.
Description	In order to give an idea about the current state of the process, the actors shall display the overall view of the process. In this overall view, all roles and their interactions in the process are presented. Moreover, the actors shall see the detailed information about the roles such as associated actors, their processes and etc.
Priority	High
Category	Overall View

Table3.13: Requirement 2.6

Identification	Req 2.6
Requirement	The process owners shall be able to setup the process modeling environment before the actors start modeling their role behaviors.
Description	Before modeling phase starts, the process owner shall be able to define the process, its roles and actors on the tool at the end of the preparation phase. Moreover, the tool enable process owners to assign actors to the roles they execute in the actual work. Therefore, the process owners shall be able to manage processes, roles, actors, messages and assignment of actors to roles using tool support.
Priority	High
Category	Process Setup

3.3.3 An Example Utilization of the Tool

In this section, the utilization of the tool is explained on a sample process. This process is a business trip application process[16] in which Employee, Manager and Travel Office Personnel take places as roles. In the process, basically, Employee fills out the business trip request and sends it to the Manager. If the Manager approves Employee's request, it sends the approved business trip request to both Employee and Travel Office Personnel. Then, the Travel Office Personnel archives the approved request and the Employee does business trip. On the other hand, if the Manager rejects the business trip request, it sends rejected request to the Employee.

As a first step to model given process on the tool, the process owner should define the business trip application process, roles, actors and assign the actors to the roles on the tool. In order to do that, the administrator component of the tool is used. Some of the user interfaces belonging to that component are given in Appendix A. In our example, the process owner assigns actor "Mert" to role Manager, actor "Zeynep" to role Employee and actor "Murat" to role Travel Office Personnel.

When the modeling environment is ready, all actors are able to model their own role behavior diagrams. After an actor logs into the system with the username and the password assigned to him/her, the home page appears. The only functionalities performed on that page are selecting

a role to model it and log out. When the actor selects a role to which s/he is assigned, the modeling page given in Figure 3.5 appears. The modeling elements of the notation, which are located at the left side of this page, are dragged and dropped on the diagram space to model role behavior. Moreover, a tool bar, at the top right of the page, includes both simple modeling functionalities like zoom-in zoom-out and saving model. It also consists of method specific ones like consistency check, displaying overall process view and being aware of the related changes (see Section 3.3.2.2). Additionally, the actor can display any role diagram of a process by selecting it from the combo box that includes all processes in the organization. In that combo box, the roles, which are editable by the related actor, are indicated with a '✓' sign based on the permission rights given by the process owner. On the other hand, the roles, which are not editable by the same actor and are only readable ones, are shown with a 'X' symbol in a similar way.

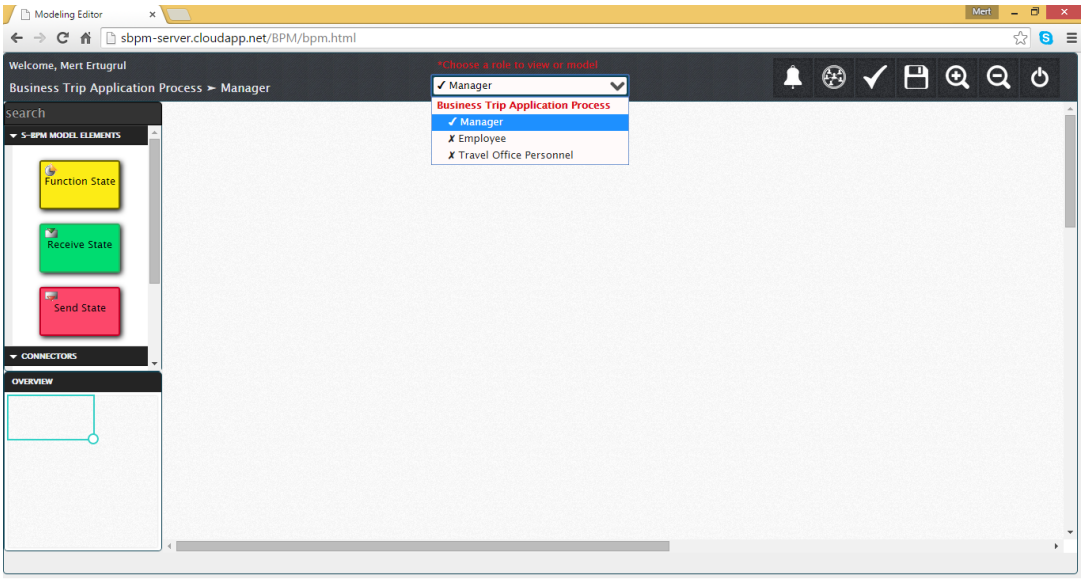


Figure 3.5: Modeling Page of the Modeling Component

In our example, actor "Mert" is assigned to only Manager role by the process owner so that he is able to model this role based on the permission rights. However, he has "read" right for all other roles in the process. After he selected the role Manager, he is ready to model it.

Due to the nature of S-BPM, actors need to send messages to other roles from the role they are assigned while defining their role behavior diagrams, and vice versa. In our example, Manager's role diagram should first start with receiving business trip request from Employee. When Manager wants to specify a message to receive, a pop up appears which enables the actors to view previously defined pairwise, local and global messages. Also, this pop up allows them to define a new local or global message. A local message is any message defined in a specific process. This type of message is only seen by the roles in the same process. On the other hand, a global message is a message which can be visible by all of the roles in all of the processes. This type of message is needed when a inter-process communication exists. Moreover, a pairwise message denotes a message sent or received between a pair of roles and it can be either a local or global message. On the pop up given in Figure 3.6, pairwise messages, which are previously sent messages from Employee to Manager, are first presented

to Manager. If the Manager does not find the message to receive from Employee among the pairwise messages, then s/he looks for that message in the local and global messages. The purpose is to prevent sending or receiving messages that corresponding roles do not expect, and to avoid definition of different messages targeting the same meaning.

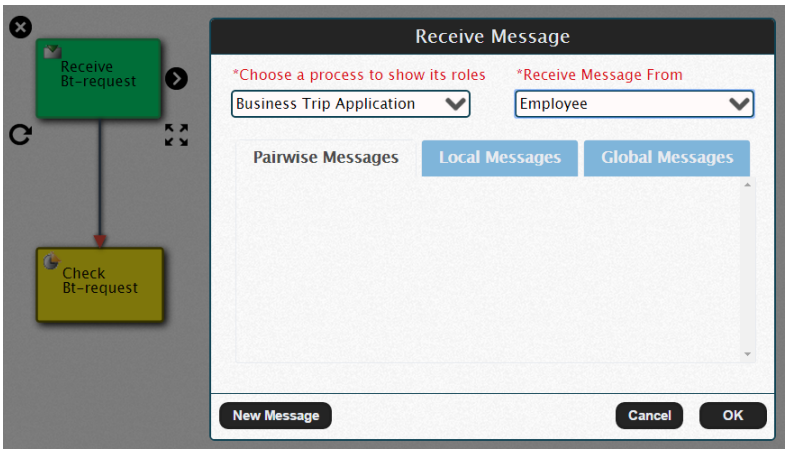


Figure 3.6: Receive Message Popup of Modeling Component

If Manager could not find business trip request message to receive it from Employee among all types of messages, s/he needs to define such a message. The interface for defining a local and global message is given in Figure 3.7. After Manager defines "Bt-request" message as a local message, s/he receives it from Employee.

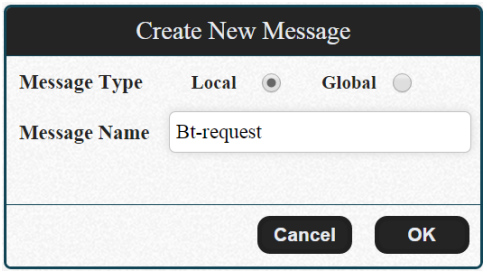


Figure 3.7: Definition of a New Message

For any collaborative work, information awareness is crucial since it enables the roles to be aware of the current state of the process. Assume that actor "Zeynep" starts modeling its own role Employee concurrently or later. Since Manager has already defined a message namely "Bt-request" and received it from the role Employee, there exists changes related to role Employee. Therefore, the actors assigned to Employee role are informed by the tool via notifications. Figure 3.8 shows the notification located on the tool bar. The number of the related changes are shown on that notification.

Figure 3.8: Notification

The changes related to a role are resulted from two different reasons. The first one is the definition of a local or global message. When a local message is defined by one of the roles in the process, other roles in the same process are informed about that message. The reason is this message may be relevant and used by any of these roles in the future. Similarly, all roles of all processes are notified about the definition of the global messages. The second reason is transferring a message to another role. Therefore, a corresponding role is aware of the messages sent to and receive from itself. Furthermore, roles (actors actually) are able to see the details of these changes. In our example, when Employee wants to see the details of the changes related to itself, the pop up given in Figure 3.9 appears. There are two changes related to Employee, which are definition of "Bt-request" local message and Manager receiving the same message from Employee.

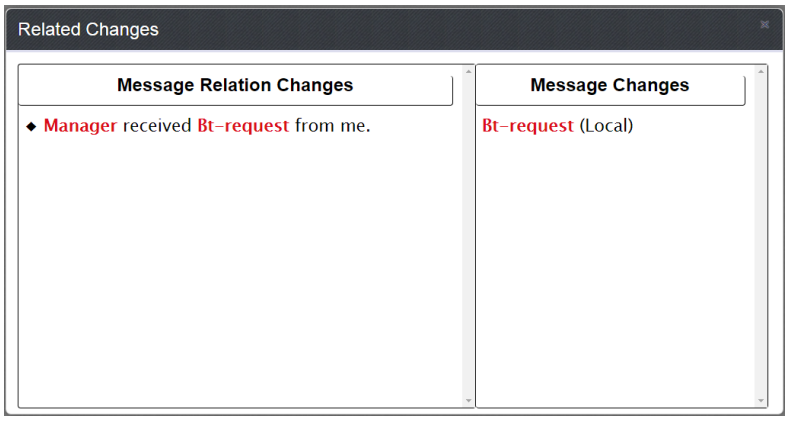


Figure 3.9: Related Changes

After being aware of the related changes, the actors of role Employee already knows that "Bt-request" message should be sent to Manager since the role Employee first fills out the "Bt-request" and then sends to the Manager to be approved in the process. When the Employee wants to specify "Bt-request" message to send to Manager, a pop up given in Figure 3.10 appears similarly. It shows previously defined pairwise, local and global messages. When the target role chosen as Manager, "Bt-request" message is displayed among the list of pairwise messages at once since it is already received from the Employee by the Manager. By selecting this message, Employee sends it to the Manager. As a result, pairwise messages match and this facility can help actors to prevent inconsistencies among their associated roles like transferring different messages for the same purpose.

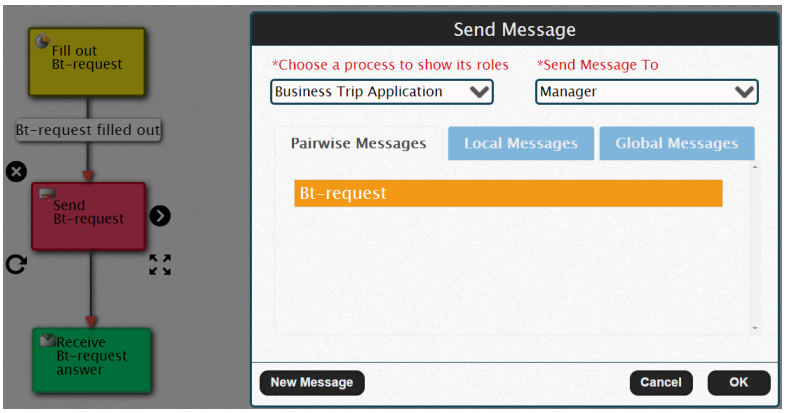


Figure 3.10: Send Message Popup of Modeling Component

Since decentralized process modeling requires a collaboration, inconsistencies among the roles are likely to occur. In order to form an integrated process model, actors need to uncover the inconsistencies among the roles they model and the other roles. For that reason, the tool provides an instant consistency check mechanism. It shows the inconsistencies among the roles from the perspective of a specific role. Figure 3.11 shows an example of consistency check results from the perspective of Manager. In the example, Manager views all of the roles with whom s/he has inconsistencies. Where the direction of the arrows represents the direction of the transfer, their colors denote the role who performs the transfer activity. In Figure 3.11, Manager sent "Approved Bt-request" message to Travel Office Personnel. However, Travel Office Personnel has not received that message from Manager yet. This transfer is denoted with a red arrow since the Manager performs the transfer and consistency check is executed from the his/her perspective. Similarly, Employee received "Rejection Info" message from Manager, but Manager has not sent this message to Employee yet. Therefore, this transfer is represented with a green arrow.

