Understanding Complex Systems Implementation through a Modeling Approach: the case of e-government in Zanzibar

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Dedication

"To my father, my mother, my husband and my children"

"The only thing we have to fear is fear itself" Franklin D. Roosevelt
Chapter 1

Introduction

The evolving nature of government operations and the evolution of new technologies has brought alternative ways for governments to improve their public service delivery [186]. In particular, ICTs are very useful (1) in enabling reliable communications at an affordable cost and (2) processing large amounts of data very efficiently. Governments from around the world are nowadays taking advantage of the benefits of ICTs to facilitate their operations and the interactions between their ministries, departments, agencies and their citizens. Recently, governments are launching the use of ICT for both national and international communications.

ICT-based solutions have helped governments to improve efficiency and transparency, and, most importantly, to reduce the costs of delivery of public services. Based on the experiences so far, ICT has also proved to be a crucial tool in overcoming technological challenges and in the creation of sound strategies towards development and economic competition. Further, ICT also proved to be a powerful tool to overcome barriers and challenges for future economic growth [100].

Whilst investments in e-government projects across the globe are growing significantly [126], it is essential to understand that using ICT is not a panacea for all problems in public and private organizations. It is beyond doubt, however, that ICT provides enormously powerful tools for development and are a catalyst for change. In recent times, for example, ICT has been used to structure activities, process services, manage human resources and public administration [43].

Most low-income countries nowadays are in transition from using human-based services into using electronic services, widely referred to as e-government systems. For western countries, however, e-government systems are not something novel anymore and have been largely introduced with clear benefits. This implies that developing countries also have to adopt these new ICT initiatives for the benefit of both national and international competitive advantages.

The primary goal for ICT application in the government’s operations can be explained as increased flexibility of access to public services at considerable ease and convenience.

Another significant benefit of e-government is its ability to transform traditional government structures into the citizen-centered approach. The use of ICT
in e-government is directly linked with the improvement of quality service delivery, efficiency, productivity, and affordability of costs for the services offered.

In addition, innovative applications of ICT in the government over the last decade resulted in the introduction of new solutions and ideas to address the complex challenges faced by governments.

It is, however, advisable that governments set a sustainable initiative to improve ICT services and to make them accessible to the least privileged, deprived and remote segments of the community, including vulnerable people.

The use of ICT in governmental systems is conceptualized as a general provision of public services to improve managerial effectiveness [162]. Hence, the term e-government is defined as the use of ICT to support the government to improve information flow and service delivery in a reliable way and to increase production, revenue and transparency [191, 79]. In this regard, ICT is used as an umbrella term to refer to the full range of services related to the use of Internet and information systems.

1.1 Research problem

Recently, a considerable number of countries have started to adopt the global trend to transform the traditional way of public administration into an automated system based on electronic services, but ICT also plays an essential role in facilitating this substantial shift itself!

Although governments are eager to adopt the new e-government system, many governments are facing the issue of sustainability for their e-government projects. Unfortunately, most of the newly established e-government systems collapse in their initial set up stages for several factors. For example, software complexity and incomplete user requirements are among the cited causes of the collapse [112]. It is astonishing to see that the issue of sustainability does not only hinder developing countries but also still is a challenge in developed nations [2].

Government projects are characterized by various patterns such as the organizational size, staff education level, project management issues, security, privacy, finance, infrastructure, business needs, and, last but not least, politics [14]. These patterns are the cornerstone for most projects designed for public use. The various stakeholders involved in these patterns may not be very open for a change. Others require novelty and appropriate innovation. Hence, any new introduction that influences the original workflow may create some resistance from some segment of the target users.

Several frameworks and guidelines are used for managing and executing large scale projects. Those frameworks were mainly designed to ensure projects are successful concerning implementation time, scope, quality and cost. Examples of frequently used frameworks are: Project Management Body of Knowledge (PM-BOK), Projects in Controlled Environment (PRINCE), Critical Chain Project Management (CCPM), Extreme Project Management (XPM), Benefits Realization Management (BRM), and Adaptive Project Framework (APF). These frameworks share fundamental practices that are used to achieve the best results.
However, when it comes to ICT based project development, various studies have shown different and additional causes that lead to project failure. These studies have identified such causes to stem from construction techniques, insufficient research for the designed project and technological factors [113, 235, 186, 145, 170]. Moreover, the gap between the design requirements and the current reality, the so-called "design reality gap", is a significant concern for public projects [111, 113, 58, 97].

Developing countries have the advantage that they can choose from various techniques and use tools and methods that have already been developed in developed countries. However, this latter advantage may be dubious since the methods and tools coming from developed countries to some extent depend on the cultural identity of western countries [48]. These techniques, tools and methods make (usually implicit) assumptions about how people feel, think and interact, and how organizations are organized. A gap between these (implicit) assumptions and the reality in the country of application, the culture gap, may have an influence on the performance of the design method. This factor typically involves preconceptions and existing rigidities. Usually, these factors are of a more subjective nature [58], though other objectives tools, such as Hofstede framework [73] are specific to measure cultural differences. The culture gap plays an important role in government projects.

