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Intention-oriented Organizational Modeling - A Top-down Approach

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Abstract

The involvement of human resources is a necessity in many organizations. In these organizations there are processes that may require decisions taken by human resources. The processes that are accomplished through human knowledge have irregular sequence of execution steps, i.e., series of activities to be carried out are not structured. On the other hand, it is also important to guide such unstructured organizational processes and resources because they work towards the achievement of an organizational intention. Thus, designing models that serves as guide in order to achieve organizational intentions is of prime importance. Intentions play critical role in organizations because they motivate organizational resources to work towards the overall development of organization. Thus, supporting modeling of intentions, strategies to achieve intentions, capabilities required by strategies, resources that provide capabilities and processes that implement strategies everything together in a holistic way is vitally important for any organizational modeling approach.

Though there are several existing modeling approaches they are not suitable when sequence of steps cannot be determined in advance. Hence, there is a need for modeling approach that enables creating models which provides information about what has to be done in order to achieve an intention rather than providing information about how to achieve an intention. Additionally, there is also need for modeling tool that allows creating descriptive models which serves as guide in order to achieve organizational intentions. This master thesis work proposes a modeling approach based on the derived requirements of intention-oriented organizational modeling. The proposed approach allows creating organizational models that acts as descriptive guide to achieve intentions. The approach is realized as a web-based modeling tool through which organizational models can be created.

In this approach, intentions are realized through strategies which are associated with capabilities that are satisfied by resources. As a result, organizational processes are realized as strategies that are associated with capabilities, resources and intentions. A motivating scenario from an organization that belongs to manufacturing sector is provided to help the reader in easily acquiring the concepts of the proposed approach. To assess the feasibility of the proposed approach and usability of the developed modeling tool, we also provide a case study centered around the motivating scenario.

Keywords: Organizational process modeling, descriptive guides, contexts, intentions, strategies, capabilities, resources

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1 Introduction

Resources of an organization play an important role to accomplish organizational intentions. Though processes reuse resources, stored execution procedure of successfully completed processes, etc., certain decisions that involve human knowledge cannot be reused. These type of processes are not structured like traditional processes because the sequence of activities to be carried out in order to execute a process cannot be pre-defined due to its dynamic changing nature, e.g., research and development process.

The processes whose required activities and order of their execution cannot be determined beforehand are called *Informal Processes* [SKL14]. These type of processes are human-centric as their dynamic nature is due to the involvement of human knowledge. These processes are vitally important for production organizations and they need to be supported and automated [Sun15]. This thesis work helps in realizing organizational modeling oriented to intention. The next section provides a detailed motivational statement of this master thesis work followed by a problem statement section which is then followed by contributions of this work. The final section provides an outline about the following chapters of the document.

1.1 Motivation

Nowadays, any task has both well defined predictable processes and less defined ambiguous processes. In tasks with less defined ambiguous processes, knowledge workers' decision plays an important role [BPT09]. For example, research and development projects are of type where *what to do next* cannot be decided in advance. These type of processes are highly unpredictable in nature and this makes it quite challenging to support and automate these type of processes. This work is a part in realizing the automation of such processes as it contributes to informal process modeling. Any approach that supports informal process automation is required to be more autonomous because, the dynamic behavior of processes are enacted by some subjects. Thus, the existing approaches available for traditional processes are not helpful in realizing the execution of informal processes.

Though sequence of steps to be carried out to execute informal processes cannot be determined beforehand, *intentions* of informal processes are known before their enactment [SBLW15]. Achieving these intentions requires another important driving force called *resources*. Resources can be anything from human actors, development environments, materials etc. These resources possess certain *capabilities* to qualify for achieving an intention. So, we need an approach that supports informal processes along with the support of intentions, resources, capabilities etc. This can be achieved by modeling through associated elements, i.e., associating intentions with strategies, strategies with capabilities and capabilities with resources. When the models are designed descriptively, i.e., providing only information what has to be done in order to achieve an intention rather than how to achieve an intention they serve as informal guides which preserve the essential information associated with informal processes to achieve an intention. Meanwhile, it also overcomes the need for pre-defining the sequence of execution steps. The non-existence of business logic facilitates more autonomy for human performers and enables establishment of best practices [SBBL14].

1.2 Problem Statement

Though there are *activity-centric* modeling and reusing of business processes such as Business Process Execution Language (BPEL) ¹ and Business Process Model and Notation (BPMN) ² are available, they are not suitable for certain type of processes whose execution steps cannot be predicted in advance [SBBL14]. This is because of the challenges in determining the sequence of activities before enacting an informal process. Another key thing to remember is, informal processes are dynamic in nature which is one of the important challenges in developing an environment that supports informal process modeling. As mentioned earlier, there is also lack of modeling tool that creates models declaratively by providing only essential information in order to enact a process.

Every organization contains multiple entities like (1) *resources*, e.g., humans, tools etc., (2) *intentions*, e.g., revenue based intentions, quarterly intentions etc., (3) *strategies*, e.g., improved customer help desk, expanding sales, etc., and (4) *capabilities*, e.g., web application developer, sales representatives, etc. Thus, organizations need an approach to model these different organizational elements oriented to intention as intention of an informal process can be known before their enactment.

¹<http://docs.oasis-open.org/wsbpel/2.0/OS/wsbpel-v2.0-OS.pdf>

²<http://www.omg.org/spec/BPMN/2.0/PDF/>

When there are multiple human resources working for a process, then there should be some sort of co-ordination and understanding between the humans which is called *collaboration* at an organizational level. Informal processes are collaborative in nature, which means that participants of informal process collaborate with each other to accomplish its intentions [SBLW15]. Designing these collaborations and assigning participants their respective privileges plays an important role during modeling of the respective informal processes. The research work about designing workspace collaboration tools [MWMY11] mentions that below points are the major problems in adopting to a workspace collaboration tools.

1. Lack of Methods
2. Methods that focus on individuals
3. Not well targeted groups
4. Not well supported editors for executing abstract descriptions

Due to the involvement of multiple resources during modeling, there is a need for organizations to make decision regarding strategy selection based on cost calculation and achieve-ability estimation. Moreover, associating capabilities with resources is helpful in the following example situation. There can be a situation where resources producing more accurate results for processing a task are preferred than resources which can produce higher throughput for processing a task. Thus, we need to associate organizational modeling elements of a process such as intentions, strategies, capabilities and resources with each other and facilitate strategy selection based on cost and achieve-ability estimation.

1.3 Contributions

The contributions of this work can be categorized as follows:

1. Provided a motivating scenario to understand the requirements of intention-oriented organizational modeling (Chapter 3).
2. Derived requirements from existing literatures and motivating scenario for supporting intention-oriented organizational modeling (Chapter 4).
3. Literature review and evaluation of existing approaches based on derived requirements (Chapter 4).
4. Proposed an approach for intention-oriented organizational modeling that satisfies the derived requirements (Chapter 5).

5. Case study on intention-oriented organizational modeling (Chapter 6).

1.4 Outline

The remainder of this document is organized into following chapters:

- Chapter 2 – Fundamentals and Related Work:** In this chapter, fundamental concepts and an overview of the related work that are essential to understand the work are provided.
- Chapter 3 – Motivating Scenario:** In this chapter, a motivating scenario has been taken and detailed explanation for each phases of the scenario has been provided. This aids the reader to understand the concepts of intention-oriented organizational modeling clearly.
- Chapter 4 –Requirements for Supporting Intention-oriented Organizational Modeling:** This chapter provides detailed requirement analysis for supporting intention-oriented organizational modeling. This chapter also provides literature review and evaluation of existing work.
- Chapter 5 – An Approach to Intention-oriented Organizational Modeling:** This chapter discusses about the approach that realizes the requirements of intention-oriented organizational modeling.
- Chapter 6 – Case Study on Intention-oriented Organizational Modeling:** This chapter validates the approach presented in Chapter 5. This chapter also discusses detailed system architecture and also presents the validation of the proposed approach.
- Chapter 7 – Conclusion and Future Work:** This chapter summarizes the results of the work and draws conclusion. This chapter also throws some light on the future work to be extended based on this work.

2 Fundamentals and Related Work

The first three sections of this chapter are the fundamental concepts that are required to understand the approach to be discussed in the Section 5.3 of Chapter 5. The fourth section provides a brief introduction about related work Informal Process Essentials (IPE) approach, as the conceptual model described in the fifth section is adapted from IPE approach. The final section is also a related work because this thesis work is part of the phase P2 of the Executing Informal Processes (InProXec) method which helps to realize IPE approach in organizations.

2.1 Definitions of Terms

In this section, the definitions of terminologies that are used throughout this document are provided briefly.

Business Process - A business process has been defined as set of activities whose final output is accomplishment of a goal [Wes12].

Business Logic - Business logic refers to the activities that need to be done to execute the corresponding business process.

Business Process Model - Business process model is a model to capture recurring activities during business process execution and enact them in an automated fashion for re-using the stored knowledge.

Informal Process Essentials - Informal Process Essentials (IPE) is a resource-driven approach that enables describing process declaratively, i.e., without describing how the intention is achieved and providing only information about what has to be achieved [SBBL14].

OASIS Topology and Orchestration Specification for Cloud Applications (TOSCA) - TOSCA is a new OASIS (Organization for the Advancement of Structured Information Standards) standard to describe composite applications and their management [KBBL13].

Winery - Winery is a modeling tool offering an HTML5-based environment for graph-based modeling of application topologies and defining reusable component and their

relationship types. It uses TOSCA as an internal storage, import, and export format [KBBL13].