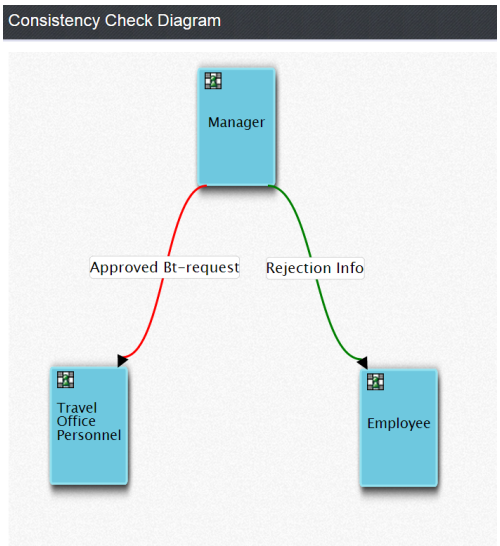


Figure 3.11: Consistency Check

Besides the aforementioned features, the roles may want to see the current state of the process model in terms of the other roles and interactions among them. Therefore, the tool provides an informative overall view that shows all roles and all interactions in the process. This overall view changes dynamically based on instantly changing interactions. Therefore, roles can learn what messages are transferred among other roles and guess which roles they will possibly interact in the future. The Figure 3.12 shows an example overall view for Business Trip Application process. A single-sided message transfer between two roles is enough to show the existence of that interaction on the overall view.

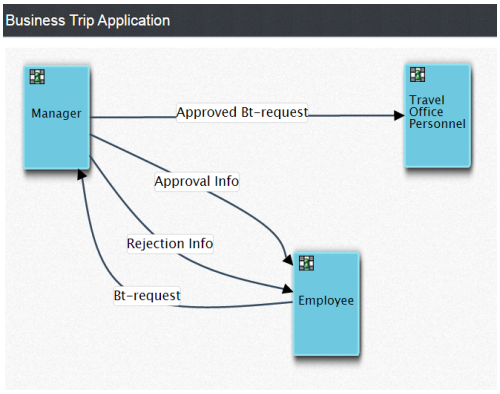


Figure 3.12: Overall View

From this overall view, roles are able to have information about other roles such as their actors and the processes they belong to. Therefore, based on this information, the actors can get in contact with each other for the possible inconsistencies among the roles they are assigned to. An example of such information is given in Figure 3.13.

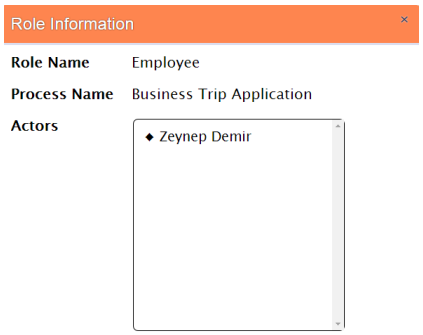


Figure 3.13: Role Information

Finally, this tool does not have a real time or asynchronous communication platform to resolve conflicts among the role behavior diagrams as stated in Section 3.3.2. However, this type of additional feature such as instant messaging, video conferencing, live chat or discussion board is left as a future work.

CHAPTER 4

EXPLORATORY AND MULTIPLE CASE STUDIES

In order to build and validate our method we conducted two types of studies which are one exploratory study and one multiple case study. Firstly, the aim of the former one was to propose a role-base and decentralized process modeling method concerning interactions among the roles. After the method was put forward based on the findings gathered from the exploratory study, the multiple case study was conducted in order to validate the ROADMap method.

This chapter is organized as follows; the first section presents the exploratory study we conducted in order to build our method. The second section gives the multiple case study to validate the ROADMap method.

4.1 Exploratory Study

In our exploratory study, we analyzed three current role-based process modeling approaches called ex-ante communication negotiation, ex-post communication negotiation and ongoing communication negotiation [42]. We employed these approaches while modeling a predetermined process in order to investigate the drawbacks and advantages of each one. We preferred to use S-BPM notation in our exploratory study since it supports role-based collaborative process modeling and also its usage grows in the industry.

4.1.1 Analysis of Current Approaches

We conducted our exploratory study on one of the main processes of a military software project of an IT company in Turkey, called software integration process. The purpose of the process is to build a well-defined procedure to make sure that the software modules of the project are integrated properly. The process mainly defines a set of activities for the integration of the software as well as ensuring that the predefined procedures and accepted standards are followed. It also examines the problems related to the integrated system. Accordingly, it helps the responsible employees to record those problems into certain databases in order to fix them in the next releases. Moreover, this process with an overall view showing the roles and the interactions among them is given in Figure 4.1. This process model was modeled as a subject interaction diagram using S-BPM notation with Metasonic Suite [35] tool as it should be. Software integration process consists of seven internal roles namely Project Leader, Software Development Team Leader, Configuration Management Engineer, Integration Engineer, PR

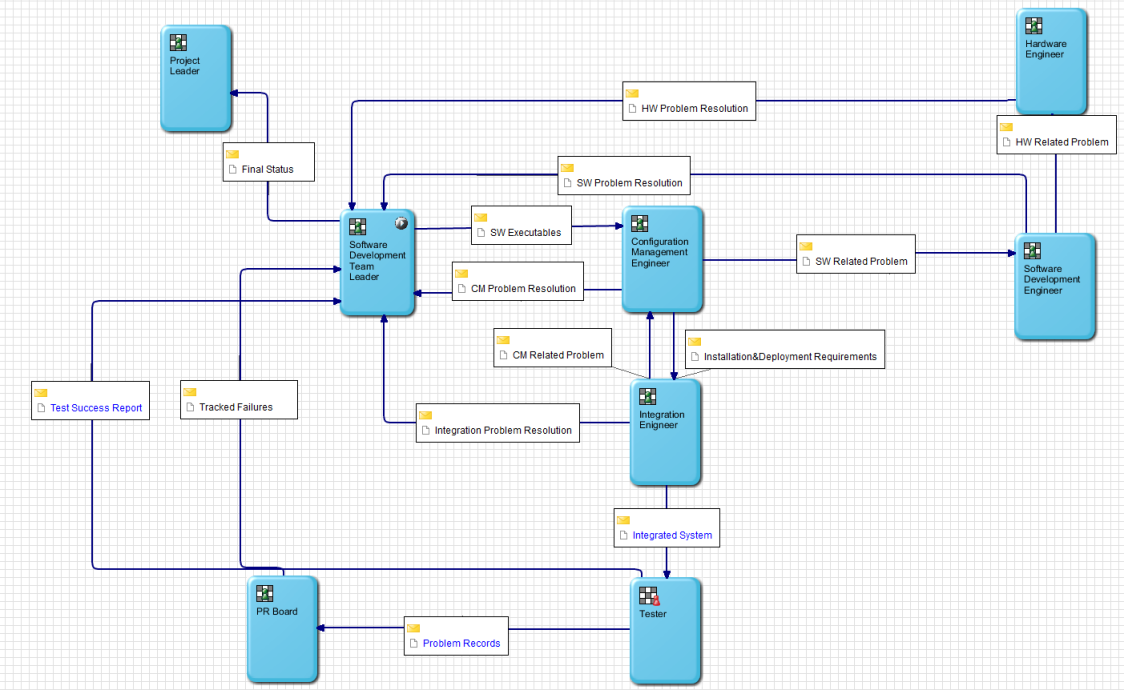


Figure 4.1: Subject Interaction Diagram of Software Integration Process

Board, Software Development Engineer and Hardware Engineer. There is also one external role, called Tester.

Although role-based modeling has a collaborative nature, a single experienced modeler, who also participates in the process and is the researcher, modeled the sample process in order to explicitly identify as many types of problems as possible.

After we employed three current role-based process modeling approaches on the software integration process, we realized that their benefits and drawbacks can be categorized under five aspects. These aspects are flexibility, conflict prevention, information awareness, overall view and latency [12]. They can be described as follows:

- **Flexibility:** This aspect indicates whether a role can define any type of messages or business objects which can be sent to or received from any time during modeling internal behavior.
- **Conflict Prevention:** This aspect reflects whether a process modeling approach have a mechanism in order to prevent conflicts among the roles in terms of messages and business objects.
- **Information Awareness:** This aspect shows whether a process modeling approach provides a facility to all roles within the process to be aware of changes related to them during modeling.
- **Overall View:** This aspect is an indicator of whether a process modeling approach allows the roles to visualize the general view of the process model including the messages and business objects to be sent or received among other roles to give an idea about

current state of the process.

- **Latency:** This aspect represents whether there exists reasons leading to latency to finish the overall process model in a process modeling approach. Although negotiation brings a time load naturally, in this aspect we consider latency that can be prevented by taking some precautions.

4.1.1.1 Ex-ante Communication Negotiation

In ex-ante communication negotiation approach, all messages transferred among the roles should be determined collaboratively before each role starts to model its own part [42]. When we apply this approach in S-BPM to model given process, first the roles in the process are mapped to subject elements of S-BPM. Afterwards, subject interaction diagram (SID) should be identified showing all sent or received messages including the business objects before each role models its own subject behavior diagram (SBD). After the SID is created collaboratively, each role will be ready to model its own part of work. In other words, every role models the subject behavior for which it is responsible based on the corresponding SID. Next, an integration step is needed to ensure that there exists no conflict about the sent and received messages among the subjects.

In our exploratory study for this approach, initially, we formed the SID then modeled SBDs for each subject. Thereafter, we checked whether all subjects are consistent with each other in terms of sent and received messages.

Flexibility: In this approach, all subjects should model their own internal behaviors with respect to the subject interaction diagram. Although modeling based on the SID provides consistency within overall process, this brings inflexibility to subjects while modeling their internal behaviors. There might be missing or redundant elements in that diagram which are not recognized during its collaborative creation. This situation can exist in the following different scenarios:

- A subject can be forgotten in SID especially in complex and large processes. Moreover, the same situation may occur when the process has many inter-process communications.
- While modeling subject behavior, a subject may require to send or receive a message or business object which is not defined in SID.
- While modeling subject behavior, a subject may give up to send or receive a message or a business object which is already defined in SID.

Assume that “Hardware Related Problem” message is forgotten in SID. When the Software Development Engineer wants to send “HW Related Problem” message to Hardware Engineer or Hardware Engineer wants to receive this message from Software Development Engineer, they cannot use this message while modeling their internal behavior until the consolidation step.

Conflict Prevention: In this approach, while the subjects model their internal behaviors, they already know what messages are sent to or received from other subjects with what business

objects. The reason is that SID includes such a communication information for all subjects. This situation also prevents occurrence of duplicate elements since this approach ensures the following conditions:

- Every message to be sent has a corresponding message to be received in another subject.
- Every message to be received has a corresponding message to be sent in another subject.
- The business objects are the same in the messages to be sent and received.
- Subjects are already defined.

In our case, Project Leader already knows that he/she receives the message "Final Status" consisting the report of the process from Software Development Team Leader to close the process and vice versa. Similarly, every subject in the software integration process knows messages to be send or received before modeling their own internal behaviors.

Information Awareness: This aspect cannot be evaluated as an advantage or a disadvantage in this approach. Since subjects model their internal behaviors and interactions based on the SID, there cannot exist a change until the consolidation step.

Overall View: Since the SID is formed with a consensus of all subjects in the process, the high level abstraction of the process is defined. Therefore, the subjects will have an idea to start modeling their behavior diagrams. Moreover, it brings high level information about both overall process and communication among other subjects.

For instance, Configuration Engineer knows that he/she should communicate with Software Development Engineer, Software Development Team Leader and Integration Engineer before starting to model its own subject behavior.

Latency: In this approach, all subjects have to wait in order to resolve their inconsistencies, even if they detect very small problem during modeling internal behaviors. Therefore, this approach does not provide immediate resolution for the conflicts and inconsistencies. As a result, this situation leads to a latency to finish overall process modeling activity.

For example, in the given process, Project Leader communicates with only Software Development Team Leader. If there exists a problem among them with respect to the messages to be transferred, it will not be resolved until consolidation step in this approach. Hence, the total time spent for modeling will increase although the problem among them does not affect the internal behavior of other subjects.

4.1.1.2 Ex-post Communication Negotiation

In ex-post communication negotiation approach, the individual work of each role has more priority than the interaction aspect. Firstly, all roles are responsible for creating separately their own part of works including the messages to be transferred from their own perspectives [42]. After that, there is a need for negotiation step to resolve the inconsistencies among them by checking the messages defined and transferred from different perspectives. Moreover, there is no SID since all subjects start to model their own internal behaviors as a first step. After subjects finish their own behaviors internally, the negotiation step starts. In this step, all

sending and receiving messages checked between the subjects. If there is a need for change due to the conflicts, related subjects update their internal behavior until an integrated and consistent model is formed.

In order to employ this approach in our exploratory study, first the roles in the process were mapped to subject elements of S-BPM. Next, we created the SBDs for all subjects in the process from the perspective of related subject. Then, we checked the messages sent and received in order to detect inconsistencies. Finally, we reached a consistent and integrated model by fixing conflicts.