The term project failure varies significantly according to context, time and viewpoint. For the sake of this study, project failure is considered to be the state where the project is unable to deliver its predefined goals and associated planning.

Because of the prevalence of project failure, a number of provisions were formed to support a successful implementation of ICT projects in the public sector [48, 158, 31, 10, 67, 190]. Due to the culture gap, implementation can be more challenging especially for standard design.

Both governmental and non-governmental organizations try to reach solutions that can enhance successful e-government implementation [173]. In 2001 an estimated number of 500 e-government projects were launched worldwide [199]. Accordingly, various studies have been initiated to support project success. For example, United Nations [290], International Telecommunication Union (ITU) [228], the World Bank [33], Organization for Economic Cooperation and Development (OECD) [211] and many more. These organizations are a significant entity for e-government success, such that, they collect detailed information for the ongoing projects and produce a summarised report as a learning opportunity and share successful experiences that can strengthen e-government initiatives.

The project development process comprises of various phases, each of which has a direct influence on the project completion. Project phases provide a broader picture to understand the general context of the project life cycle that can predict possible reasons for the failure. In fact, a project starts at the conception phase, followed by requirements identification, then planning, which results in the implementation phase, and ends with testing and use [194]. Project failure can occur during any phase of a project development life cycle. However, failure during the requirements elicitation phase has a significant impact on both the effectiveness and efficiency of the resultant system [272], because it directly defines user accep-
tance criteria [132]. For this reason, in this study, we are joining other scholars such as Kimaro, Anthopoulos and others to investigate the failure caused by design reality gap [14, 145].

In general, system development for public use is known to be very challenging in both developed and developing countries [48]. Research shows that more than half of information system projects implementation results in total or partial failure with regard to management issues, while more fail to meet user expectations [14, 132, 113]. Even though there are more factors contributing to these failures, the design gap ranks the top for the failures that occur at the earlier stages of the project development [113].

Our assumption is that cultural differences play an important role concerning this type of failure. Then, using the natural language of the participants, while using an organizational approach that is open for diversification of the participants can reduce that failure rate. These should be supported by an effective means of reducing problem complexity. Hence, this study is classified into three pillars:

1. The first pillar is the linguistic-based approach to modeling, described in 7.3.1. In this pillar, we first discuss a natural-language based approach to the modeling process and distinguish the two primary roles: the domain expert and the system analyst.

2. The second pillar is a decomposition mechanism for typical large-scale problems such as the introduction of e-government, in 7.3.2. In this pillar, we discuss the complexity of the issue at hand, which can be characterized as a public sector project. We will see how this complexity can be mastered by making a hierarchical decomposition of the overall task, thereby introducing various intermediate levels of abstraction. This leads to sub-processes, where each level has its independent concerns. As a result of this decomposition, the organizational aspects of the modeling process become more prominent.

3. The third pillar is the use of the ICT Roundtable method for process organization described in 7.3.3. In this pillar, we will discuss the ICT Roundtable approach as a mechanism to effectively organize the modeling transformations with multiple domain experts and numerous system analysts.

This study focuses in particular on the investigation of ICT project design issues by considering the state-of-the-art e-government in Zanzibar.

1.2 Main research question

Developing a project for public use can involve very complicated processes. This is mainly because public projects include many stakeholders that have different needs. This fact is known to be the root cause of project failures and hence, loss of money. Hence, this research aims to contribute to the sustainability of public projects. The key research question is:

"How to develop a sustainable public system that is aware of cultural issues in general and for Zanzibar in particular?"
1.2. MAIN RESEARCH QUESTION

1.2.1 Specific research questions

To provide specific directions to the problem identification, we decompose the research question into the following sub-questions that will help to derive the solution within the context of the public system domain.

**RQ1** What are core variables for public system implementation, and how do they influence project deployment?

This question aims to understand the components for public system implementation, and their impact in sustainability.

We provide a general framework for e-government implementation.

**RQ2** How to characterize the cultural identity of a country and of an organization in general and for Zanzibar in particular?

For this question we make use of existing cultural models as a guide in implementing a sustainable e-government systems.

**RQ3** What is the current condition for e-government implementation in Zanzibar?

In this question, we consider the current situation for our case of e-government implementation in Zanzibar. For this, we use the SWOT analysis method (Strength, Opportunity, Threats and Weaknesses) to analyze the status of the country for strategic e-government implementation.

**RQ4** How can we model the conceptual structure of a complex domain by using natural language approximations?

We describe the role of modeling in software system development and show how the use of a natural language approach can be beneficial. We use decomposition to handle various domain language differences as they occur on different levels of interest. We also provide an e-government conceptual model to increase sustainability in government projects.