2.2 Human-centric Process

The role of humans in organizations has been evolving over time. The shift from "personnel" to "human resources" acknowledges the importance of humans as organizational resources. There is an incredible number of pressure on today's organizations [May16] due to dynamic nature of organizations. For example, organizational changes like addition of new organizational alliances, new structures and hierarchies, new ways of assigning work and a very high rate of changes like changes in the workforce, including employees' priorities, capabilities and demographic characteristics. Thus, it is impossible to do one hundred percent perfect forecasting of dynamically changing processes in an organization.





In order to manage such a dynamic environment, organizations need skilled human resources with previous knowledge of handling unforeseen scenarios. Thus, human resources are vital part of any organizations as they have skills of acute future orientation to understand changing organizational environment. Humans in organizations carry out many important activities. Managers and Human Resource (HR) professionals organize jobs of each and every human in the organization so that they can effectively perform these jobs. Thus, humans in any organization are viewed as resources of the organization which is a contemporary part of Human Resource Management [Bia16].

Collaboration exists in every levels of an organization. For example, at management levels of an organization, managers and HR professionals work together to assign employees their roles and task in the organization. This helps the employees of the organization to adapt to its environment. In a flexible organization, employees' roles and responsibilities changes dynamically based on the requirements and business priorities. Thus, the need for network of representations between the human resources is arising. This network of representation sets up an environment to support collaborative work of business related process. This kind of support to represent human resource network has been realized in the work by author Canko [Can15]. The concept of *virtual human representation* described by author is an extension of actor-concept described in *Informal Process Essentials* [SBBL14]. The prototype *Human Resource Representation* developed in a work [Can15] saves the information such as capabilities, roles, responsibilities, etc., as a virtual human web ontology instance which can be re-used in web-based environments. These kind of human representation are highly helpful to organizations with dynamically changing resources. These representations can describe and match resources with their capabilities based on the requirements.

2.3 Organizational Modeling Notations

The organizational modeling element notation has been selected based on the guidelines mentioned in the literature [Moo09] and these notations are adopted from another thesis work [Sie15]. Though these notations modeling are not part of this master thesis, this is provided in this section for the sole purpose of aiding the reader to understand the concepts better through pictorial representations. Also, by observing the fact that business process modelers are already well-known with the present process modeling notations such as Business Process Modeling Notation 2.0 (BPMN) [Gro11] and ArchiMate notation[Gro13], the shape depiction of organizational model elements has been designed similar to those existing process notations.

Due to the importance of shapes in expressing information visually, the notations are chosen in such a way that each element of organizational notations differ by shape. A legend holding respective name of each notation is shown in the following images to denote the meaning of each shape. The description of each element in the organizational model notation is shown in the Table 2.1.

Element	Definition	Notation
Intention	Intention is a purposeful concrete step taken by organizations or individuals to achieve an expected outcome.	
Capability	Capability is an ability that should be possessed by a resource that work towards achievement of one or several intentions.	
Context	The environment that forms the setting for an event, statement, or idea and in terms of which it can be fully understood. There are two Contexts: initial and final. Initial context is the situation which describes the driving forces that trigger the process to start. Final context is the expected situation once the process has finished. Both initial and final context are represented by an hexagonal shape except the final context has thick edges than initial context.	
Strategy	A method or plan chosen to bring about a desired future, such as accomplishment of an intention.	



Resource	The people or tools those/that needed to fulfill the middle objectives or work towards the achievement of an intention.	
Relationship	Relationship between two elements is used to specify how the source and target element is related.	

Table 2.1: Organizational Modeling Notations

2.4 Overview of Informal Process Essentials

In this section, we provide an overview about the concepts introduced in the approach Informal Process Essentials (IPE) [SBBL14]. As mentioned earlier, the modeling elements of the proposed approach in the following Chapter 5 is adapted from IPE approach. Hence IPE approach serves as an important related work required to understand the proposed approach and conceptual model discussed in this document.

The execution steps of an informal process are recorded as models. These models can be represented as graphs, state machine diagrams, linguistic descriptions, etc. Models are used in various fields like manufacturing, scientific, IT, etc. These models are mainly useful in re-using the predefined solutions. Such models have numerous benefits [IGRR09] like process performance improvement, understanding of the process, model-driven process execution, etc. The performance of informal processes depend on dynamic nature of human knowledge, i.e., they are subject to change and carried out based on experience of previous knowledge.

The authors describe following as the properties of an informal process (1) business logic of informal processes is not defined explicitly before the enactment, (2) informal processes are collaborative in nature which requires resources with interrelationships (3) a resource can participate in multiple informal processes and (4) resources can change dynamically.

The authors also provide following requirements that support informal processes with the above described properties. The summarized requirements are (1) ability to represent informal process as models and ability to execute it, (2) due to involvement of multiple resources, ability to define relationships among the resources, (3) resources should be visible in process representations and (4) support for dynamically changing resources.

The authors also compare existing approaches in the literature with the above requirements. It has also been concluded that analyzed approaches only satisfies some of the requirements but not all the requirements completely. So the authors propose a new *meta-model* approach that satisfies all the requirements. In this IPE meta-model approach, resources are related to each other and work towards achievement of an intention, i.e., a goal.

As mentioned in Section 2.1, resources are drivers to achieve intentions in the informal processes. In the IPE approach, author states that when the desired process result is repeated the same set of resources can be selected and engaged towards collective intention of that process. It has been mentioned in the IPE approach that Informal Process Essentials (IPE) meta-model describes the following about informal process: (1) describes the constituents informal process such as performers, data and software tools and (2) describes how to make core element ready for the enactment of the informal process. IPE models begin from initial context and after achieving the main intention it results in another context. The relationship between IPE approach and conceptual model of intention-oriented organizational modeling is explained in the next section.

2.5 Intention-oriented Organizational Modeling - Conceptual Model

The conceptual model of organizational modeling elements used in intention-oriented organizational modeling is shown in the Figure 2.1. This conceptual model shows that intention contains multiple strategies. An intention can be achieved through a strategy, which is a plan of action designed to meet the intention. Strategies require capabilities and contain IPE process to realize strategies. The capabilities can be further resolved into resources. Thus starting from defining intentions, we define strategies then required capabilities and IPE models. The capabilities and process models define the required resources.

Organizational process modeling of this approach is an *intention-oriented* as they support modeling based on intention and required resources thrive to successfully achieve organizational intention by using qualified autonomous agents, i.e., actors under certain *context definitions*. As we mentioned before, in our context resources can be anything like people, IT tools, data that are used to accomplish the objectives, etc. Emerging intentions can result in the requirement of new capabilities, i.e., an ability required to achieve an intention. Resource models are also provided in the developed prototype to make precise definition of resources needed.



Figure 2.1: Intention-oriented Organizational Modeling - Conceptual Model

The concept of *Informal Process Support Model* (IPSM) [SBBL14] has been introduced to make use existing knowledge of human performers. In this approach, the initial creator of a model is experienced human performers such as business experts. Based on their experience, they add relevant resources of an informal process. The models are generated at runtime based on the interactions and activities of corresponding human performers. An informal process targets for accomplishment of an intention. The intention can be refined by defining strategies, which can then be further refined recursively as independent informal processes. The intention-based approach enables describing processes declaratively, i.e., without describing *how* the intention is achieved, and providing only information about *what* is achieved. The IPE approach [SBBL14] suggests that this avoids need of predefined business logic in the representations of informal processes. Each resource can be related to another resource in the context of an informal process using predefined or custom *relationships*. Since IPE realizes strategy, each informal process starts from a context, i.e., *initial context* and aims to achieve an intention. After accomplishing the intention, there is a resulting context called as *final context*. The beginning state before achieving intention is called as initial context and the end state after achieving intention is called as final context.

2.6 Executing Informal Processes

In this section, we present an overview about the *Executing Informal Processes* (InProXec) method [SBLW15]. Implementing IPE approach in organization requires the application of InProXec with different phases. The InProXec method enables modeling of informal processes and automated provisioning of resources modeled in these processes. Since



Figure 2.2: Steps of the InProXec approach

this thesis work is realizing intention-oriented modeling of organizations, this thesis work covers second phase of InProXec which is *Model Informal Process* (P2). The method described in Figure 2.2, initializes informal process models in an automated fashion. The author also proves feasibility of the InProXec method with a suitable case study. In the following paragraphs, a short overview about different phases of the InProXec method has been provided and with a detailed description about the second phase of the *InProXec* method is provided in the Section 5.2 of Chapter 5.

As shown in the Figure 2.2 adapted from the InProXec approach, the InProcXec method consists of three different phases:

Integrate Resources of Informal Processes (P1) - The first phase aims for creating the required infrastructure to enable modeling and automated initialization of informal processes. This is because the required modeling tools of informal processes modeling has to be presented to business experts, as they require it for next phase P2. So, the required resource definitions for informal process modeling are allocated by *execution environment integrators* developed by technical experts during this phase. The final output of this phase is *resources definitions* are used by phase P2.

Model Informal Processes (P2) - This phase makes use of resource definitions made available in the first phase P1. Based on this resource definitions, business experts can create informal process models. This phase has been explained in detail in the following Section 5.2 of Chapter 5

Execute Informal Processes (P3) - Initialization of models developed in phase P2 happens automatically using execution environment integrators developed in phase P1. When an IPE Model is compiled and engaged with resources, it results in successful initialization. This successful initialization results in an IPE Model Instance. A model instance contains additional meta-data about executed processes such as the information about start time, history of the resource model, time of changes made, etc. In phase P2, the functionality to instantiate acquirable entities are not included. Thus, in third phase P3 the informal process models of phase P2 is taken and transformed into initialize-able self-contained *Deployable Informal Process Essentials Archives(DIPEA)* [SBLW15] takes place. This results in DIPEAs enacting required informal process. To realize, phase P3 an *IPE Model Compiler* also been introduced in the approach. Additionally, this phase also employs *IPE Runtime* which parses DIPEAs and runs the executables contained in those archives. During this phase, the autonomous actors work towards intentions of informal processes using acquired resources and other involved resources.