Flexibility: In this approach, since there does not exist a SID defined at the beginning and the subjects model their own behaviors independent from others. Therefore, they are allowed to define any type of messages to be sent to or received from any subject they want. In other words, each subject models its own behavior and its communications with other subjects from its own perspective without any restriction.

In the given case, Integration Engineer can define any type of messages. Also, s/he can send it to or receive it from any other subject without being restricted during modeling its own internal behavior.

Conflict Prevention: This approach allows all subjects to model their internal behaviors from their own perspectives. Therefore, they are not aware of each other in terms of the messages they define and transfer. As a result, conflicts are likely to arise among these subjects. These conflicts may occur in the following scenarios:

- Duplicate messages or business objects may occur. In other words, two different messages targeting the same meaning can be defined by two different subjects.
- Messages and business objects to be sent or received may differ between two pair subjects in terms of cardinality and type.

For instance, Integration Engineer may need to receive two different messages, which are “Installation Requirements” and “Deployment Requirements” from Configuration Management Engineer. However, for the same purpose, Configuration Management Engineer may model its own behavior such that it sends a single message called “Installation&Deployment Requirements” to Integration Engineer. Therefore, there would exist both type and cardinality conflicts for the same purpose. Moreover, Software Development Team Leader sends a message called “SW Executables” to Configuration Management Engineer and Configuration Management Engineer receives a message called “Software Binaries”. Thus, there exists two different messages actually corresponding to the same purpose. As a result, we have duplicate messages in this scenario.

Information Awareness: In this approach, subjects do not communicate with each other until each of them finishes modeling of its own part of work. Without communication it is not possible for any subject to know the changes related to itself until the conflict resolution phase.

In our study, when the Software Development Team Leader defines a message called "Tracked Failures" to be received from PR Board, PR Board does not become aware of that message until the consolidation step.

Overall View: As there does not exist a SID concept in this approach, all subjects in the process are unaware of the messages and business objects transferred among other subjects. Thus, they have no idea about the overall process until the consolidation step.

For example, Integration Engineer is unaware of "Final Status" message which is received by Project Leader from Software Development Team Leader.

Latency: In this approach, the subjects are unaware of the overall process and identify their communications with other subjects from their own perspectives. Therefore, it is likely to appear a large amount of conflicts at the end of the modeling session. In this approach, absence of negotiation during modeling leaves the conflict resolution to a consolidation step. As a result, solving these accumulated conflicts leads to a latency to finish overall process model.

In our study, Configuration Management Engineer and Software Development Team Leader have intense interactions with other subjects. If other subjects communicating with these two subjects send or receive different messages corresponding to these two subjects, it is likely to appear a huge amount of conflicts. Hence, solving them would be time consuming for Software Development Team Leader and Configuration Management Engineer.

4.1.1.3 Ongoing Communication Negotiation

In ongoing communication negotiation approach, the roles start to model their own internal behaviors as a first step similar to the ex-post approach. However, the communication and negotiation in terms of the messages to be transferred should be handled immediately whenever they are identified [42]. In other words, when a message is identified, this information instantly delivered to the corresponding role. If there exists a conflict or inconsistency, it is resolved simultaneously between related two roles. This situation continues until all roles finish modeling their parts and a consistent process model is achieved. When we apply this approach in S-BPM to model given process, first the roles in the process are mapped to subject elements of S-BPM as in other two approaches. In this approach, there does not exist a SID since all subjects start to model their own internal behaviors similar to ex-post approach.

To employ this approach on the sample process, we started to create SBDs for all subjects in the process as a first step. Whenever a subject transfers a message to the other subjects, the corresponding subject is informed immediately about that message.

Flexibility: There exists no SID defined at the beginning in this approach similar to ex-post approach and subjects model their own behaviors without being constrained. Therefore, they can define any type of messages and send it to or receive it from any subject in the process.

For example, Hardware Engineer can define and transfer any message to any corresponding subject without being restricted by any aspect.

Conflict Prevention: In this approach, whenever a subject defines a message to send it to or receive it from another subject, they communicate and negotiate on that message. Therefore, each subject knows what to send or receive so that there cannot appear duplicate messages or business objects. As a result, this situation prevents fundamental changes of overall process model.

In our study, when Tester defines the message called “Problem Records” to send to PR Board, PR Board defines that message as received from the Tester. Since the subjects communicate and negotiate instantly, each message to be received has a complementary message to be sent at the other side. Therefore, in this approach there cannot be any duplicate messages or business objects.

Information Awareness: In this approach, whenever a message to be sent or received is identified, the corresponding subject is informed instantly. Therefore, the other side of the communication becomes aware of the message as soon as it is defined.

In the study, as soon as the Software Development Engineer defines a message called “HW Related Problem” to send Hardware Engineer, Software Development Engineer informs Hardware Engineer about this message. Thus, Hardware Engineer becomes aware of that message so that it should receive from Software Development Engineer instantly.

Overall View: Since there exists no SID in this approach, the subjects in the process have no idea about the interactions among other subjects in terms of messages and business objects. Hence, the subjects are unaware of the overall and current state of the overall process.

In our study, for example, Tester is unaware of the message "Final Status" which is defined by Software Development Team Leader to send it to Project Leader.

Latency: Ongoing approach prevents accumulation of conflicts via immediate communications. However, this intense communication among subjects brings an overload since all transferred messages are communicated and negotiated between the pair ones. As a result, this results in a latency to finish the overall process model. Moreover, while subjects model their own internal behaviors, they may be interrupted by the other subjects for the negotiation of the messages. This factor also increases the time spent for modeling since focusing back on modeling internal behavior might be a problem especially in the complex processes.

In the study, Software Development Team Leader would be interrupted by many other subjects since it has many connections with other subjects. Therefore, the time for modeling its internal behavior increases due to intense communications. Also, this may lead to an increase in time for modeling the overall process.

4.1.2 Discussion

By considering the benefits and drawbacks of three current process modeling approaches in terms of flexibility, conflict prevention, information awareness, overall view and latency aspects given in Table 4.1, we discuss how a novel method can be developed. In other words, we propose an outline of a role-based process modeling method which solves the drawbacks of given three current modeling approaches and includes their benefits.

Flexibility: In rigorous order approaches like ex-ante communication negotiation, roles need to be consistent with the initial definition of the messages which are determined collaboratively. In ex-ante approach, any possible problem cannot be resolved until consolidation step. It means that roles cannot edit and delete the existing messages or create the new ones. In order to prevent this situation, the proposed method should be flexible similar to the ex-post and ongoing communication negotiation approaches. In other words, roles should be free to define any type of messages and business objects to be sent to or received from any role any

Table4.1: Comparison of Current Role-based Process Modeling Approaches

	Ex-ante	**Ex-post**	**Ongoing**
Flexibility	Not Flexible	Flexible	Flexible
Conflict Prevention	Via initial definition of messages	No conflict prevention	Via immediate negotiation
Information Awareness	NA	No information awareness	Via immediate communication
Overall View	Via high level abstraction	No overall view	No overall view
Latency	Due to waiting for consolidation step	Due to absence of communication until consolidation step	Due to communication and negotiation overload

time during modeling. As a result, any role will be able to define and transfer any type of messages or business objects without being dependent on any restriction.

Conflict Prevention: Unlike ex-post communication negotiation, the proposed method should include conflict prevention mechanism in order not to spend much time on conflict resolution during integration. In ex-ante communication negotiation approach, conflict prevention is satisfied via a definition of all communication acts at the beginning. However, in ongoing communication negotiation approach conflict prevention is achieved via direct negotiation among roles. Since definition of all communications in ex-ante approach brings inflexibility as mentioned above, conflict prevention mechanism should be implemented via negotiation during modeling. However, this negotiation does not have to be performed for each interaction instantly in order not to distract the focus of the roles on their internal behaviors.

Information Awareness: Information awareness is crucial in any kind of collaborative work. Unlike ex-post communication negotiation approach, the proposed method should provide information awareness facility to the roles since information awareness reduces the possibility of the conflicts during modeling. Also, it makes the roles be aware of the current state of the process and decreases the time spent for conflict resolution. As a result, as in ongoing communication negotiation approach, the proposed method should include an information awareness mechanism. Recall that, in ongoing approach, when a change related to a specific role occurs, that role becomes aware of the details of that change immediately. However, how the type of information awareness mechanism should be in the proposed method in terms of immediacy will be discussed in "Latency" part.

Overall View: Ability to visualize the overall view of the process during modeling is important since it may give an idea about behaviors and interactions of all other roles in the process. However, as in ex-ante approach, the overall view should not be a high level abstraction mechanism that restricts the roles to model their own parts of work. Rather, the proposed method should provide an informative overall view for the roles. In fact, it should display which

roles communicate with each other and what messages are transferred among them at any time without restricting how roles model. Recall that, ex-post and ongoing communication negotiation approaches do not support such an overall view of the process.

Latency: Collaboration is likely to bring latency naturally since it involves communication and negotiation among multiple roles. We defined latency as reasons for delay which can be prevented by taking some precautions. All of the given approaches include latencies which could be avoided. Among them, in ex-ante communication negotiation, even if the roles find a small problem about the interactions, they need to wait until a consolidation step. Therefore, inflexibility may lead to latency in this approach. Moreover, in ex-post communication negotiation, the roles are unaware of each other and they need to wait until the consolidation step to resolve conflicts. Therefore, there may occur a large amount of conflicts and time spent for conflict resolution takes much more time. As a result, the absence of conflict prevention mechanism may cause latency in that approach. Finally, in ongoing communication negotiation approach, the immediate appearance of the related changes may bring a cognitive overload to roles while they are modeling their own behaviors. Immediate negotiations for conflict prevention distracts roles as well. Therefore, immediate negotiations and distraction of focus during modeling internal behavior may cause latency.

The proposed method should have a pull-based information awareness mechanism to minimize the latency. It means that changes first should be recorded immediately whenever they occur. Then, a small and non-distractive information should be sent to the related role about the changes. However, details of the changes should be presented to the roles whenever they need to see the details. Thereby, the roles are not distracted by the changes while they are concentrated on modeling their internal behaviors. Moreover, the roles can be aware of the messages sent to or received from the other roles whenever they need to define corresponding one. Also, unlike in ongoing communication negotiation approach, inconsistencies and conflicts do not need to be resolved immediately in order not to distract roles during modeling. Therefore, both pull-based information awareness and on-demand conflict resolution mechanism may minimize the latency.

4.2 Case Studies

After we proposed our method based on the findings from literature review and exploratory study, we need to apply it in the organizations. Case study research strategy is a strong strategy to allow researchers to explore complex social relationships [24]. Also, it is preferred for investigating contemporary events while the behaviors cannot be manipulated by the researchers [72]. Therefore, conducting a case study research to observe the validity of our claims is a suitable research strategy. Moreover, case studies can be designed in several ways like single and multiple case study designs. Multiple case studies consists of single cases and they are usually seen as the creators of more robust and reliable evidences. Therefore, multiple case study is suitable for this study as we need to examine more than one phenomena for replication. As a result, we can gather data from multiple sources to generalize the results about the validation of our method.

4.2.1 Research Questions

RQ 1: To what extend does ROADMap method cover the aspects that are identified in the exploratory study?

RQ 1.1: Does ROADMap method cause restrictions about definition or transfer of messages during modeling role behaviors?

RQ 1.2: Does ROADMap method have a mechanism to prevent conflicts?

RQ 1.3: Does ROADMap method provide current changes related to the roles themselves whenever they demand?

RQ 1.4: Does ROADMap method provide an informative overall view of the process including the roles and interactions among them?

RQ 1.5: Does ROADMap method cause to a significant latency to finish modeling?

RQ 2: What are the drawbacks and additional benefits of the ROADMap method?

Based on the findings from intensive literature review and the exploratory study, we elicited the requirements and proposed our method ROADMap. Then, in order to validate whether the ROADMap method fulfills these requirements we determined the research questions. The aim of the first research questions is to validate our method in terms of the flexibility, conflict prevention, information awareness, overall view and latency. The second research question is for the investigation of the weaknesses and strengths of the ROADMap method.

In order to answer these two questions we carried out a multiple case study which is composed of two single case studies.

4.2.2 Multiple Case Study Design

In order to validate our role-based and decentralized process modeling method and answer the research questions, we planned to select two cases for the multiple case study. In order to do that, we decided which sampling techniques will be used for the selection of the cases. Moreover, we needed to determine which data collection techniques and data analysis methods will be applied for these case studies.

4.2.2.1 Selection of the Cases

In order to conduct case studies, we planned to select two processes from two different organizations. For each case, the aim is to model a selected process of the organization using the proposed ROADMap method. For the selection of the organizations for both cases, convenience sampling technique was planned to be applied since it is easy for the researcher to reach the participants from the selected organizations. On the other hand, we expect that processes to be modeled will not be very small sized and there should be reasonable amount of interactions among the roles in these processes. Therefore, purposive sampling technique was decided to be used for the selection of the processes to be modeled and the participants. Moreover, since role-based and decentralized process modeling requires that each role in the

process models its own part of work, the participants of the case studies will be the stakeholders of the processes. Also, these participants will be expected to perform their role behaviors as actors in their real organizations.

We planned to select cases in such a way that the actors who are not familiar with process modeling will be the participants in the first case study. However, the participants, who are experienced in process modeling, will be picked up for the second case study. The reason is to show that satisfaction of the aspects for the proposed method, given in research question 1, does not depend on the process modeling experience of the participants. Also, in order to obtain clear explanation about the weaknesses and strengths about the proposed method, experienced and unexperienced participants were planned to be selected for the cases.

4.2.2.2 Data Collection

In order to make a valid and reliable comparison between the case studies, the data was planned to be collected in the same way in both cases. First, a case study database was decided to be created in order to repeat case studies easily. Also, data gathered from the case studies was determined to be stored in the same structure so that the information patterns will be clear.

Since interviewing is a crucial way for checking the accuracy of the observation, supporting observation with an interview is meaningful [19]. Therefore, for both cases we planned to use interview, observation and questionnaire techniques in order to collect data. In other words, participants' answers given to the interview questions and questionnaire questions will be gathered. Also, field notes to be collected via observations during the case studies, will constitute a part of the data.

In both case studies, the data was planned to be collected via the same instruments in both cases so that they could be easily compared. Data was decided to be gathered via interview, questionnaire and field notes as stated above. The followings give information about the instruments which will be used in the case studies.

- **Interview:** In this study, interviews can be considered as a central and crucial instrument. The same structured interview was planned to be conducted to all participants of both cases. Although the structured interview is not flexible, it is suitable for multiple case studies since it is easy to replicate for each participant and each case. The interview questions were decided to include mostly closed questions and a few open ended ones. The questions in the interviews were determined to be prepared by the researcher and reviewed by an expert. The interview questions will be about the features of the proposed method and its weaknesses and strengths. Moreover, in order to ensure validity, the researcher should be careful about not leading the participants while they answer interview questions. Also, one question at a time will be asked to the participants.
- **Questionnaire:** A questionnaire was also decided to be used to gather data in the case studies. It will be prepared by the researcher and reviewed by an expert similar to the interviews. The questions were determined to be prepared as typical five-level Likert items. This type of questions are useful to learn how strongly the participants agree to given statements. Moreover, in order to provide internal validity, the questionnaire questions will be prepared as Likert item versions of the interview questions.

- **Field Notes:** The field notes were also decided to be applied as an instrument while the participants are applying the proposed ROADMap method. The non-participant observation was planned to be conducted and each observation will take the time needed for the modeling session. As a result, the researcher will take detailed notes about the application of the method based on his observations while the participants are modeling processes using the proposed method.

4.2.2.3 Data Analysis

Before starting the analysis of data gathered from the participants, it is needed to know what kind of data we will have. Mostly, we will have text-based data which are field notes coming from the observations, and answers of the questions of interviews. Since our data are mostly qualitative we planned to apply a qualitative data analysis method to interpret it. Qualitative content analysis is suitable for the data gathered from interviews and observations. It is used to see summarized and integrated way of the content of speech or text by converting raw data into meaningful themes or categories to answer research questions[74]. Moreover, we will obtain some quantitative results coming from the five-level Likert questions in the questionnaires.

In qualitative content analysis, first we will define our pre-set themes as follows:

1. flexibility of interactions
2. conflict prevention
3. information awareness
4. informative overall view
5. latency
6. weaknesses of the method
7. strengths of the method

After we determine the themes, we planned to conduct coding phase for the data. Next, we decided to match the codes with the themes in order to collect related data together to find related answer for a specific research question. Moreover, we may have multiple codes for some of the themes so that matching codes with these themes is crucial phase. Finally, we will interpret the data and report our meaningful findings based on data obtained from interviews and observations.

In order apply quantitative content analysis for the data gathered from questionnaires, we planned to carry out median and frequency analysis according to answers of five-level Likert questions. Therefore, we could support the qualitative analysis results with the quantitative analysis results.

4.2.3 Case Study Conduct

We conducted two case studies in order to validate ROADMap in two different organizations. Based on criteria given in Section 4.2.2.1, we selected the organizations as Department of

Information Systems in Informatics Institute, METU for the first case study and a small software development and consultancy organization from METU Technopolis for the second case study.

4.2.3.1 Case Study 1

We selected *IS100 Examination* process to be modeled from the Department of Information Systems in Informatics Institute, METU. IS100 is an undergraduate course called Introduction To Information Technologies and Applications. All students of METU are responsible to take IS100 course during their education period regardless of their departments. Also, this examination process was not defined before the case study.

After determination of the process to be modeled, we met the stakeholders of the *IS100 Examination* process. In that meeting, we decided the roles which are involved in the process as *Administrator*, *Course Coordinator* and *Course Assistant*. Next, we assigned the actors to these roles. For the first role namely *Administrator*, there was only one actor whereas for the *Course Coordinator* there were two actors. There were about fifteen actors for the *Course Assistant* role. To model the process using ROADMap method, we selected representative actors for each role during the meeting. The selection of the participants was made according to criterion that none of the actors has prior knowledge or experience about process modeling. Therefore, before the modeling phase all actors were trained about process modeling concept and S-BPM methodology by an expert. This training session took about one and half hour. In this session, basic concepts about business processes were first introduced to the actors. Next, basic concepts of process definition, process modeling, some significant points on process analysis and modeling principles were explained. After the training related to process modeling was given, the actors learned how to model processes with S-BPM from process descriptions in natural language. Also, they modeled a sample process, which is a small scaled process, using S-BPM methodology. They used Metasonic Suite [35] tool for that purpose. Since we wanted actors to discover the features of our method themselves, we did not train them about ROADMap method before the case study in order not to affect them. However, the preparation phase includes a training session about ROADMap method. Finally, environment setup was done for the *IS100 Examination* process on ROADMap tool support. As a result, the preparation phase of ROADMap method was finished.

After the preparation phase, the actors were ready to model their role behaviors of *IS100 Examination* process. For the modeling phase, representative actors were gathered in the same room and they modeled their own role behaviors concurrently. During modeling they were allowed to chat and these conversations were noted as field notes by the observer who was the researcher. The modeling phase took about half an hour. After all actors finished their own parts, the overall process model was compared to actual work and the actors agreed on that the model reflected the actual process. After the participants finished modeling phase, they were interviewed about the ROADMap method separately. Moreover, the audio data from the interviews were recorded with their permissions. Finally, the questionnaires were conducted to each participant just after the interviews. Where the brief description of the *IS100 Examination* process in natural language is given in Appendix B, the role behavior diagrams for each role obtained from the participants in the case study are given Appendix C.

4.2.3.2 Case Study 2

We selected *Training* process to be modeled from a small software development and consultancy organization from METU Technopolis. Training process is applicable to all kinds of training services in which a specific subject is introduced to the participants in the form of a seminar or a workshop. In order to select this process, fourteen processes of that organization were examined. In these processes, the number of roles varied in the range of 2 and 6 roles. Therefore, we tired to select a process which includes an average number of roles. Also, all processes were defined in natural language.

After we determined the process to be modeled for the case study, we met the stakeholders of the *Training* process. In that meeting, we specified the roles which are involved in the process as *Trainer*, *Reviewer*, *Attendee* and *Team Leader*. Following that, we assigned the actors to these roles. There were three, three, two and two actors for the roles *Trainer*, *Reviewer*, *Attendee* and *Team Leader* respectively. In order to model this process using ROADMap method, we selected representative actors for each role during the meeting which was similar to the first case study. In this case, there were totally three actors to model the process although there were four different roles in the processes. However, one actor was responsible for modeling two different roles, which are *Reviewer* and *Team Leader*. In fact, he performed both roles in the actual process. Furthermore, although the role *Attendee* is an external role of the process, the actor modeling this role was an employee of the organization. Since he knew all activities of *Attendee* role and also participated in *Training* process as an attendee in the past, we choice him to model that role. Moreover, the selection of the participants for this case was made with respect to the criterion that all of the actors were experienced in process modeling. Hence, there was no need to train the participants about process modeling. They were only trained about S-BPM methodology by an expert before the modeling phase. Similar to Case Study 1, the actors modeled a sample process with S-BPM notation and used Metasonic Suite [35] tool for the process definition. This training session took about forty five minutes even if the participants were experienced in process modeling with BPMN and eEPC notations. The reason is that they spent much time to understand the differences between S-BPM and the other notations. Moreover, as in the first case, we did not train the participants about ROADMap method in order not to affect them although preparation phase consists of a training session about ROADMap method. Therefore, we expected the actors to discover the features of the method themselves for the validation. Finally, environment setup was done for the *Training* process on ROADMap tool support as the last step of preparation phase.

When the representative actors were ready to model their role behaviors of *Training* process, they were gathered in the same room and they modeled their own role behaviors concurrently. Similar to the first case, they were allowed to chat during modeling and the conversations among them were noted as field notes by the observer. As in the first case study, the observer was the researcher himself in that case. The modeling phase took about half an hour. After the actors finished their own parts of work, the overall process model was compared to process definition in natural language and all actors agreed on that the model was same as the process definition in natural language. After modeling phase, the data collection via interviews and questionnaires were conducted as in the first case study. In other words, the participants were interviewed about the ROADMap method separately and the audio data were recorded with their permissions. Lastly, the questionnaires were carried out for each of the participants just after the interviews. The brief description of the *Training* process in natural language is given in Appendix B and the role behavior diagrams gathered from the participants at the end of the

case study are given in Appendix C.

4.2.4 Threats To Validity

Due to the application of case study research, there are some possible threats to validity. In order to handle these threats that can be arise during or conducting case studies, some actions were planned and taken before conducting multiple case study. In this section, the actions, which were conducted to prevent these threats, are explained.

When the case study activities are not suitable to evaluate the proposed method and the interviews are not carried out in a correct way to find answers to research questions, a problem related to construct validity is likely to occur [73]. In order to make sure that the construct validity is provided in our study, the interview and questionnaire questions and design of the multiple case study were reviewed by two experts before conducting the case studies.

Internal validity is another concern since we needed to make conclusions based on the findings from the application of our method. Credibility is the corresponding design test for internal validity. Therefore, in order to increase the credibility of the study, we used multiple source of data collection instruments for both case studies namely interviews, questionnaires and field notes obtained from observations. Also, the questionnaire questions were prepared as Likert item versions of the interview questions. As a result, the internal validity of the study was provided.

External validity is also very crucial since it handles the generalization of the case study results [55]. Transferability is a design test in case study design related to external validity. In order to increase transferability, replication logic, cross-case analysis and thick description can be used. In this study, transferability was achieved by conducting multiple case study where replication logic was applied. We applied ROADMap method in two different organizations. Also, we ensured that we applied replication logic consistently for both cases in terms of the ROADMap tool support since it guides participants to apply ROADMap method. As a result, we eliminated the threats to external validity by applying multiple case study with replication logic. However, we selected medium scaled processes in terms of the complexity and the number of roles they include. Therefore, we still need to apply the ROADMap method on large scaled processes to increase the external validity of the study.

Finally, dependability is the design test for the reliability of the study. Using case study protocol, developing and refining it and using multiple researchers can be options for increasing the reliability in case studies. In this study, the case study protocol was defined for each case study. Both cases were conducted according to that protocol. Therefore, other researchers can carry out the same study by following the methodology. Moreover, a case study database was developed. Lastly, the interpretation of the results of the study was reviewed by the participants in order to increase the reliability of data analysis. As a result, the reliability of the study was provided via dependability design test.

CHAPTER 5

RESULTS

This chapter presents the findings gathered from the case studies and discusses them. These findings were analyzed and interpreted based on the data obtained from the interviews, questionnaires and the observations carried out by the researcher. During analysis of the data, the methodology given in Section 4.2.2.3 was used. Also, the interview questions are given in Appendix D.

Recall that Research Question 1 is related to fulfillment of the aspects that are identified in the exploratory study in terms of flexibility, conflict prevention, information awareness, overall view and latency. On the other hand, Research Question 2 investigates the drawbacks and additional benefits of ROADMap method.

5.1 Case Study 1

In the interviews, all participants pointed out that ROADMap method allowed them to define new messages any time in an easy way and without causing any restrictions during modeling. Also, they all specified that they did not have to use the previously defined messages in the system since they may not need them for their role behaviors. Therefore, whenever they need a message which was not previously defined in the system, they are able to define a new message during modeling. On the other hand, one of the participants mentioned that although the method permits the actors to define new messages any time in a flexible way, their meanings may be misunderstood by the other actors. Therefore, there should be syntactic and semantic rules to define them. In fact, we observed these two situations together during the case. One of the pair roles remarked that the name of a specific message did not meet its meaning so that corresponding role defined a new message flexibly as they negotiated. Furthermore, all participants stated that they were not restrained while they transfer messages to other roles in the process using ROADMap method. In other words, they sent any messages to or received them from other roles freely during modeling. In the mean time, the participants pointed out that transferring messages flexibly makes elicitation of the actual work easier and more clear.