3 Motivating Scenario

In order to help in understanding the concepts of organizational modeling, a motivating scenario has been taken and explained through the modeling notations mentioned in the Section 2.3 of Chapter 2. This scenario also helps in validating the developed web-based modeling tool in the Section 6.4 of Chapter 6. The motivating scenario has been chosen based on the collected real life scenarios provided in another thesis work [Sie15]. The motivating scenario is taken from the context of manufacturing sector.

In this chapter, the first section provides a brief introduction about the motivating scenario. The last section provides an explanation about the organizational modeling elements discussed in motivating scenario.

3.1 Intention-oriented Organizational Modeling Example

The concept of intention oriented organizational modeling can be explained with the following scenario taken from a manufacturing organization. Consider a budding manufacturing company which designs, develops, manufactures and sells personal computers, tablets and laptops. The CEO's main intention of the quarter is *to increase the revenue and number of unit sales*. The initial context describes the situation before starting the execution of intention. The initial context also provides statement that motivates to start the process. The final context describes the situation that is achieved once the intention executed successfully. Intentions connect initial context definitions with final context definitions [SBBL14]. There are also low level intentions other than the main intention which helps in achieving main intention as a collection of several intentions in a measurable form.

The Figure 3.1 provides the details of organizational intentions, strategies, capabilities and resources. There can be multiple strategies followed to achieve a main intention. The main intention in the motivating scenario can be achieved by following all of the below mentioned strategies which requires resources with matching capabilities and achievable low level intentions associated with these strategies.

1. Through increasing the revenue by expanding market sales.

3 Motivating Scenario



Figure 3.1: Motivating Scenario

2. Through increasing advertisements which helps customer to know about the product.
3. Through improving the existing customer help desk portal, as it helps to maintain good customer relationship.

3.2 Intention-oriented Organizational Modeling Elements

It is important to explain each of the organizational modeling element using an example as it helps in understanding the requirements of intention-oriented organizational modeling discussed in the Section 4.1 of following Chapter 4. Before we proceed with detailed description of each modeling elements we provide an example scenario to know the dynamic nature of organizational modeling. For example, in our above mentioned motivating scenario in the Section 3.1 one of the intention is to *expand sales geographically*. Before executing this intention, few ground works like collection of laptop usage statistics such as average buying capacity of the consumers, average computer knowledge of the people in new geographic location has to be done. Thus the execution

of main intention i.e *increase revenue and number of unit sales*, requires collaboration of people with different skills and expertise. For example, resources with skills to collect and study statistics are required. If in case none of the organizational resources provide required capability then the organization can get it served from external resources or further modularize the intention so that it can be provided by internal resources itself. This makes to emerge new intentions dynamically. The team working towards achievement of main intention should also be ready to accommodate new resources with new capabilities and skills. For example, there is a software development team, which work towards achievement of the intention *improve customer help desk portal*, i.e., this team develops software that automatically attends and records user queries. Suppose, if there arise a new requirement of *supporting help desk through mobile applications* then the system should accommodate new resource with *mobile application developer* capability.

3.2.1 Contexts

The execution of manufacturing processes such as the one provided in Figure 3.1 are not similar to execution of typical business processes. This is because, the execution of manufacturing processes mostly depends on the information collected from the real world, i.e., the execution context [SBLW16]. A context definition provides mechanism to act adaptively based on the current situation. This is achieved in the production environment by describing each process with a specific context definition [SBLW16]. For example, in our motivating scenario the initial context provides details about status before achievement of the main intention i.e it specifies the situation of the organization which triggers the execution of main-intention. The initial context *quarterly goal of increasing the revenue and number of unit sales*, helps to decide the main intention and its related low level associates. On successful achievement of main-intention the organization reaches it desired final context of *increased revenue and number of unit sales*. Along with successful reaching of the final context, this also provides tools such as web-based help desk portals, automated ad software etc., that are developed as part of this execution. When the final context definition has been reached the process completion starts. This process final state can be stored [Sun15] and same set of resources can be re-used in future executions with similar contexts and intentions.

3.2.2 Intentions

Intentions are defined hierarchically, in our approach intentions are located in top level of the hierarchy, which are refined until concrete lower level of the hierarchy is reached.

In this thesis context, intentions are not associated with capabilities directly, instead intentions are associated with strategies which are then associated with capabilities. For example, in our motivating scenario the main intention is to increase revenue and number of unit sales which also has other low level intentions such as *improving the customer help desk portal* and strategies such as (1) through expanding sales and (2) through advertisements. The relation between strategies and intentions are denoted by the term *contains* in Figure 3.1 as strategies are methods through which intentions can be achieved. There can be situation where an intention can be related to another intention. For example, consider a situation in our motivating scenario where customer help desk team not willing to give up the systems they are working for a long time even if it is a better solution for organization as a whole. For example, a real life scenario has been provided in the thesis work [Sie15] and also it has been suggested that such intentions are called contradicting intentions and it has to be handled in some way by the modeling approach.

3.2.3 Strategies

Strategies are used to identify the most appropriate method of utilizing capabilities through which an intention can be achieved. Strategies are associated with both intentions and capabilities. Each strategy needs certain capabilities to successfully execute an intention. So we need to associate strategy with a capability that has matching resource. Resources are the potential holder of the capability, i.e., to satisfy a capability we need resources. Capability and its associated resources are also shown in the Figure 3.1. In our motivating scenario, the main intention can be achieved through two strategies *through expansion* and *through advertisements*. These two strategy further contains intentions such as *expand geographically*, *expand based on target customers* and *implement an automated ad software*. Since strategies contain intentions they are related through the term *contains* in the Figure 3.1. As mentioned earlier, informal process models are realized through strategies. This is achieved through strategy containing capabilities and resources. For example, consider a small part in our motivating scenario of achieving an intention expand geographically through strategy product distribution. To achieve this intention through a specified strategy we need resources with product distribution capability. This results in informal process as a strategy that has capabilities, resources that are created out of capabilities and an intention of that contains specific strategy.

3.2.4 Capabilities

Resources tend to possess certain capabilities that allow them to do something that they want or need to do something. Each organizational capability must be provided by a resource in the organization. In our context, capabilities that are associated with resources are called as *functional capabilities*. The type of capability that contains functional capabilities are called as *cross functional capabilities*. Strategies are associated with cross functional capabilities, which contains functional capabilities out of which resources are created. In our motivating scenario to achieve a main intention, we need several capabilities such as product distribution capability, graphics designer capability etc. Thus, in the Figure 3.1, strategies and associated capabilities are related through the term *requires*.

3.2.5 Resources

Resources of an organization can be anything that satisfies required capability to achieve an intention. Each resource has different types of relationship with other resources based on how they communicate with other resources [SBLW15]. For example, in our motivating scenario described in Section 3.1 has an intention to *improve customer help desk portal*. This intention can be achieved by providing skills improvement training to the existing employees or by recruiting newly skilled employee. Here the manager has permissions to decide whether to improve skills of existing employee or recruit new employee. But the team lead has only restricted permission like what type of skills are required for the project and also decision of team lead depends on decision of manager. Thus, manager and team lead are related in this simple example.

4 Requirements for Supporting Intention-oriented Organizational Modeling

This chapter positions the thesis work in the field of process modeling with respect to the other existing approaches. The first section provides detailed requirement analysis of intention-oriented organizational modeling. The last section provides a detailed literature review about the existing approaches. A detailed evaluation of the existing approaches with the proposed requirements is also provided in the last section.

4.1 Requirement Analysis of Intention-oriented Organizational Modeling

The requirements of intention-oriented organizational modeling has been derived from existing literatures [MHL+07; MBH+10; BCV06; Lac16; BFV12] and from the motivating scenario described in Chapter 3.

4.1.1 Organizational Intention Transparency (R1)

An intention can be broken down into definitive actionable components upon which individual resources can act. When these lower level intentions are made achievable for individual resources, they can be combined to provide successful execution of higher level intention, i.e., main intention. This requires privilege for different organizational members to observe lower level and higher level intentions. Additionally, intentions should also be traceable from different levels of the organizational hierarchy. This means that the status of each intention can be accessed by members in different levels of the organizations. This level of transparency within an organization reduces inefficiencies during intention execution, and is a key factor in attracting and retaining high performers in the labor market [MHL+07]. Requirement R1 has to be satisfied in the modeling

phase itself as the designing of intentions, strategies and their recursive structures are done during the modeling phase. The main pre-requisites for this requirement to be satisfied are, intentions can be refinable and organizational members can view intentions at different levels.