All participants stated that they were able to see the previously defined messages using ROADMap method. This feature prevented them from defining duplicate messages targeting the same meaning. Therefore, they used the messages which were suitable for them instead of defining duplicates. Moreover, ROADMap method enabled the participants to see previously transferred messages by a corresponding role before they send a message to or receive a mes-

sage from that role. Hence, the participants preferred to use corresponding messages to send or receive messages as responses so that they avoided to transfer a different message which might lead to conflicts. We observed that different messages targeting the same meanings were sent and received between two roles only once in this case. However, it was handled in a short time by negotiation of the actors playing these roles. Additionally, all participants remarked that they were able to see the inconsistencies anytime related to themselves among the other roles they interacted with. Therefore, they were aware of the inconsistencies in an ongoing way so that they took preventive actions for them immediately.

In the interviews, all participants specified that they were able to be aware of the changes related to themselves whenever they occurred. In other words, ROADMap method notified the roles immediately whenever a new local or global message is defined, or a message transfer is occurred related to themselves. The roles were noticed with the appearance of a small notification icon. Furthermore, all three participants stated that immediate awareness of the related changes is crucial since they may take immediate actions based on the changes. Also, they stated that being aware of these changes immediately helps them to form their own role behavior diagrams easily. Moreover, we observed that the notifications did not distract the focus of the participants on their role behavior diagrams. Even, one of them was not aware of the notifications, so these notifications accumulated until middle of the modeling session. After he realized there had accumulated a number of notifications, he intuitively checked and compared the transferred messages. Additionally, the participants were able to get the details of the changes related to themselves whenever they demanded. Also, they pointed out that the details gave enough information about the changes.

All participants pointed out that they were able to see all roles in the process and their interactions with each other instantly in terms of the messages sent and received. This information was enough to have a knowledge about overall picture of the work knowledge for them. Also, this overall view did not restrict the participants from modeling their role behaviors. Moreover, we observed that some participants frequently used this feature to have an information about current state of the process during modeling.

None of the participants encountered a cognitive overload during modeling which leads to significant latency to finish their modeling activities. In the interviews, two of the participants remarked that they could easily focus on their own role behaviors since small and non-distractive notifications were provided to make them aware of the changes. Moreover, there did not appeared accumulation of conflicts at the end of modeling session. Although a very small number of conflicts occurred during modeling, all participants resolved them in an ongoing way easily. Therefore, the participants did spend much time to resolve conflicts which leads to a crucial latency to finish modeling overall process. Finally, the participants specified that they never faced with restrictions causing the latency to finish modeling in the interviews.

The frequency analysis of the answers given to the questions of questionnaire related to aspects mentioned above indicated in Figure 5.1.

According to participants, the weaknesses of the ROADMap method are given below:

- The explanation of the control flows on the tool could not be changed easily.
- There does not exist an annotation box element in the notation, so the explanation of the model or the model elements could not be shown in order to inform other roles.

- There does not exist semantic and syntactic rules for defining messages.
- A filter option to search for previously defined messages is not implemented.
- There does not exist a user manual for the tool and the notation.
- The actors of each role model their role behaviors in the same room without any problem while solving inconsistencies among them. However, the tool suffers from a communication and negotiation platform like instant messaging, video conferencing or live chat for the geographically distributed actors.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
I found ROADMap method flexible to define a new message any time during modeling.					3
I found ROADMap method flexible to transfer any messages any time during modeling.					3
ROADMap method has a mechanism to prevent conflicts.					3
ROADMap method immediately informed me about the changes related to myself during modeling.					3
Notifications distracted my focus during modeling.	2	1			
ROADMap method provided the details of the current changes related to myself whenever I demanded.					3
ROADMap method provided an informative overall view showing the roles and the interactions in the process.					3
ROADMap method provided an overall view which restricts to model role behavior.	1	2			
I faced with a cognitive overload during modeling leading to significant latency to finish modeling.	2	1			
There appeared an excessive amount of conflicts whose solution leaded to significant latency during modeling.	1	2			
I encountered a significant latency caused by restrictions to finish my modeling activity.	2	1			

Figure 5.1: Frequencies of the Answers for Case 1

The additional benefits of the method other than the mentioned ones are listed below:

- The tool support of the method is simple and easy to use.
- The tool support of the method is easy to learn and its user interface is satisfactory.

5.2 Case Study 2

In the interviews, all participants stated that there were no restriction to define new messages any time during modeling. ROADMap method naturally encouraged them to define new messages whenever they do not exist in the previously defined messages pool. However, one participant pointed out that there is a need for checking already defined messages carefully to avoid duplications before definition of a new message. Moreover, all participants were flexible while transferring the messages to other roles. In other words, roles in the process were free to send or receive any messages defined in the system to any other roles during modeling. Also, one participant remarked that sending or receiving a previously defined messages in different levels and its use by the different roles is very helpful.

All participants stated that they were able to see the previously defined messages using ROADMap method as in Case Study 1. We observed that they intuitively looked for the message they wanted to use among previously defined local and global messages. If they could not find it, then they defined a new message. Therefore, the participants avoided defining different messages having the same meaning. Furthermore, ROADMap method provided the participants with viewing the messages previously sent or received by a corresponding role when they tend to transfer a message that corresponding role. Similar to prevention of message definitions which are semantically same but syntactically different, this feature helped the participants to avoid transferring different messages targeting the same meaning as corresponding messages. According to our observations, this kind of inconsistency did not happen during the case study. Moreover, all participants agreed with they were able to see current inconsistencies among them whenever they demand. Accordingly, we observed that they easily took actions for these inconsistencies to prevent converting them into conflicts. Also, they modeled their role behaviors in a cycle in which they modeled a bit, checked consistencies and resolved them. Hence, they iteratively performed this cycle until reaching the overall and consistent process model. Lastly, one participant stated that viewing the current inconsistencies leads to self-verification for his role behavior model. Therefore, he could confirm his own model with every moment.

All participants agreed on they were immediately informed whenever a change occurred in the system related to themselves as in case study 1. Therefore, they had opportunities to be aware of these changes as soon as possible in terms of the messages newly defined and transferred. They all also specified that they could edit their role models or negotiate with the corresponding roles based on information coming from notifications. Moreover, the notifications did not distract focuses of the actors on their role behavior models during modeling. Finally, in the interviews, all three participants pointed out that they easily could reach the detailed information related to notifications whenever they demand. This information was sufficient to be get informed about the changes. Beside that, one participant wanted to have a right to choose the notification type depending on the complexity of the process and intensity of the online roles at a specific time. However, rest of them preferred seeing the details of the notifications

on-demand as in ROADMap method.

All three participants could view the the roles in the process and the current messages sent and received among them whenever they demanded. Therefore, they could have high level information about the current state of the overall process. Moreover, two participants explained that they could make sense of the messages defined by the other actors in the pool by looking at overall view. Also, they stated that the ability to view roles and their interactions gave a chance for them to predict the possible roles which they interact with in the future. Finally, we observed that all participants used this feature very often during modeling.

Similar to the participants of case study 1, none of the participants in this case faced with a cognitive overload during modeling which causes a significant latency to finish overall process model. They stated that ROADMap method naturally made the actors focus on their own role behavior models and did not allow them to divert their attention to other parts of the work. Moreover, all participants agreed on that there did not exist an excessive amount of conflicts, whose resolution would take a significant amount of time to finish overall process model. However, they stated this reason could stem from either the complexity of the process to be modeled or the fact that they started modeling simultaneously. Finally, ROADMap method did not cause a latency, which was resulted from any restrictions, to finish modeling activities.

The frequency analysis of the answers given to the questions of questionnaire related to aspects mentioned above are indicated in Figure 5.2.

According to participants, the weaknesses of the ROADMap method are given below:

- The messages cannot be edited or deleted.
- There does not exist an option for animating notifications to make them more visible.
- There does not exist a baseline mechanism to tag versions of the process models.
- All model elements on the drawing diagram can not be selected at the same time.
- There does not exist an indicator to separate used an unused messages in the local and global message pools.
- The tool suffers from a communication and negotiation platform like instant messaging, video conferencing or live chat for the geographically distributed actors to resolve the conflicts.
- The tool does not consist of an off-line mode to model processes.
- The notation does not include icons for the message types sent or received like document, form, list and etc.

The additional benefits of the method other than the mentioned ones are listed below:

- The tool support of the method is simple and easy to use.
- The tool support of the method is easy to learn and its user interface is satisfactory.
- The tool support being web and cloud-based is an advantage since its maintenance is easy and it does not require a specific installation for each modeling environment.

- The regulation of the actors' access rights prevents actors to intervene into the models of other roles.

- Forcing actors to choose messages and roles for sending or receiving a message after creation of a *send* or *receive* state model element is beneficial. Therefore, it prevents the actor to define empty *send* and *receive* states.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
I found ROADMap method flexible to define a new message any time during modeling.					3
I found ROADMap method flexible to transfer any messages any time during modeling.					3
ROADMap method has a mechanism to prevent conflicts.					3
ROADMap method immediately informed me about the changes related to myself during modeling.					3
Notifications distracted my focus during modeling.	1	2			
ROADMap method provided the details of the current changes related to myself whenever I demanded.					3
ROADMap method provided an informative overall view showing the roles and the interactions in the process.					3
ROADMap method provided an overall view which restricts to model role behavior.	1	2			
I faced with a cognitive overload during modeling leading to significant latency to finish modeling.	2	1			
There appeared an excessive amount of conflicts whose solution leaded to significant latency during modeling.	2	1			
I encountered a significant latency caused by restrictions to finish my modeling activity.	2	1			

Figure 5.2: Frequencies of the Answers for Case 2

5.3 Discussion on Case Study Results

In this section, we discuss the results of both case studies we conducted. Firstly, we observed that all participants agreed on the flexibility of ROADMap method. In other words, the participants could define new messages and transfer them to any roles in the process any time during modeling. Moreover, all participants confirmed that ROADMap method has a conflict prevention mechanism. Put it differently, they all were able to see the previously defined and corresponding messages so that they avoided defining duplicate messages targeting the same meaning. Also, they all used consistency check mechanism to solve inconsistencies among them and to prevent them converting into conflicts. Additionally, all participants from both cases agreed on that ROADMap method immediately informed them via notifications about the changes whenever they occurred. Also, these notifications did not distract their focuses on their role behavior diagrams. Moreover, they were able to view the details of these changes whenever they demanded. Furthermore, all participants stated that ROADMap method provides an overall view on which all roles and the interactions among them take place. Therefore, they had information about the overall process as a common picture. Lastly, none of the participants encountered a significant latency to finish modeling the whole process which may be resulted from cognitive overload, any restrictions or resolution of accumulated conflicts at the end of the modeling. As a result, the case study results satisfied the Research Question 1 in terms of the aspects namely flexibility, conflict prevention, information awareness, overall view and latency. Also, we observed that the results did not depend on the knowledge and experience of the participants about process modeling. Therefore, this method can easily be applied in the organizations in order to elicit the process knowledge.

According to results of the case studies, we put the weaknesses and the strengths of ROADMap method except from the aspects given in Research Question 1. The participants who have no knowledge about the process modeling discoursed the absence of some process modeling specific facilities like annotations, filters to search defined messages, user manuals or semantic and syntactic rules to define messages. On the other hand, the participants experienced in process modeling remarked more general disadvantages of ROADMap method such as nonexistence of baseline mechanism to tag versions, absence of off-line mode and the inadequate message management. However, they all agreed on the idea that ROADMap method does not provide a communication and negotiation platform for geographically distributed users to solve inconsistencies and conflicts among them. Moreover, all participants found the tool support of ROADMap method simple and easy to use. Also, they shared the same idea that the interface of the tool is satisfactory. Furthermore, we observed that the participants who have prior knowledge about process modeling remarked that the web and cloud-based architecture is an advantage for a process modeling tool. We believed that they discovered this facility as an advantage since they knew the difficulties of collaborative modeling with desktop applications. Recall that the Research Question 2 is related to weaknesses and strengths of ROADMap method. Therefore, we answered this question as a result of case studies.

We analyzed the importance of the aspects given in Research Question 1 for role-based and decentralized process modeling. We asked some questions to the participants related to necessity of these aspects in both interviews and questionnaires. According to participants, defining and transferring messages any time during modeling in a flexible way is necessary since each role starts to be aware of the messages to be defined, sent or received as long as they deeply analyze and model their own role behaviors. Moreover, all participants agreed on the idea that a mechanism that avoids conflicts among the roles is a necessity since conflicts are likely

to occur in decentralized process modeling especially for the large and complex processes. Since each role models its own role behavior from its own perspective, there is a need for conflict prevention mechanism. Furthermore, all participants from both cases remarked that immediate information awareness is crucial and necessary. Beside that, five participants preferred seeing details of the changes whenever they demand in order not to be distracted by crowded notifications. On the other hand, only one participant favored to view the details of the changes whenever they occurred in a box. Finally, all participants stated that viewing the overall view of the process in terms of the roles and their interactions, is necessary and important in order to have an idea about the overall process and to make sense of its roles and messages. Also, they pointed out that they would prefer an informative overall view as in ROADMap method instead of a restrictive one.