4.1.2 Organizational Strategy-based Cost Estimation (R2)

Linking strategies with capabilities that has matching resource enable us a cost estimation for each strategy. This is because strategies are associated with organizational capabilities which in turn are associated with organizational resources. To incorporate the cost estimation of strategies, we have to understand the recursive structure of the strategies associated with process definitions and then with the resource definitions. Further on, the cost of a strategy can be analyzed using the costs of derived process definitions and then with resource definitions. Including resources cost in strategy cost calculation is important. This is achieved by associating resource models' cost with process models' cost. The recursion is stopped when each resource definition is associated with cost. At the moment an intention is achieved, some resources should be allocated through strategy to maintain the desired state [MBH+10] and this helps business experts in making resource selection based on strategy cost during modeling itself. For example, if resource is associated with a certain cost then this cost is considered for strategy implementations cost calculation based on which cost to achieve an intention through a strategy is calculated. Since intentions are achieved through strategy we should also be able to calculate cost of intention based on cost of its strategies. Allocation of resources is mainly done at the operational level, hence requirement R2 has to be satisfied during the modeling phase. The pre-requisites to satisfy this requirement are resources associated with cost and strategy cost estimation that includes all recursive structure.

4.1.3 Organizational Strategy Achieve-ability Estimation (R3)

The validity of an organizational strategy is assured when the strategy is associated with valid capabilities. A capability can be considered as a valid capability when it has matching resource. A valid strategy can be implemented as independent informal process. Lower-level entities can be used to estimate higher-level entities' achieve-ability, thus enabling validation of strategic alignment of strategies' recursive structure [BCV06]. Requirement R3 can be done during the modeling phase of the process as strategy achieve-ability estimations are done before starting the execution of the process. For a strategy to be achieve-able the required pre-requisites are, strategy should be associated with valid capability that is associated with matching resources and strategy can be implemented as independent informal process.

4.1.4 Intention Oriented Working Style (R4)

As each member of the organization is aware of the higher level and lower level intentions, member can engage for explicit intentions. Intention orientation is the degree to which a person or an organization focuses on tasks and its end results. Strong intention orientation advocates that focus on a task is more. Such a focused task ends in a result that is favorable to both employees and organization. Those with strong intention orientation will be able to accurately judge the effects of reaching the intention as well as the ability to fulfill that particular intention with current resources and skills [Lac16]. Hence we associate processes implicitly with intentions through strategies which enables people to work towards certain intentions. The distinction between explicit knowledge of each low level intention should not be seen as a division but rather as a continuum which aligns towards achieving the higher level intention. Though requirement R4 seems to be part of requirement R1, R4 happens during modeling phase and could also happen during execution phase due to the dynamic nature of informal process. The pre-requisites for this requirement are satisfaction of R1 and organizational members requiring understanding of the intentions and how they can be reached.

4.1.5 Participative Organizational Modeling (R5)

Different members of an organization participate to create organizational intentions, as a result organizational models are shaped based on input provided by different members of the organization but directed by the executives. The social involvement of different members in a business process model can be regarded as a process optimization phase, where the organization seeks efficiency by extending the reach of a business process to a broader class of people [BFV12]. Since the requirement itself is about developing models based on input from different organizational members, the requirement has to be satisfied during modeling phase. The pre-requisites to satisfy this requirement are satisfaction of R1 and intention-oriented organizational modeling has to be done based on input provided by different members of the organization.

The requirement satisfaction phases and pre-requisites to satisfy each requirement are provided in the Table 4.1

4.2 Literature Review and Evaluation of Related Work

In the literature, several work has been done in order to support and automate the business processes such as strategy-driven [BJN+05], activity-centric[YMMS09], activity-

Requirement	Requirement Satisfaction Phases	Pre-requisites
R1	Modeling phase	(1) Main intention can be refinable, (2) Organizational members can view the intentions at different levels.
R2	Modeling phase	(1) Resources associated with cost, (2) Strategy cost estimation that includes all recursive structure.
R3	Modeling phase	(1) A valid capability which has matching resource, (2) Strategies can be implemented as independent informal process.
R4	Modeling and Execution phases	(1) Satisfaction of R1, (2) Organizational members require understanding of the intentions and how they can be reached.
R5	Modeling phase	(1) Satisfaction of R1, (2) Intentions has to be modeled based on the input provided by different members of the organization.

Table 4.1: Requirements Analysis

oriented [LR00], artifact-centric [CH09], capability-driven [SGHZ12] and ArchiMate [Gro12]. A detailed description about these approaches and their level of satisfying the requirements mentioned in Section 4.1 has also been provided.

4.2.1 Strategy-driven

Strategy driven approach is decision oriented modeling approach that focus on goals of the processes and refine goals until the operational level. This approach defines business process in terms of goals and strategies in order to achieve the goals. It also uses map representation system that contains goals and strategies. In this approach, goals are refinable but details regarding visibility of goals has not been addressed. Thus requirement R1 is partially satisfied as the approach satisfies one of the pre-requisites. The details about cost of strategy and resource is not addressed. Hence requirement R2 is not satisfied. The requirement R3 contradicts with the process rule of this approach which states that "There is no goal/strategy in the map that can be considered as the subset of another one". So achieve-ability estimation of a strategy based on its association with valid capability and recursive structures cannot be determined in this approach.

Requirement R4 is partially satisfied, as it satisfies R1 partially and this approach also requires understanding of goals by the organizational members. The requirement R5 is partially satisfied, as the approach partially satisfies requirement R1. But another pre-requisite, i.e., intentions has to be modeled based on the inputs provided by different members of the organization to satisfy R5 is not addressed by the approach.

4.2.2 Activity-oriented

Traditional work-flows are based on activity-oriented process models and executed based on these models. Requirements R1, R4 and R5 are not satisfied as details of modeling based on intentions are not provided because the approach itself is activity-oriented. Though the details about cost calculation is addressed but cost calculation associated with strategies is not addressed. Hence, requirement R2 is partially satisfied as cost calculation based on resources is possible. Though this approach does not support sub-processes directly, it provides support for plugging in sub process extensions which can be executed as independent process. But both the pre-requisites of R3 are not met by this approach. Since none of the pre-requisites of requirement R3 is met, the requirement R3 is not satisfied by the approach.

4.2.3 Activity-centric

The activity-centric approach also supports knowledge workers by providing shared activity constructs (i.e., activity-oriented constructs) as a computational unit for organizing the work. Though this approach provides team level view of past and ongoing work by supporting propagation of completed activities to the existing activities, the approach is not intention-oriented. Thus, requirements R1, R4 and R5 are not met as the approach itself is activity-centric. The information about cost of achieving a strategy is not mentioned. Thus, requirement R2 is not satisfied. The approach also does not provide any information regarding association of strategies with valid capability. Thus, requirement R3 is also not satisfied.

4.2.4 Artifact-centric

Artifact-centric is a data-centric approach to model business processes based on business relevant data. The artifact-centric approach combines business data (artifacts) and business process in a holistic way. Requirements R1, R4 and R5 are not satisfied as details of intentions and modeling based on intentions are not provided as the approach

itself is artifact-centric. The requirement R2 which is about cost calculation is also not addressed. Though the approach allows modularity of business operations at various levels, it is not associated with strategies. Hence requirement R3 is also not satisfied.

4.2.5 Capability-driven

The capability driven approach also proposes to support the changing environment of organizations. This approach aims to aid development of business models by connecting goals and capabilities. Though goals are refinable in this approach, there is no information about the visibility of goals. Hence requirement R1 is partially met. This approach claims that, it overcomes the challenge of high cost in developing applications but there is no clear details about how cost calculation is done, hence requirement R2 is not addressed. It does not provide any information about strategy associated with valid capability. Hence, requirement R3 is also not addressed. The first pre-requisite for requirement R4 is partially satisfied and second pre-requisite is also satisfied by the approach. Thus, requirement R4 is partially satisfied. The first pre-requisite for requirement R5 is partially satisfied and second pre-requisite is not addressed by the approach. Thus, requirement R5 is also partially satisfied.

4.2.6 ArchiMate

ArchiMate provides an integrated modeling approach by allowing to model based on both activities, i.e., business process and business functions such as knowledge, resources, etc. ArchiMate allows modeling based on goals and provides visibility of whole process, supports viewpoints in different levels of modeling. Thus, requirement R1 is addressed. ArchiMate does cost calculation based on goals and resources. Thus, requirement R2 is partially satisfied as details regarding the cost calculation of strategies and its recursive structure not provided. The pre-requisites to satisfy requirement R3 are not addressed. Thus, requirement R3 is not addressed. Requirement R4 is satisfied because both the first and second pre-requisites are satisfied. Similarly, requirement R5 is also satisfied because the approach satisfies first and second pre-requisites.

4.2.7 Summary of the Evaluation

The Table 4.2, shows the evaluation of related works based on the derived requirements. From the table one could comprehend that none of the evaluated approaches satisfy all the requirements together. Thus, we propose a new intention-oriented organizational

Approach	R1	R2	R3	R4	R5
Strategy-driven	(1)+Refinable, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)~R1 partially satisfied, (2)+Addressed	(1)~R1 partially satisfied, (2)-Not addressed
Activity-oriented	(1)-Activity-oriented, (2)-Activity-oriented	(1)+Addressed, (2)- Not addressed	(1)-Not addressed, (2)-Not addressed	(1)-Activity-oriented, (2)-Activity-oriented	(1)-Activity-oriented, (2)-Activity-oriented
Activity-centric	(1)-Activity-centric, (2)-Activity-centric	(1)-Not addressed, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)-Activity-centric, (2)-Activity-centric	(1)-Activity-centric, (2)-Activity-centric
Artifact-centric	(1)-Artifact-centric, (2)-Artifact-centric	(1)-Not addressed, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)-Artifact-centric, (2)-Artifact-centric	(1)-Artifact-centric, (2)-Artifact-centric
Capability-driven	(1)+Refinable, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)~R1 partially satisfied, (2)+Addressed	(1)~R1 partially satisfied, (2)-Not addressed
ArchiMate	(1)~Addressed, (2)- Not addressed	(1)+Addressed, (2)-Not addressed	(1)-Not addressed, (2)-Not addressed	(1)+R1 satisfied, (2)+Addressed	(1)+R1 satisfied, (2)+Addressed

Table 4.2: Summary of the Evaluation

modeling approach in the Section 5.3 of Chapter 5 that satisfies all of the derived requirements of intention-oriented organizational modeling.