	Strongly Disagree	Disagree	Neither Disagree Nor Agree	Agree	Strongly Agree
I believe that being flexible on defining and transferring messages any time is a necessary feature.				1	5
I believe that a mechanism that helps to avoid conflicts is a necessary feature.				1	5
I believe that being immediate aware of changes related to myself is a necessary feature.				3	3
I would prefer seeing details of the changes related to myself whenever they occur instead whenever I demand.	2	3		1	
I believe that seeing the overall view of the process is important to have an idea about the current state of the process model.				4	2
I prefer an informative overall view rather than a restrictive one.				3	3

Figure 5.3: Frequencies of the Answers for Discussion

We observed that all actors from both case studies frequently asked to each other whether they finish modeling their own role behavior models or not. Therefore, they made sure whether the overall process model was reached its final state. This situation was not a problem for the actors since they were at the same location during modeling. However, this situation may bring a drawback for the geographically distributed actors.

As a result, we observed that opinions of all participants show similarity with high level requirements of a role-based and decentralized process modeling method elicited based on the exploratory study we conducted. The frequency analysis of the answers given to related questions in the questionnaire are indicated in Figure 5.3.

CHAPTER 6

CONCLUSION AND FUTURE WORK

This chapter provides a discussion on the outcomes of proposed ROADMap method. Moreover, possible steps to be followed in the future work are presented.

6.1 Conclusion

In this study, we proposed a role-based and decentralized process modeling method called ROADMap method to enable process stakeholders to model their own works in a role-based, distributed and collaborative way. In order to build our method, first we conducted an exploratory study to observe the benefits and the drawbacks of current role-based process modeling approaches. These approaches differ in time when the message specifications among the roles happen. Based on our findings, we grouped the advantages and disadvantages of these approaches into five aspects namely flexibility, conflict prevention, information awareness, overall view and latency. Therefore, the first contribution of this study is the identification of the given aspects. By considering these aspects we proposed ROADMap method including the idea behind it, a tool support implementing this idea and a suitable notation. Therefore, the second and the main contribution of this study is to propose a role-based and decentralized process modeling method that improves the weaknesses of the current role-based approaches and keeps their strengths in terms of the identified aspects.

ROADMap method consists of two main phases namely preparation and modeling. The preparation phase is preceding phase of modeling phase. The actors and the roles of the process to be modeled are identified and matched. Also, training and environment setup are performed in this phase just before modeling. In modeling phase, the actors model the work of the roles they are assigned to using the tool support and the notation.

ROADMap method is flexible since it enables the actors to define new messages or transfer them to other roles any time while actors model their own role behaviors. Since each actor models its own role behavior from its own perspective in role-based and decentralized process modeling, conflicts are likely to occur. Therefore, the method prevents the conflicts via an instant consistency check mechanism and a mechanism to show previously defined and correspondingly transferred messages. Moreover, ROADMap method has an on-demand information awareness system. Whenever a change occurred related to a role, that corresponding role is instantly informed via a small and non-distractive notification. However, the details of the changes are presented when the related actors of that role demand that information. Furthermore, the method provides an instant overall view of the process in which the

roles and all interactions among them take place. Therefore, the actors are able to have high level information about current state of the process. Lastly, ROADMap method minimized the latency to finish overall process model caused by restrictions, cognitive overload and time to required for resolution of accumulated conflicts.

We supported our method with a notation and a tool. The third contribution of this study is that we extended the S-BPM notation with the logical operators in order to enable actors to model processes more explicitly. Since S-BPM notation does not include logical operators, its behavioral perspective representation is weak. Our logical operator extension for S-BPM notation enhanced its behavioral perspective. As our forth and final contribution, we implemented a web and cloud-based tool for the method since collaborative works are more meaningful with tool supports. We implemented the idea of role-based and decentralized process modeling method we proposed in this tool. Our tool is the first web and cloud-based modeling tool that enables the actors to model their own works concurrently in a role-based, decentralized and bottom-up manner.

In order to validate ROADMap method we conducted a multiple case study including two single case studies. The aim of the case studies was to validate that ROADMap method drives the requirements we extracted from the exploratory study and to identify its strengths and weaknesses. In order to that, we selected two processes from two different organizations. We conducted the first case study in Department of Information Systems in Informatics Institute, METU. The actors modeled *IS100 Examination* process which consists of three roles using ROADMap method. We carried out the second case study in a small software development and consultancy organization from METU Technopolis. The actors modeled *Training* process composed of four roles using ROADMap method. In the first study, the participants were selected from the actors who were not familiar with process modeling before. On the other hand, the participants for the second case study were selected among the actors who had prior knowledge or were experienced in process modeling.

According to results, all participants from both case studies found the ROADMap method flexible, and conflict preventive. Moreover, they agreed on that the method presents the changes related to themselves instantly via notifications and they were able to view the details of these changes whenever they demand. Furthermore, they all shared the idea that the method enables actors to view current state of the overall process consisting of roles and interactions among them. Additionally, none of them encountered a significant latency to finish modeling resulted from cognitive overload, any restrictions or resolution of excessive amount of accumulated conflicts. As a result, all participants approved that the ROADMap method satisfies all requirements specified in the exploratory study.

Case study results showed that all participants from both cases favored the simplicity and easiness of use of the tool support. Also, the participants stated that web and cloud-based architecture is advantageous over other modeling tools. Moreover, both groups complained the nonexistence of communication and negotiation platform like live chat and instant messaging for geographically distributed actors. Furthermore, the participants not experienced in process modeling suggested small improvements related to use of tool. On the other hand, the participants experienced in process modeling found more general weaknesses like inability to model processes in off-line mode and nonexistence of tag mechanism for versions of the models.

Case studies showed that ROADMap method fulfills all requirements identified in the ex-

ploratory study we conducted. Also, all participants agreed on the necessity of the requirements found in the exploratory study. Therefore, the proposed method is successful for role-based and decentralized process modeling. Moreover, the results of both case studies are parallel and they do not depend on whether the participants have knowledge about or experienced in process modeling before using ROADMap method. Therefore, this method can be easily applied in organizations even by the actors who are not experienced in process modeling.

6.2 Future Work

We conducted a multiple case study including two single case studies in order to validate ROADMap method. Although we provided external validity with multiple case study design, we will conduct more case studies in different organizations to increase the external validity. Moreover, the processes modeled in the cases were medium scaled in terms of the complexity and the number of roles they include. Therefore, we are planning to repeat case studies on large scaled process to observe the effects of the ROADMap method on role-based and decentralized process modeling. In addition to that, we will also carry out case studies on processes which have geographically distributed roles.

According to case study results, we identified some weaknesses for tool support of ROADMap method. Firstly, we should add an extension for tool support which implements a communication and negotiation platform such as live chat, instant messaging, video conferencing or etc. in order to solve inconsistencies or conflicts among the geographically distributed actors. Furthermore, we are planning to implement an off-line mode at which the tool could be run without internet connection. Also, we should add a mechanism to tag versions of process models so that a baseline for them can be created. As a result, the revision control is provided with such a mechanism. Additionally, we should reorganize message management by adding functionalities for *editing* and *deleting* messages, *viewing* used and unused messages and *search* with filters. Also, the tool support should direct the actors to define messages in a syntactic and semantic rules. We will also add a user manual of tool support and notation for the modelers who are not experienced in process modeling.

Although ROADMap method supports multiple actors to model the same role simultaneously, the tool support does not allow these actors to see the changes made by other actors assigned to the same role in real time. Therefore, we will implement a real time and collaborative modeling platform for the actors assigned to the same role to model the same role behavior at a time.

According to case study results, all participants except one preferred viewing the details of the changes on-demand in order not to be exposed to a cognitive overload. However, one participant remarked that the right to choose notification type should be left to the actors depending on the complexity of the process and the number of online roles at a time. Hence, we are planning to present options for the information awareness to the actors. As a result, in addition to the current state of the information awareness system of ROADMap method, the actors can display the changes immediately without a second move if they prefer seeing their details whenever changes occur.

In ROADMap method, we extended the S-BPM notation with logical operators in order to im-

prove its behavioral perspective. In addition to that, we are planning to enhance its functional perspective by adding a hierarchy concept for process models and state modeling elements. This will enable activities to be decomposed into sub-activities. However, improving behavioral and functional perspectives may also result in side effects. Therefore, there is a need for a study to observe the consequences of these improvements.

In order to measure the efficiency of the ROADMap method in the organizations, we will conduct studies in which it is compared to centralized and other decentralized process modeling approaches in terms of total time and effort needed for modeling. Moreover, we are planning to improve the tool support to collect some quantitative measures such as number of conflicts among the roles, number of interactions for each role, time for modeling a specific role behavior and overall process model and etc. Therefore, such data will be input for analysis of process models and reporting as well as comparison of ROADMap method with other methods.

The accuracy of the process models in terms of representation of the actual work highly depends on the degree of stakeholder involvement during modeling. Although ROADMap method motivates the process stakeholders to model their own works in role-based manner, the validation of the role behavior diagrams is needed to be applied. Hence, we are planning to add such a step to ROADMap method to make sure that individual role behavior diagrams represents the actual work with high accuracy.

Finally, we observed that actors had conversations to ask each other whether they finish modeling their own role behaviors or not. Since we conducted each case study in the same space, we did not encounter a problem related to it. However, there is a need for a sign to inform other roles about the current situation of a specific role behavior such as *completed* or *in progress* especially for off-site roles. Therefore, we will implement such a facility for ROADMap method in the future.

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APPENDIX A

ADMINISTRATOR COMPONENT SCREEN SHOTS

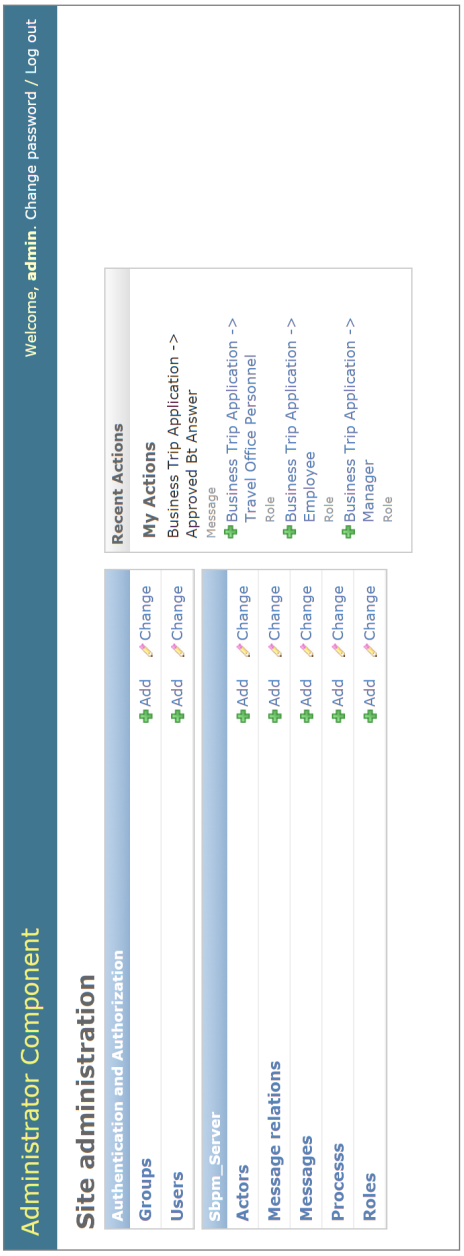

Figure A.1: Home Page

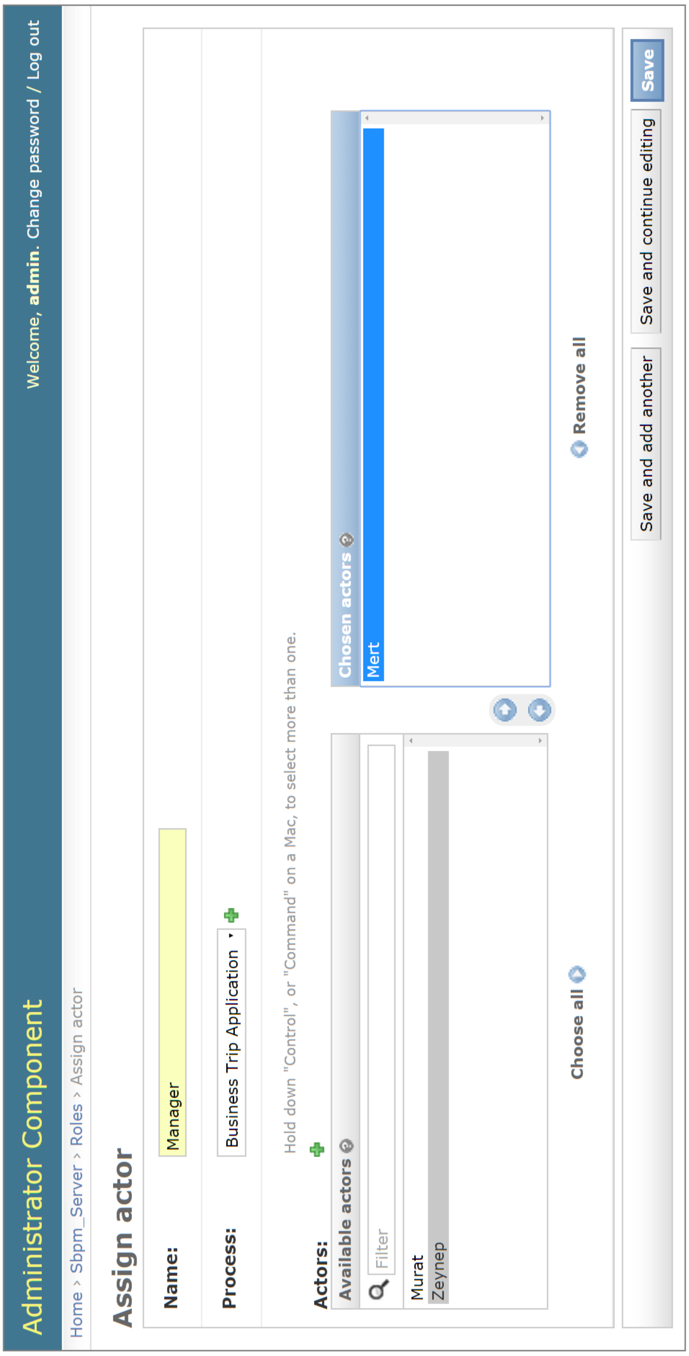

Figure A.2: Assign Actor Page

APPENDIX B

PROCESSES MODELED IN CASES

B.1 IS100 Examination Process

As a first step, course coordinator prepares the exam questions. After preparation of the questions s/he defines the exam in the IS100 system. After that, the course coordinator sends exam places and participation list to the course assistants. Before the exam starts, course assistant opens the class and computers. Next, s/he defines the start and end date of the exam for the specific section on the system. Afterwards, the course assistant matches the IDs of the students on the participation list and gets it signed. When the exam time comes, course assistant starts the exam. If there is a problem during the exam, s/he submits the problem to the course coordinator. When the course coordinator takes the problem, s/he checks it whether s/he can resolve the problem herself/himself or not. If the problem stems from the system and course coordinator cannot solve the problem, s/he sends it to the administrator. Administrator investigates the problem and resolves it. After that, s/he informs the course coordinator about the solution. After solution of the problem, the course coordinator informs the course assistant. When the exam time is up, the course assistant finishes the exam on the system for the specific section and sends the participation list to the course coordinator. Finally, the course coordinator finishes exams for all sections.

B.2 Training Process

As a first step, team leader assigns an employee from BG who has a deep knowledge about the training subject as a trainer and sends course information to him/her. After that, the trainer prepares the course notes in accordance to the course notes template and submits them for review to the reviewer. If the trainer uses notes from a previous BG project, then s/he does not need to get them reviewed. The reviewer is responsible for reviewing the course notes. S/he firstly examines the course notes and then identifies the anomalies about the course notes. After that, the reviewer records all anomalies in the review record, then submits it to the trainer. Finally, s/he places issues related matrices about the review under control and closes the review session. After the trainer gets the review record about the course notes, s/he resolves all anomalies if there exists. Then s/he ensures course notes are ready for distribution to the attendees before date of delivery. The trainer is responsible for distributing the course notes, course title page and the form of attendee information to the attendees just before the course. Also, s/he files a copy of course materials into the project folder. Then, s/he executes the course. When the course is finished, the trainer gathers attendee information forms which are filled out by the attendees. Moreover, if the current session is the last session of the training,

the trainer also gives the evaluation forms to the attendees for the evaluation of the training. After attendees finishes filling out the evaluation forms, they give the forms back to the trainer. After the last session is conducted, the trainer submits the list of attendee evaluation forms to the team leader. Team leader examines these forms and calculates customer satisfaction point using project evaluation matrix based on the attendee evaluation forms. Then, s/he places project evaluation matrix under control and finally closes the training project.