5 An Approach to Intention-oriented Organizational Modeling

This chapter describes in detail about the technical approach that has been taken to solve the problem mentioned in the Section 1.2 of Chapter 1 and to satisfy all of the requirements mentioned in the Section 4.1 of Chapter 4. The first section of this chapter provides an overview of the intention-oriented organizational modeling process. The second section discusses in detail second phase (P2) of the InProXec method, i.e., Model Informal Processes. The third section discusses in detail about the *top-down approach*, which helps to realize the intention-oriented organizational modeling. The fourth section discusses the design methodology followed to realize this approach as a web-based modeling tool.

5.1 Overview of the Modeling Process

The main focus of this approach is to develop a web-based modeling tool that satisfy all of the requirement of intention-oriented organizational modeling and can be used by business experts to model the informal processes, intentions, strategies and capabilities. Also in this thesis work, the scope of modeling is limited only to the descriptive type of modeling i.e., models that describe processes declaratively by providing only information about what has to be done. As we mentioned before, the resource definitions required for the modeling tool is made available from the first phase P1 of the InProXec approach. Business experts develop descriptive models through the developed modeling tool using these resource models to achieve main intention that contains strategies. The reason for following descriptive modeling approach is due to the fact that models reuse descriptive data and these stored models provides means of execution for the phase P3 of InProXec. The models developed through this approach provides necessary concepts and elements for intention-oriented organizational modeling. Resources are abstract description which are made concrete during initialization of an instance. There are also participant specific views based on the participating resources' role. For example, based on the privilege provided to a participant he can view, edit, own or follow the instances. Initializing resource-centric models requires *acquiring* and engaging



Figure 5.1: Steps of Model Informal Process

interrelated resources [SBLW15] which is explained in a detailed way in the following sections of this chapter.

5.2 Second Phase of InProcXec - Model Informal Process

This approach of Informal Process Modeling is directed towards modeling the informal process based on their intentions rather than their activities. Since this phase is part of InProXec method, the properties and requirements of informal process described in previous approaches [SBBL14; SBLW15] also applies to informal process modeling phase. The developed system serves as an holistic web based modeling tool to create, view and update all the associated elements of informal process like contexts, intentions, capabilities, strategies and resources. Also from our detailed explanation in previous sections about the importance of resources in organizational modeling and along with the fact that phase P2 receives resource definitions as input from phase P1 of InProXec method, we can apprehend that resource definitions are the lowest level in the hierarchy of intention-oriented organizational modeling approach. The sequence of steps to be carried out using the developed modeling tool has been shown in the Figure 5.1.

Model Context Definitions (M1)

The first step is to model context definitions, where we can model both (1) basic properties like name and namespace of a context definition and (2) entity specific properties like contained contexts, entity definitions, etc., of a context definition.

Model Intentions (M2)

Similar to context definition modeling (M1), the second step (M2) is to model intentions. The context definitions created in step M1 can be used to specify initial and final contexts of an intention. Intentions can contain related intentions such as (1) sub-intentions and (2) contradicting intentions. These type of sub intentions and contradicting intentions are also modeled as intentions in this step and their type of relation to a specific intention are mentioned. Intentions are defined hierarchically, which can contain and extend intentions. It is depicted by a double circle in organizational modeling notations. The sub-intentions are refined starting from main intention. Intentions are associated with strategies. Strategies required to achieve an intention are added to entity specific properties of intention as achieving strategies in this step.

Model Strategies (M3)

Once intentions are identified and modeled, the third step (M3) is modeling of strategy to achieve a specific intention. As mentioned earlier in Section 2.5, an intention can have multiple strategies. A strategy is a method or plan chosen to bring desired results, such as achievement of an intention or solution to a problem. Strategies are associated with capabilities. The capabilities required by strategy are added to entity specific properties of strategy in this step.

Model Required Capabilities (M4)

After modeling of strategies, capabilities required to achieve an intention in a specific strategy is modeled. A strategy can require multiple capabilities which has been explained in detail with a suitable example in the following Chapter 3. A capability is the ability to provide business values like software applications, resources and potential of the actor to make decisions even in changing situations [SGHZ12]. Capability describes the ability provided by a resource or required by an intention. The performers of an informal process should possess certain skills and roles to achieve the intention. These type of required skills are modeled during this step.

Create Resource Models (M6)

After matching the resources and capabilities i.e after finding the correct resource that has the capability to carry out the process, the resource models are created. The need for modeling a new intention may arise in parallel during modeling of resources. This

has been explained with a suitable example in the following Chapter 3. A resource can be a people or tool those/that drive towards the successful execution of the process. It is key for achieving specified process intentions. In the context of this work, the definition of organizational resources refers not only the entities that are capable of doing work but also entities that have an impact on the outcome of the processes, e.g., software tools, human performers, data etc.

Extract as an IPE Model (M7)

After the completion of above mentioned steps, the modeled entities can be extracted as an IPE model which can be reused.

The steps are matching of required organizational capabilities (M5) that are satisfied by resource models and integration of required resources (P1) are not part of the current functioning tool. If there is no suitable matching capability then phase P1 of InProXec can be carried out again until a matching capability is found. If capabilities are satisfied resource models can be created. The created resource models(M6) along with modeled capabilities can be extracted as an IPE Model(M7) which will be provided as input for the next step achieve intentions (M8). After the achievement of an intention, the status of intention is updated inside the specific intentions's property.

5.3 A Top-down Modeling Approach

As we mentioned earlier, the modeling approach in our context is descriptive modeling approach which starts from the top level intention and refines modeling until the operational bottom level is reached. Hence, it is called top-down modeling approach. The purpose of selecting top-down modeling approach is because based on the suggestions provided in the literatures [MBH+10; BJN+05; SBLW16] that the value of intention in the top of hierarchy propagates till the lower levels and helps in making investment-related decisions while at same time integrating cost and benefit estimates from all levels. Moreover, by creating declarative models using top-down modeling approach. Models are easily changeable as they are decoupled from their operational terms. Such declarative approaches provide more flexibility and enable easier change of the business process models. The integration of declarative models using top-down modeling approach also provides a coupling of cost-benefit and strategy achieve-ability estimation with operationally measurable business intention and supports the evaluation of business intention success and the effectiveness of the chosen strategies. In the Figure 5.2, it is shown how this modeling approach starts modeling from top level intentions and

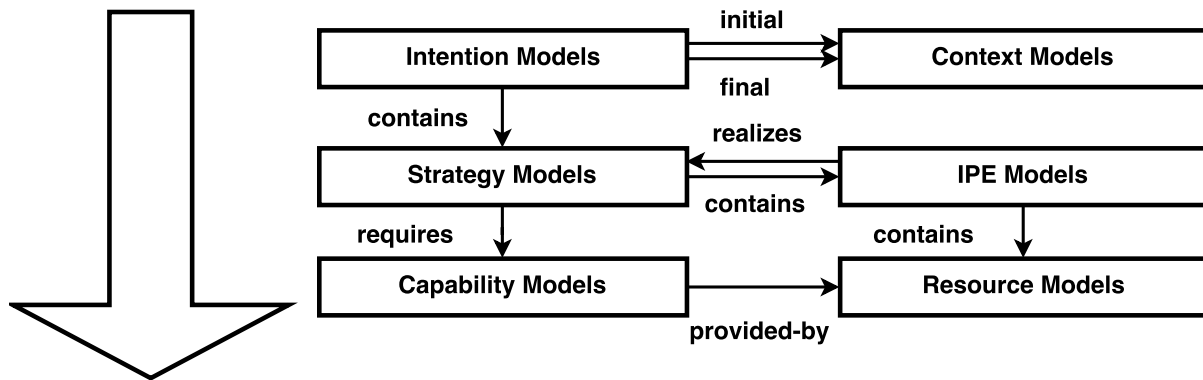


Figure 5.2: Intention-oriented Organizational Modeling - A Top down Modeling Approach

does modeling until the operational lower level is reached and how the organizational modeling elements are associated with each other.

The approach is evaluated based on the derived requirements in the Section 4.1 of Chapter 4 as follows :

Organizational Intention Transparency (R1) : From the Figure 5.2, one could understand that (1) intentions are refinable and as per the current design of the approach, (2) organizational members can view the intentions at different levels. Thus, requirement R1 is satisfied by the approach as it satisfies all of the pre-requisites.

Organizational Strategy-based Cost Estimation (R2) : During the modeling phase itself, business executives can make decisions based on the strategy cost estimation. In this approach (1) resources are associated with cost and (2) the cost estimation of strategies include all its low level structures. Thus, requirement R2 is satisfied by the approach as it satisfies all of the pre-requisites.

Organizational Strategy Achieve-ability Estimation (R3) : Similar to requirement R2 cost calculation, strategy achieve-ability estimation based on strategy's association with valid capability is also estimated during modeling phase itself. In this approach (1) a capability is considered as valid only when it is associated with matching resource and (2) from the Figure 5.2, one could understand how independent informal process realizes strategy. Thus, requirement R3 is satisfied by the approach as it satisfies all of the pre-requisites.

Intention Oriented Working Style (R4) : This approach (1) satisfies requirement R1 and (2) when modeling through this approach members require understanding of intention and its associated elements for successfully achieving the main intention. Thus, requirement R4 is satisfied by the approach as it satisfies all of the pre-requisites.

Participative Organizational Modeling (R5) : This approach (1) satisfies requirement R1 and (2) intentions are modeled collaboratively based on input received from different members of the organization. Thus, requirement R4 is satisfied by the approach as it satisfies all of the pre-requisites.

5.4 Design Methodology

This section discusses in detail the method of designing the web-based modeling tool that realizes the approach proposed in the Section 5.3. When designing the user interface components and functionalities required to develop the tool, most of the similar functionalities are designed as common functions for re-using the functions. This reduced unnecessary functional redundancies and overhead. Some of the important methodologies followed with respect to user interface components design are (1) multiple items to be selected from multiple list items are displayed as *list group* and (2) selecting single item from multiple items are displayed as *drop down*. For example, to select multiple strategies from a list of strategies, available strategies are displayed as a list from which the user can select desired number of strategies. Another important methodology followed during user interface design is, for every entity the properties should be displayed only under the respective properties tab. For example, in the Figure 5.3, the basic properties such as name, target namespace and process type of an informal process model should be displayed only under the respective basic properties tab and similarly for all other tabs. This methodology is followed uniformly throughout the design of all the entity types such as intention definitions, strategy definitions, capability definitions, context definitions, instance definitions and informal process definitions.

All data are stored only under the data artifact. This applies to the labels and text fields of all user interface elements and this data can be updated only through the handler function. Through the *settings* option, user can add new namespace type and intention relation type. From the Figure 5.3, it is clear that a standard design methodology has been followed to display the list of available entity types such as intentions, strategies, capabilities etc., and to display their respective properties such as basic, entity specific, instance data, etc., properties. Though the top-down modeling approach 5.3, shows that definition of each entity type is contained within another entity type, as per the user interface design, separate entities references each other using the unique reference identifier but does not contain all properties of referenced entity. For instance, a strategy containing an intention should contain only the intention's unique reference identifier but not the actual intention itself. Later, in the view of strategy, actual intention properties are fetched and displayed based on the unique reference identifier.

Intention-oriented Organizational Modeling Log-in

[Home](#) [About](#) [Contact](#) [Settings](#)

Informal Process Definitions ▾

Strategy Definitions ▾

Intention Definitions ▾

Cross Functional Capability Definitions ▾

Functional Capability Definitions ▾

Instance Definitions ▾

Context Definitions ▾

Entity Type - Informal Process Definitions Copy Start Start by Copying

Namespace and Name - (<http://www.example.org/TOSCA/PHPApp>) Customer support process

Basic Properties **Entity Specific Properties** Instance Data Participant List Resource Model

Name

Target Namespace

Process Type

Update

Figure 5.3: User Interface Design of the Modeling Tool

6 Case Study on Intention-oriented Organizational Modeling

In this chapter, the first two sections provide implementation details along with the reason for making certain decisions regarding the implementation of web-based modeling tool. The third section provides an architecture of the functioning system and fourth section provides application flow of the functioning system. The fifth section explains how motivating scenario has been realized using the proposed modeling approach. Successful modeling of the motivating scenario using the developed editor serves as a proof for usability of the web-based modeling tool. Hence, the final section validates the system by validating it with the requirements for supporting intention-oriented organizational modeling.

6.1 Technologies and Frameworks

In order to realize the web-based modeling tool of intention-oriented organizational modeling, a formal inquiry was done to choose suitable technologies and frameworks required. The below specifications were finalized and *client-side scripting* [SV12] was chosen, due to the fact that developed tool is web-based single page application (SPA).

1. *ClojureScript*¹ as the programming language
2. *Model-view-controller (MVC)* [Dea09] as the architecture pattern
3. *Re-frame*² as the pattern for writing SPA [MP13] in ClojureScript, using Reagent

Other than the above listed frameworks and technologies, frameworks like *react-bootstrap*³, *jquery*⁴ were also used to provide more optimal view of the tool. Along with

¹<http://clojure.org/about/clojurescript>

²<https://github.com/Day8/re-frame>

³<https://react-bootstrap.github.io/>

⁴<https://jquery.com/>

this we have also used libraries like *bidi*⁵ and *pushy*⁶, to handle page navigation from current location to the desired location in the URL (Uniform Resource Locator) of the browser. *Clojure* is a dynamic, general-purpose programming language, combining the approachability and interactive development of a scripting language with an efficient and robust infrastructure for multi threaded programming. *ClojureScript* is a compiler for Clojure that targets JavaScript which has been designed to emit JavaScript code. In our implementation, we have used both Clojure and Clojurescript artifacts. We also used *Reagent*⁷ which provides a minimalistic interface between ClojureScript and React⁸. *Re-frame*⁹ is a pattern for writing applications in ClojureScript, using Reagent.

6.1.1 MVC Architecture

The architecture of the developed user interface is based on the *Model-View-Control* (MVC) design pattern. The MVC paradigm allows to separate business logic from the code that controls presentation of user interface and event handling [Ora16]. Each entity view in the web page is made up of combination of at least one Model, View and one or more Controls.

Model artifact stores the required data structure for web-based modeling tool. In the developed model artifact, the data structure of modeling elements with their values are stored.

View artifact contains HTML (HyperText Markup Language) elements and HTML constructs that describe the way of displaying the data from Model to the user. Most of the common functionalities that render user interface components are re-used.

Control artifact contains the handler functions which can only change the model. Even the initial values of the model are put inside the control. This artifact has functions that updates default database, which then causes a re-render of view that makes the user to see a new view.

Apart from the above artifacts, there is another important artifact that registers subscription functions i.e., query layer of the data. As view components never source data directly from default model, we use *subscription* functions. Subscription functions returns values that change over time i.e based on a user events.

⁵<https://github.com/juxt/bidi>

⁶<https://github.com/kibu-australia/pushy>

⁷<http://reagent-project.github.io/>

⁸<https://facebook.github.io/react/>

⁹<https://github.com/Day8/re-frame>



Figure 6.1: MVC Pattern of Adding New Entity

Example: Component using MVC Pattern

The Figure 6.1 below shows how the components interact with each other using the MVC pattern with a simple example of adding new modeling entity data. This functionality is same for all the types such as intentions, strategies, capabilities and informal processes.

1. User clicks the tab *Add New* button in the developed editor.
2. In response to the user click, view displays the respective user interface component for entering the new entity data details.
3. User enters the required basic details for adding new entity data and clicks save button.
4. View dispatches data to control, as control can only modify the model.
5. Control inserts/updates data into the model.
6. View displays the updated model as it has been subscribed to the model.

6.2 Architecture of the Functioning System

Also from the Figure 6.2, it is clear that we followed the MVC architecture to design the user interface. Business experts can use the web-based modeling tool to view/update the descriptive entity details. Whenever a change in the model data is detected respective



Figure 6.2: Architecture of the Functioning System

handler function is *dispatched* and the corresponding handler function can only *update* the model. Since we associate every modeling element with another modeling element, model data of an element is required by another element which are resolved using the unique reference identifier. For example, intention *improve help customer help portal* is required by the strategy *through application development*. This is because for strategy (through application development), intention (improve help customer help portal) is the target intention.

6.2.1 Application Flow

In this sub-section we provide an overview about how page navigation from current location to the desired location happens in URL¹⁰ of the browser. The external libraries used for route navigation, parses URL into data structures and also generates URL from data structure defined as required routes. We call a function to dispatch route, with the matched route. Then we also have another function that parses the URL, to turn URL into data structure representing it. From the Figure 6.3, it is clear that route navigation for each entity items happens based on their entity type and its own unique reference identifier.

Each entity item has basic properties such as *name* and *target namespace*. The entities are identified using their unique id which is generated using the unique combination of name and target namespace. Other entities that are associated with a particular entity are resolved through this unique identifier. For example, in our motivating scenario consider the intention *improve the customer help desk portal* when creating model for this intention, business expert provide name and namespace for this intention and add it to the database. A unique identifier is generated for the intention model using the

¹⁰URL- Uniform Resource Locator



Figure 6.3: Implementation of URL Navigation



Figure 6.4: Realization of Motivating Scenario

combination of name and namespace by the system. For example, the strategy in the motivating scenario *through application development* that is associated with an intention, contains only the unique identifier of intention as reference.

6.3 Realization of Motivating Scenario

The realization of motivating scenario is explained by integrating the concepts discussed in Chapter 3 and the informal process modeling approach discussed in Chapter 2. From the Figure 6.4, it is clear that to realize the motivating scenario using the proposed approach it is important to model them step by step as mentioned in the informal process modeling approach. The developed modeling tool also supports dynamic changes in the models whenever there is a need to add new models. As each models are designed in individual modeling step, details of individual modeling steps are provided in the following sub sections.

6.3.1 Realization of Context Definitions

In the informal process modeling approach, the first modeling step is to model the context definitions (M1). Each informal process starts from an initial context and aims to achieve an intention [SBBL14]. After reaching an intention, there is resulting IPE Context. In the motivating scenario, the user can add new contexts by providing basic properties such as name of the context and target namespace of the context as they serve as unique reference identifier for these contexts. After successfully adding the basic properties, user can provide entity specific properties such as contained contexts inside the main context, entity definition details about the contexts and participant list with respective privileges for each participant are also provided. The required context definitions are modeled first because these definition are required for modeling intention definitions and process definitions.