APPENDIX C

PROCESS MODELS FORMED DURING CASE STUDIES

C.1 IS100 Examination Process

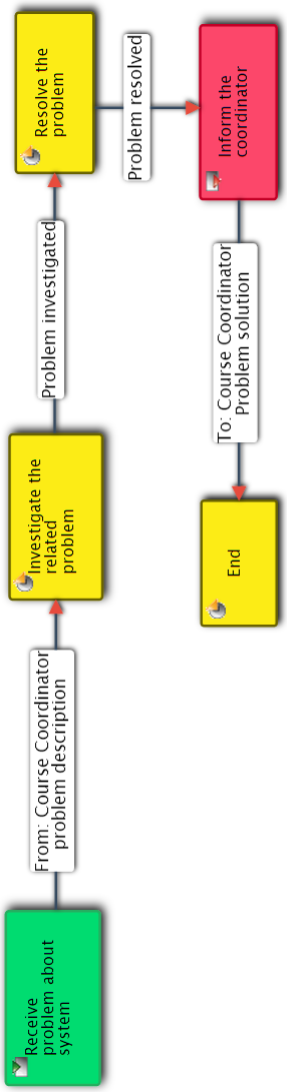

Figure C.1: Role Behavior Diagram of Administrator

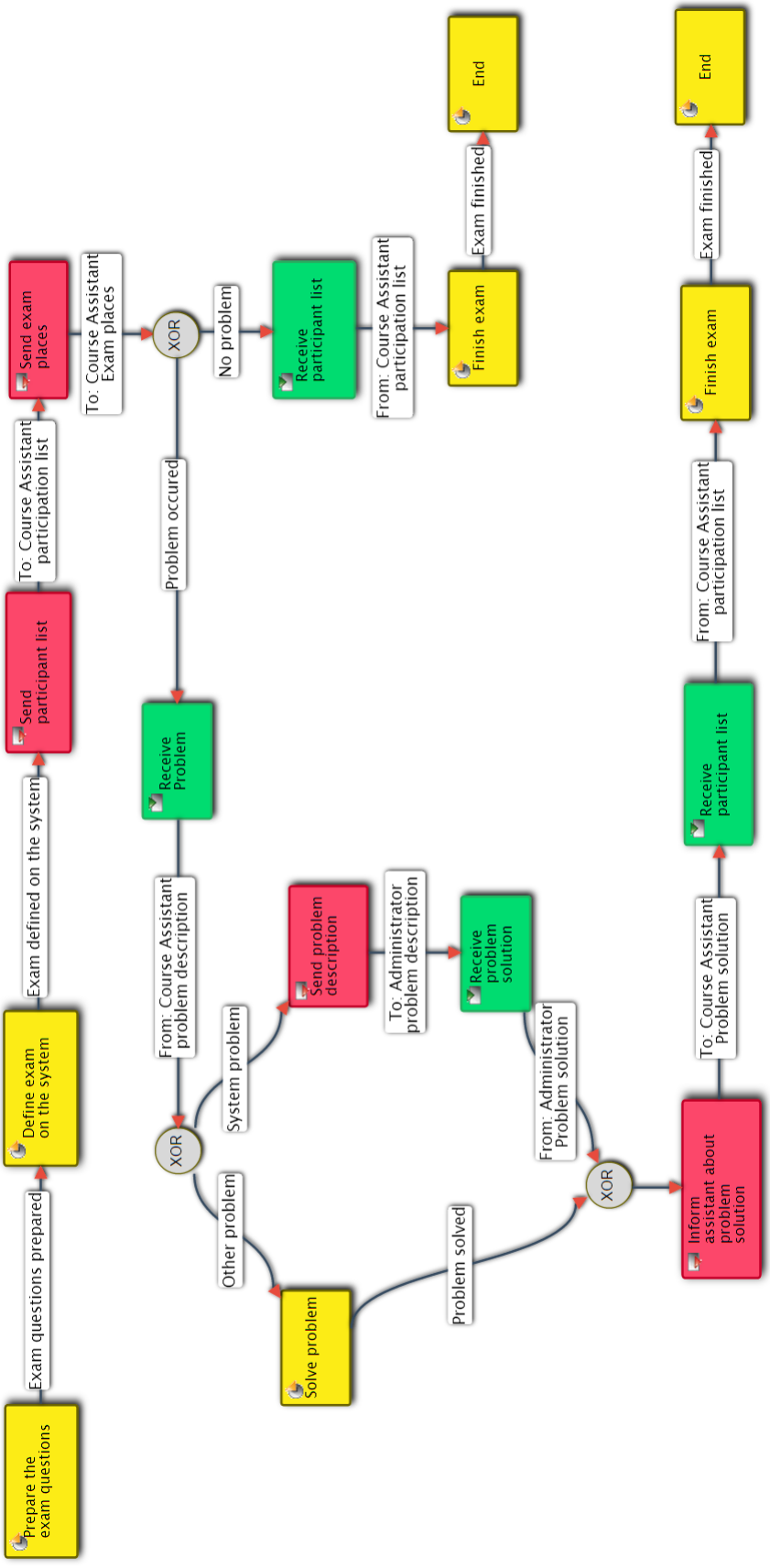

Figure C.2: Role Behavior Diagram of Course Coordinator

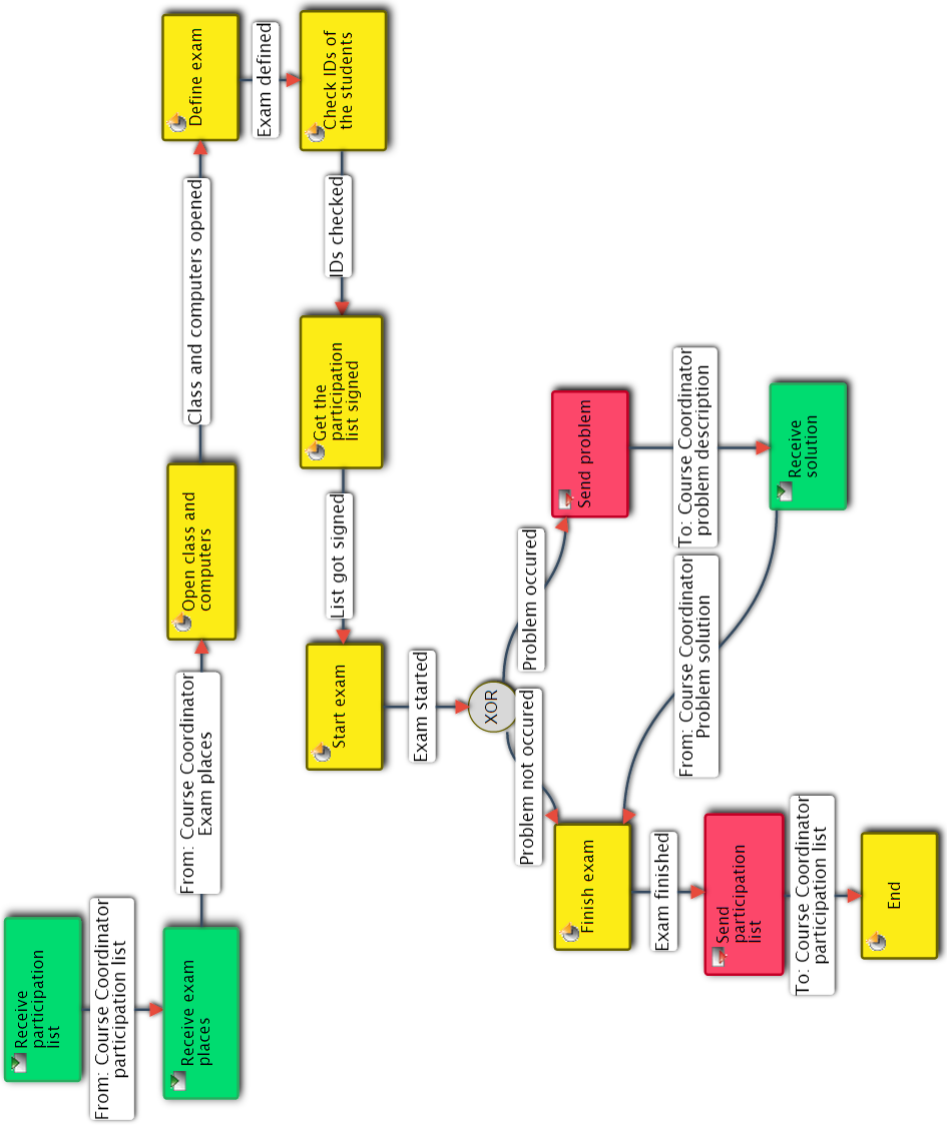

Figure C.3: Role Behavior Diagram of Course Assistant

C.2 Training Process

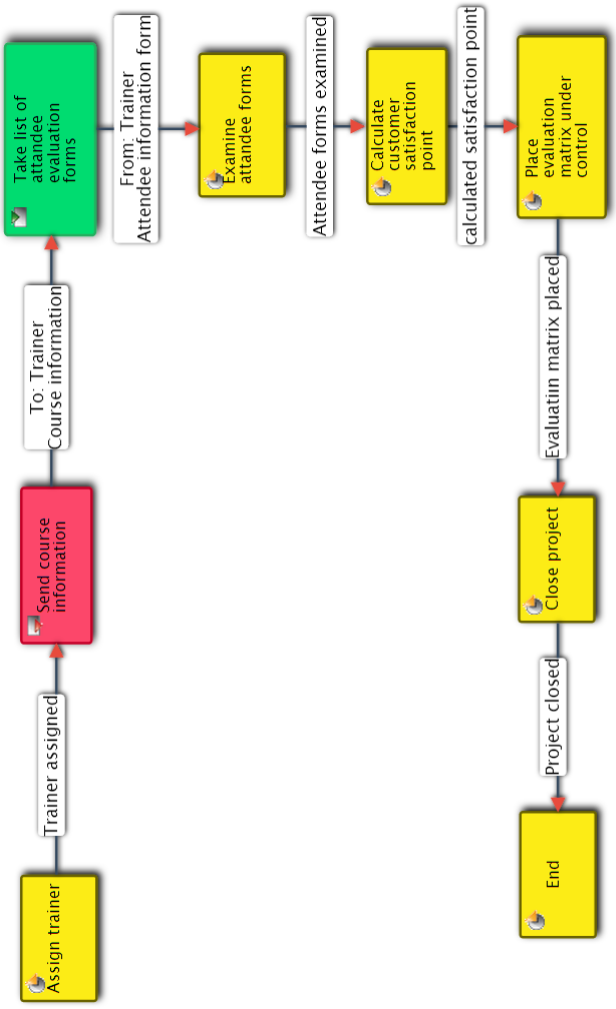

Figure C.4: Role Behavior Diagram of Team Leader

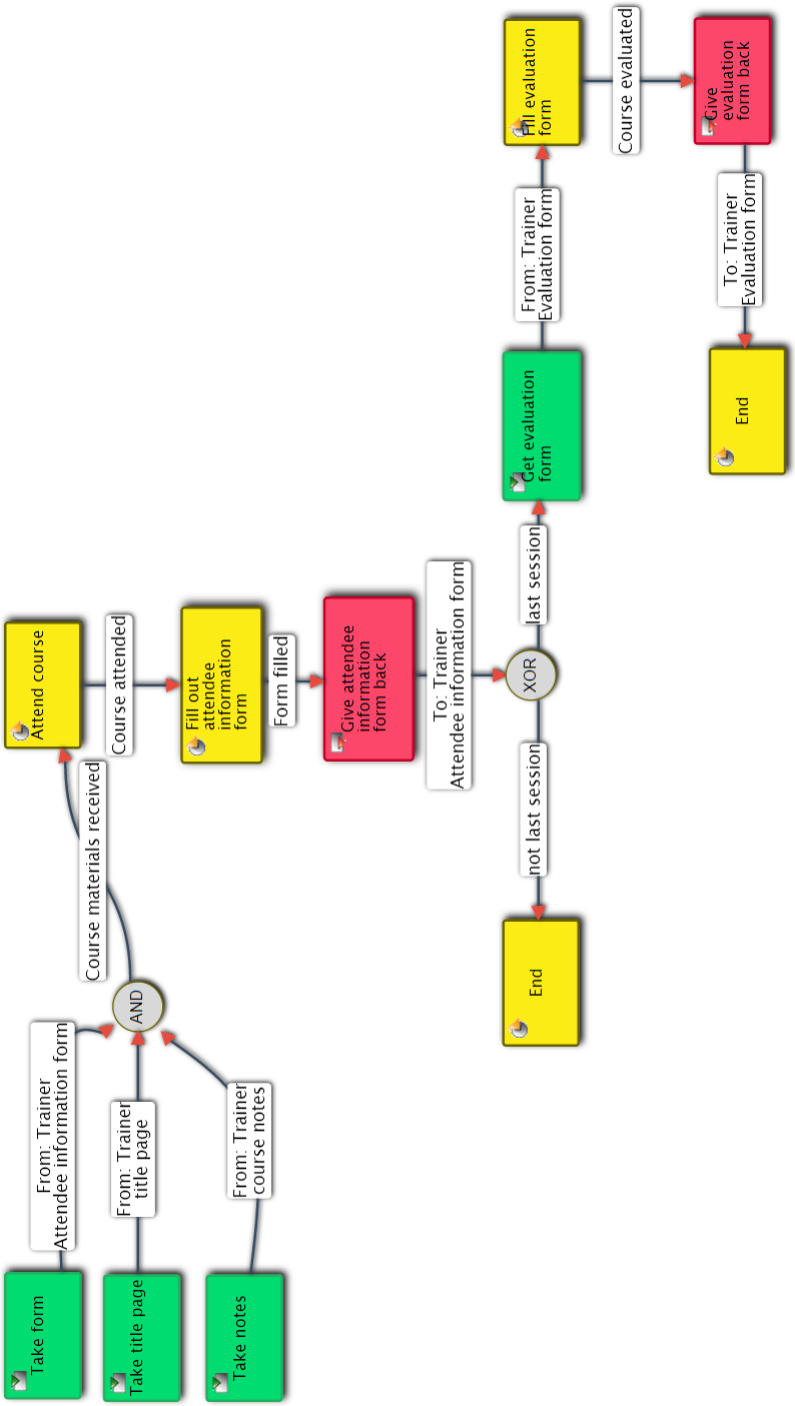

Figure C.5: Role Behavior Diagram of Attendee

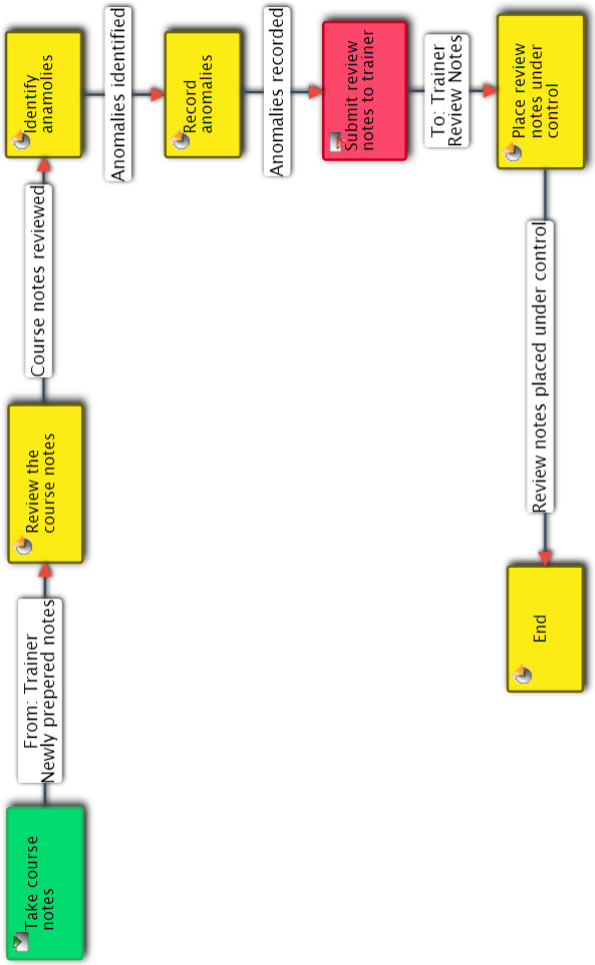

Figure C.6: Role Behavior Diagram of Reviewer

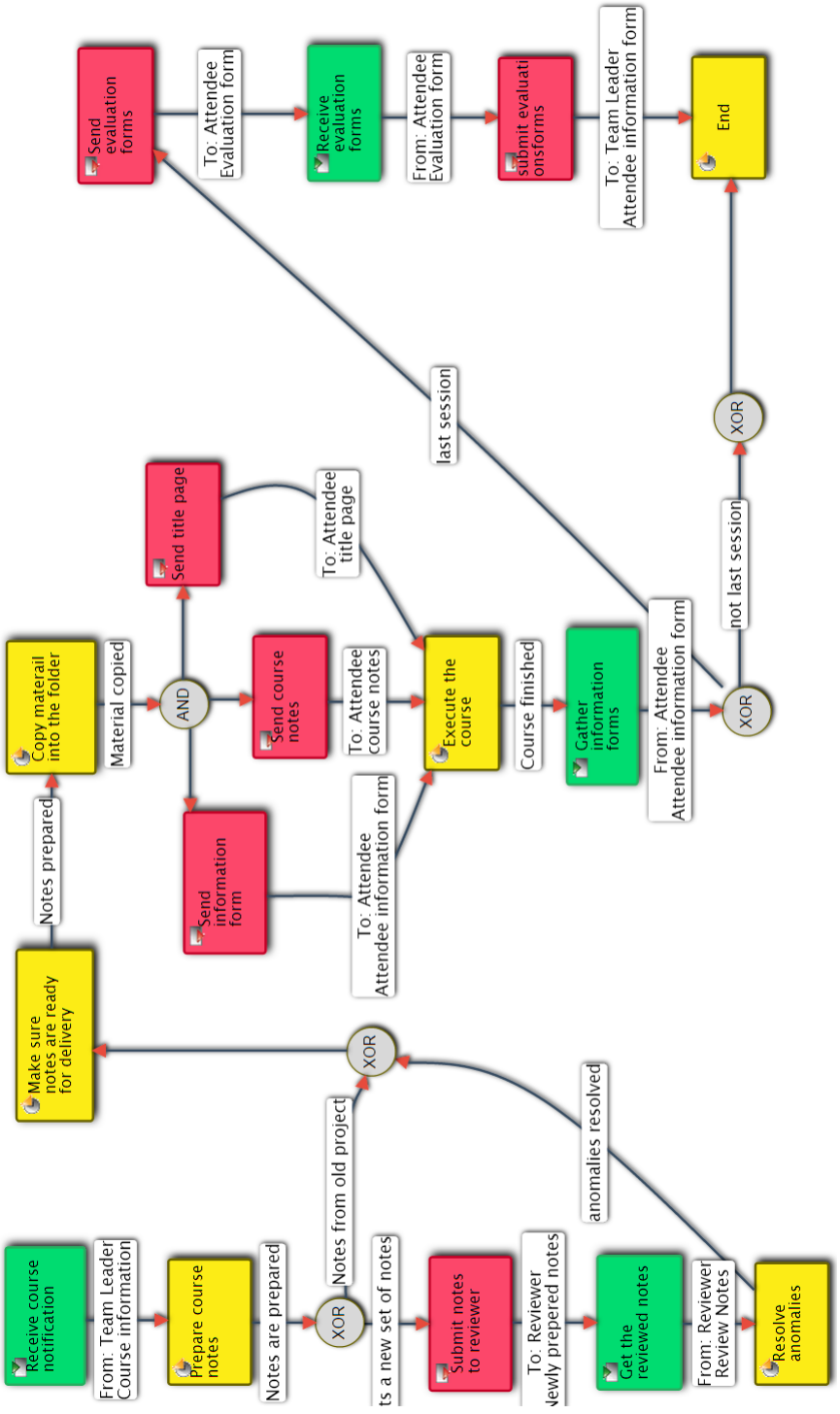

Figure C.7: Role Behavior Diagram of Trainer

APPENDIX D

INTERVIEW QUESTIONS

1. Did you face with any restrictions when you want to use a message which is not previously defined? Why?
2. Did you face with any restrictions while sending a message to or receiving a message from other roles? Why?
3. Is being flexible about defining and transferring messages any time a necessary feature for role-based and decentralized process modeling? Why?
4. Were you able to see the previously defined messages while defining a new message? If so, did this feature help you to avoid defining duplicate messages?
5. When you want to send a message to or receive a message from another role, were you able to see the previously transferred messages from that corresponding role. If so, did this feature help you to avoid conflicts?
6. Were you able to see the inconsistencies anytime related to yourself among the other roles you interacted with? If so, did this feature help you to avoid conflicts?
7. To what extend were you immediately informed about the changes related to yourself?
8. Did the notifications distract your focus during modeling? Why?
9. To what extend were you able to see the details of the changes related to yourself?
10. Would you prefer seeing the details of the changes whenever they occur or whenever you demand? Why?
11. To what extend were you able to see the roles in the process and current interactions among them during modeling?
12. Is viewing the roles in the process and the current interactions among them a necessary feature for decentralized and role-based process modeling? Why?
13. Did you encounter a cognitive overload during modeling which leads to significant latency to finish modeling? Why?
14. Did there appear an excessive amount of conflicts whose resolution would take a time which leads to significant latency during modeling?
15. Did you face with a significant latency to finish modeling, caused by restrictions on creation of your model?

16. What are the drawbacks of ROADMap method?

17. What benefits does the ROADMap method provide other than the given aspects namely flexibility, conflict prevention, information awareness, overall view and latency?

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