6.3.2 Realization of Intention Definitions

After modeling context definitions(M1), the second step of the modeling is to model the intentions (M2). For example, in our motivating scenario we have main intention as "increase revenue and number of unit sales" and other low level intentions that emerged out of main intention and strategies of the main intention. The user can provide descriptive information about particular intention as intention definition. Similar to context modeling, the user has to provide basic properties such as name and target namespace required for unique identification of this entity. After providing basic properties, the user has to provide entity specific details of the intention such as due date and time for intention completion, priority of the intention, cost of the intention, other related intentions that are contained under this particular intention. The strategies to achieve this intention and contexts of the intention are also provided as entity specific properties. The participant list with respective privileges for each participant are also provided.

6.3.3 Realization of Strategy Definitions

After modeling context definitions (M1) and intention definitions (M2) user can proceed to model the strategies (M3) which is third step of the modeling process. For example, in our motivating scenario user can model the strategies such as *through expansion,through advertisements* and other required strategies as third step of the modeling process. Similar to earlier modeling steps, during the modeling of strategy also user required to provide basic properties such as name and target namespace. After providing the basic properties, entity specific properties such as target intentions of the strategy, capabilities

and process definitions associated with strategy are also provided. Since strategy is also an interactive acquirable entity similar to intention, participant list details are also provided during modeling of strategies

6.3.4 Realization of Capability Definitions

Modeling of capability (M4) is the fourth step in intention-oriented organizational modeling. There are two types of capabilities. Functional capabilities and cross-functional capabilities. Functional capabilities are the capabilities that associated with other entity types. Cross-functional capabilities contains multiple functional capabilities. Similar to earlier entity types' basic properties such as name and target namespace are added to get the unique reference identifier and entity specific properties for capabilities are added. Since cross functional capability contains functional capabilities, it holds the identifiers of the functional capabilities contained in it. Functional capability definitions also has participant list details similar to intention definitions and strategy definitions.

6.3.5 Realization of Process Definitions

By modeling the business processes based on the resources that work towards certain intentions, informal processes are modeled without predefining their business logic [SBBL14]. Also as mentioned earlier each informal process starts from an initial context and aims to achieve an intention that results in a final context. Thus we require context definitions and intention definitions before modeling process definitions. Similar to earlier modeling of entity types, process modeling also require basic properties such as name, namespace and entity specific properties such as associated intentions, contexts and resources. Process definition also has participant list similar to other entity types.

6.3.6 Realization of Resource Definitions

Each resource that provides certain capability required by intention can be related to another resource which are defined using predefined or custom *relationships* [SBBL14]. These resources are managed through *Resource Organizers*, this is because resource organizers are used to bring together the relevant interrelated resources that work towards to achieve an intention. TOSCA [BBKL14] can be used to model all nodes and relationship among them. In this work, we consider resources as nodes to make use of the TOSCA's service. In the developed modeling tool, the resource models are managed by embedding the open source modeling tool Winery web page [KBBL13] in

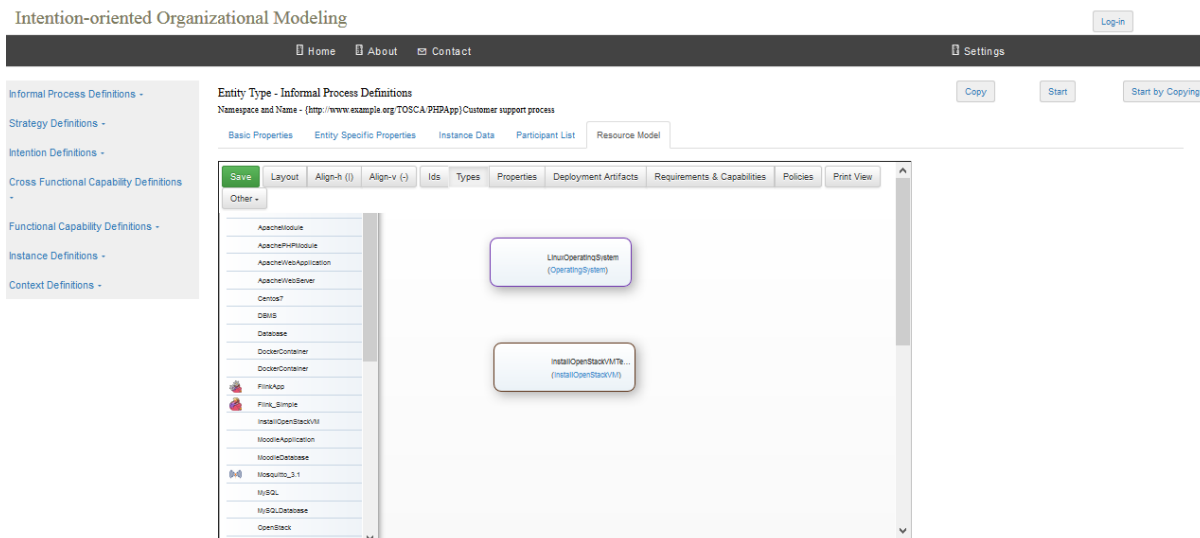


Figure 6.5: User Interface Screen of Resource Model

the modeling tool's web page. This is because it creates a new service template that contains an application topology by using the topology modeler. Winery also offers all available node types in a palette. From there, user can drag the desired node type and drop it into the editing area. There the node type becomes a node template i.e., a node in the topology graph. Node templates can be annotated with requirements and capabilities, property values, and policies. The screen shot of modeling sample resource has been provided in the Figure 6.5.

In order to achieve this we use TOSCA repository URL referring to winery and the other one referring to topology modeler of the winery. Using these values we create corresponding URL required for our modeling based on the name and namespace properties of an entity. The functionality to generate resource model page, using TOSCA repository URL and topology modeler URL is provided below.

```
{topology-modeler-url}?repositoryURL={encoded-tosca-repository-
url}&ns={encoded-target-namespace}&id={encoded-identifier}#
```

6.3.7 Realization of Instance creation

Initializing resource-centric processes requires acquiring and engaging interrelated resources [SBLW15]. As mentioned earlier, the phases of compiling and initializing of informal process models are not within scope of this work. Only the functionalities such as creating instances, extracting instances and editing instances are part of the functioning tool. This is because initializing informal process models starts after the

Intention-oriented Organizational Modeling

Home About Contact Settings

Log-in

Informal Process Definitions -

Strategy Definitions -

Intention Definitions -

Cross Functional Capability Definitions -

Functional Capability Definitions -

Instance Definitions -

Context Definitions -

Entity Type - Instance Definitions

Namespace and Name - (<http://www.example.org/TOSCA/PHPApp>) Increase revenue and sales instance

Basic Properties Entity Specific Properties Entity Definitions

Add New Update

Source Model Entity Type

Source Model

Start Date

Start Time

End Date

End Time

Instance URI

Instance State

Instance Status

Cost

Intention Definitions

Increase revenue and sales

2016-06-07

11:11:10

2016-06-07

12:11:10

<http://www.example.org/InstanceURI1>

Running

0 out of 2 instances completed

28 Euro/Hour

View

Figure 6.6: User Interface Screen of Instance Descriptor

initial context defined in an IPE model [SBLW15]. Thus, it is important to discuss realization of instance creation which are required for subsequent phases P3 and P4 of Executing Informal Processes (InProXec) method. Acquirable entity types' models can be converted into instances. For example, resource definition is converted into *resource instance*. A model instance contains additional meta-data about the executed processes such as the information about the start date and time, end date and time, instance status, cost, source model etc. From the screen-shot image 6.6 it is clear that these properties of an instance can be edited through the developed tool. Only when a acquirable model is successfully initialized it can be engaged to adapt the process execution of emerging requirements [SBLW15].

The developed tool supports creation and updation of descriptive information about instances. Each instance belong to any one of the acquirable entity type such strategies, intentions and informal processes. Any entity that has instances are also listed inside the *Instance data* tab of each entity. From the user interface screen Figure 6.7, it is clear that the editor has ability to add, remove and extract instance descriptors for any entity type. An instance descriptor of a functional capability refers to a resource definition meaning that a capability is provided by a resource.

6.4 Validation of Requirements

This section evaluates the current functioning tool against the derived requirements of intention-oriented organizational modeling.



Figure 6.7: User Interface Screen of Acquirable Entities

Organizational Intention Transparency (R1): Using the modeling tool intentions at different levels can be modeled which satisfies first pre-requisite of R1. With the current functioning system any user can view intention at different levels which satisfies second pre-requisite of R2. Thus, requirement R1 is satisfied by the functioning system as both of its pre-requisites are satisfied .

Organizational Strategy-based Cost Estimation (R2): The functionalities of modeling tool itself calculates and displays the strategy cost calculation based on strategy implementation and resource cost. This cost information helps the business experts to make certain decision based on cost calculation during modeling. The functioning tool satisfies requirement R2 as both of its pre-requisites are met by the tool.

Organizational Strategy Achieve-ability Estimation (R3): Similar to cost calculation, strategy achieve-ability estimation based on its association with valid capability is also determined and displayed during modeling phase itself. The functioning tool satisfies requirement R3 as both of its pre-requisites are met by the tool.

Intention Oriented Working Style (R4): Any user and create intention models, strategy models, informal process models etc., through the developed tool provided the user has understanding about main intention and its recursive structure. The requirement R4 is also satisfied by the functioning tool as it satisfies both the pre-requisites of R4.

Participative Organizational Modeling (R5): Each entity type that can be interactively acquirable has list of participants with their corresponding privileges. The users can edit, view, own or follow based on their privilege. Thus, the tool satisfies the requirement R5.

7 Conclusion and Future Work

In this document, we first started Chapter 1 with motivational and problem statement followed by contributions of this work. In Chapter 2, the fundamental concepts and related work from existing literature has been provided in detail. In Chapter 3, a motivating scenario has been taken and explained based on the guidelines and real life scenarios discussed in some previous work. In Chapter 4, a detailed requirements analysis based on existing literatures, a motivating scenario and evaluation of existing approaches has been provided. This is followed by Chapter 5, which provides an approach that satisfies all of the derived requirements. A detailed case study has been provided in Chapter 6, which helps to assess feasibility of the proposed approach. This chapter also validates the developed web-based modeling tool by providing examples that satisfies the derived requirements discussed in Chapter 4 and also conformance of the motivating scenario discussed in Chapter 3 with the developed system.

This work provides an approach that satisfies all of the requirements of intention-oriented organizational modeling and realized the proposed approach as a web-based modeling tool. The models developed through this approach act as a complementary informal guides and definitions required for intention-oriented organizational modeling.

Future Work

The web-based modeling tool developed as a part of this master thesis work will be integrated with back end such that it can generate deployable entities from the current descriptive information. The future work also includes providing mobile modeling approach, enabling logging in functionality through few of the popular social network accounts and enhancing the user interface features of the modeling tool.

Bibliography

- [BBKL14] T. Binz, U. Breitenbücher, O. Kopp, and F. Leymann. “TOSCA: portable automated deployment and management of cloud applications.” In: *Advanced Web Services*. Springer, 2014, pp. 527–549 (cit. on p. 50).
- [BCV06] S. J. Bleistein, K. Cox, and J. Verner. “Validating strategic alignment of organizational IT requirements using goal modeling and problem diagrams.” In: *Journal of Systems and Software* 79 (2006), pp. 362–378 (cit. on pp. 27, 28).
- [BFV12] M. Brambilla, P. Fraternali, and C. K. Vaca Ruiz. “Combining Social Web and BPM for Improving Enterprise Performances: The BPM4People Approach to Social BPM.” In: *Proceedings of the 21st International Conference on World Wide Web*. 2012, pp. 223–226 (cit. on pp. 27, 29).
- [Bia16] A. Bianca. *The Role of Human Resource Management in Organizations*. [Online; accessed 2016-05-03]. 2016. URL: <http://smallbusiness.chron.com/role-human-resource-management-organizations-21077.html> (cit. on p. 14).
- [BJN+05] I. Bider, P. Johannesson, S. Nurcan, A. Etien, R. Kaabi, I. Zoukar, and C. Rolland. “A strategy driven business process modelling approach.” In: *Business Process Management Journal* 11 (2005), pp. 628–649 (cit. on pp. 29, 38).
- [BPT09] BPTrends. *Case Management: Combining Knowledge With Process*. [Online; accessed 2016-06-30]. 2009. URL: <http://www.bptrends.com/bpt/wp-content/publicationfiles/07%2009%20WP%20CaseMgt%20CombiningKnowledgeProcess%20White.doc%20final.pdf> (cit. on p. 9).
- [Can15] M. Canko. “Investigating the Virtual Representation of Human Resources.” Diploma Thesis. University of Stuttgart, Faculty of Computer Science, Electrical Engineering, and Information Technology, Germany, July 2015, p. 83 (cit. on p. 14).
- [CH09] D. Cohn and R. Hull. “Business artifacts: A data-centric approach to modeling business operations and processes.” In: *Bulletin of the IEEE Computer Society Technical Committee on Data Engineering* 32 (2009), pp. 3–9 (cit. on p. 30).

- [Dea09] J. Deacon. “Model-view-controller (mvc) architecture.” In: *Online*[Citado em: 10 de março de 2006.] <http://www.jdl.co.uk/briefings/MVC.pdf> (2009) (cit. on p. 43).
- [Gro11] O. M. Group. *Business Process Model and Notation (BPMN) 2.0*. [Online; accessed 25-November-2015]. 2011. URL: <http://www.omg.org/spec/BPMN/2.0/PDF/> (cit. on p. 15).
- [Gro12] T. O. Group. *ArchiMate 2.1 Specification*. [Online; accessed 2016-05-04]. 2012. URL: <http://pubs.opengroup.org/architecture/archimate2-doc/> (cit. on p. 30).
- [Gro13] T. O. Group. *Archimate 2.1*. [Online; accessed 25-November-2015]. 2013. URL: http://pubs.opengroup.org/architecture/archimate-doc/ts_archimate/ (cit. on p. 15).
- [IGRR09] M. Indulska, P. Green, J. Recker, and M. Rosemann. “Business process modeling: Perceived benefits.” In: *International Conference on Conceptual Modeling*. 2009, pp. 458–471 (cit. on p. 16).
- [KBBL13] O. Kopp, T. Binz, U. Breitenbücher, and F. Leymann. “Winery—a modeling tool for TOSCA-based cloud applications.” In: *Service-Oriented Computing*. Springer, 2013, pp. 700–704 (cit. on pp. 13, 14, 50).
- [Lac16] T. Lacoma. *What Is Goal Orientation?* [Online; accessed 18-November-2015]. 2016. URL: <http://smallbusiness.chron.com/goal-orientation-20360.html> (cit. on pp. 27, 29).
- [LR00] F. Leymann and D. Roller. “Production workflow: concepts and techniques.” In: (2000) (cit. on p. 30).
- [May16] K. E. May. *Work in the 21st Century: The Changing Role of Human Resources*. [Online; accessed 2016-05-03]. 2016. URL: <http://www.siop.org/tip/backissues/tipjan98/may.aspx> (cit. on p. 14).
- [MBH+10] V. Mandić, V. Basili, L. Harjumaa, M. Oivo, and J. Markkula. “Utilizing GQM+ Strategies for business value analysis: An approach for evaluating business goals.” In: *Proceedings of the 2010 ACM-IEEE International Symposium on Empirical Software Engineering and Measurement*. 2010, p. 20 (cit. on pp. 27, 28, 38).
- [MHL+07] T. McManus, Y. Holtzman, H. Lazarus, J. Anderberg, E. Berggren, and R. Bernshteyn. “Organizational transparency drives company performance.” In: *Journal of Management Development* 26 (2007), pp. 411–417 (cit. on p. 27).
- [Moo09] D. L. Moody. “The physics of notations: toward a scientific basis for constructing visual notations in software engineering.” In: *Software Engineering, IEEE Transactions on* 35 (2009), pp. 756–779 (cit. on p. 15).

- [MP13] M. S. Mikowski and J. C. Powell. "Single Page Web Applications." In: *B and W* (2013) (cit. on p. 43).
- [MWMY11] T. Matthews, S. Whittaker, T. Moran, and S. Yuen. "Collaboration Personas: A New Approach to Designing Workplace Collaboration Tools." In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2011, pp. 2247–2256 (cit. on p. 11).
- [Ora16] Oracle. *MVC Architecture*. [Online; accessed 2016-05-03]. 2016. URL: https://docs.oracle.com/cd/E13174_01/alui/devdoc/docs60/Overview_of_the_Portal_Architecture/Portal_UI/PlumtreeDevDoc_Overview_MVCArchitecture.htm (cit. on p. 44).
- [SBBL14] C. T. Sungur, T. Binz, U. Breitenbücher, and F. Leymann. "Informal Process Essentials." In: *Proceedings of the 18th IEEE Enterprise Distributed Object Conference (EDOC 2014)*. 2014, pp. 200–209 (cit. on pp. 10, 13, 14, 16, 18, 21, 36, 49, 50).
- [SBLW15] C. T. Sungur, U. Breitenbücher, F. Leymann, and J. Wettinger. "Executing informal processes." In: *Proceedings of the 17th International Conference on Information Integration and Web-based Applications & Services*. 2015, p. 54 (cit. on pp. 10, 11, 18, 20, 25, 36, 51, 52).
- [SBLW16] C. T. Sungur, U. Breitenbücher, F. Leymann, and M. Wieland. "Context-sensitive Adaptive Production Processes." In: *Procedia CIRP* 41 (2016), pp. 147–152 (cit. on pp. 23, 38).
- [SGHZ12] J. Stirna, J. Grabis, M. Henkel, and J. Zdravkovic. "Capability driven development—an approach to support evolving organizations." In: *The Practice of Enterprise Modeling*. Springer, 2012, pp. 117–131 (cit. on pp. 30, 37).
- [Sie15] S. C. P. Sierra. "Investigating Informal Processes." Diploma Thesis. Tilburg University, University of Stuttgart, University of Crete, June 2015, p. 85 (cit. on pp. 15, 21, 24).
- [SKL14] C. T. Sungur, O. Kopp, and F. Leymann. "Supporting Informal Processes." In: *The 6th Central European Workshop on Services and their Composition (ZEUS 2014)*. 2014, pp. 49–56 (cit. on p. 9).
- [Sun15] C. T. Sungur. *An Approach to Supporting and Automating Informal Processes*. 2015 (cit. on pp. 9, 23).
- [SV12] S. Sierra and L. VanderHart. *ClojureScript: Up and Running*. "O'Reilly Media, Inc.", 2012 (cit. on p. 43).
- [Wes12] M. Weske. *Business process management: concepts, languages, architectures*. Springer Science & Business Media, 2012 (cit. on p. 13).

- [YMMS09] S. Yarosh, T. Matthews, T. P. Moran, and B. Smith. “What is an activity? Appropriating an activity-centric system.” In: *Human-Computer Interaction–INTERACT 2009*. Springer, 2009, pp. 582–595 (cit. on p. 29).

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place,date,signature