**RQ5** How can the modeling approach model the dynamics of complex systems?

This question aims to express the proper technique to be used as a tool to discover system dynamics characteristics. We extend system dynamics modeling to handle more subtle situations, in terms of the domain language approximations.

**RQ6** What is the effect of cultural differences on design and development of ICT projects and how can modeling successfully be applied in a collaborative environment?

This question intends to consider cultural characteristics as a core factor influencing development success.

In this question we propose the three-pillar approach to control the quality in the design process.
Thus, formulated questions can answer our research objectives. Using three pillars, we investigate our research aim using the natural language approach, decomposition mechanism, and the ICT Roundtable approach. Furthermore, other supporting techniques such as, SWOT analysis and DPSIR framework were added to reach our intended goal.

1.3 Justification for this study

This research aims to be a contribution to answering the reported high failure rates of public system development and its implementation. Various proposals have been made to minimize the failure rate of public projects [48, 158, 31, 10, 67, 190]. However, most previous studies’ approaches were primarily centered on theoretical approaches [107] and on framework based methods [48, 31, 10]. In contrast, this study considers an evidence-based approach that is aware of cultural influences that influence the e-government design and implementation process. We focus on multi-stakeholder involvement in the requirements phase.

Zanzibar already started various preliminary steps to introduce e-government systems. These processes have had significant importance for the future investment in government administration automatization. System evaluation and analysis stimulates successful future systems implementation. The multi-stakeholder approach can be applied to system development and implementation in both developed and developing countries. However, developing countries have more challenges and difficulties for public project implementation due to their infrastructure and cultural characteristics. Therefore, the exploratory examination is critical to avoid extra costs, delays or even failures of the entire project.

Sometimes system development and implementation can be an uncertain process. Our assumption is that the critical factors are (1) communication, (2) organization and (3) adaptation. During the phase of requirements engineering, we use conceptual modeling and system dynamics approaches to describe system the relevant concepts and their behavior and decision making, as experienced in a multi-stakeholder environment to improve completeness and acceptance of the result.

The method proposed here, referred to as Linguistic Approach in a Round Table setting (LART), is intended to work in complicated situations to extract user requirements. The proposed method may provide various alternatives, each with consequences being assessed for the system development process. The development process includes stakeholder voices to stimulate local ownership that is very important for system deployment. The proposed method is expected to lead to useful tools for decision-makers.

1.4 Scope

The scope of this study is divided into two parts. The first part describes the modeling development process (the way of modeling), and the second part is the implementation of the model (the way of working). The idea of modeling is made
of four steps: (1) the conceptual design: at this phase, the selected domain is conceptualized using semi-natural language technique to stimulate understanding between stakeholders; (2) the behavioral model: at this phase, we investigate the behavior of the conception using causal diagram and extended causal diagram; (3) the simulation phase: this phase quantifies the resulting causal description using system dynamics tools.; (4) the implementation phase represents the validation procedure in real case example in the e-government systems. The way of working, on the other hand, exploits two organizational techniques; ICT Roundtable approach and collaborative engineering technique. The ICT Roundtable approach characterizes stakeholder involvement from different organization levels. The cooperative engineering deploys thinkLet pattern to enhance the working environment in case of misunderstanding and security. Hence, anonymity and conflict resolution would be an option, (see Figure 1.1) for a detailed description.

Figure 1.1: Research setting

1.5 Research approach

Based on this research question, the accomplishment of this study was primarily constructed following the design science methodology as defined as "the design-science paradigm seeks to extend the boundaries of human and organizational capabilities by creating new and innovative artifacts" [276]. Other techniques added more value to this research such as conceptual design, SWOT analysis and literature review. The purpose of this addition was to answer the research questions. Figure 1.2 illustrates the research methodologies adopted for this work. The method of this research was adopted from [276] and [114].

In research on information systems and related studies, two complementary methods are used: design and behavioral sciences. Yet, these methods are a distinct paradigm for research. Both are the foundational to Information Systems discipline, positioned at the confluence of people, organizations, and technology. These methods are used to acquire knowledge related to the management of information technology and its use. The behavioral science methodology, for instance, seeks to develop and verify theories that explain or predict human or organizational
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CHAPTER 1. INTRODUCTION

Figure 1.2: Detailed research methodology [276, 114]

behavior. On the other hand, design science aims to extend the boundaries of social and organizational capabilities by creating new and innovative artifacts [276].

To be precise, our research method is made of four patterns of working structures: way of thinking, way of controlling, way of modeling and way of working (see also [236]). The implementation of these techniques is aligned with the design science approach as illustrated in Figure 1.3.

Figure 1.3: Working structure of the study

The design science (DS) methodology was explicitly applied to fit the way of modeling and the way of controlling (see Chapter 6). In this respect, we deployed Object Role Modeling (ORM) to understand the behavior of the domain. The ORM was primarily used to engage domain experts in the modeling complexities. It is certain that domain experts are well informed in their environment and fields of expertise, but they are probably not well experienced with modeling techniques. As a result, using the ORM brings the ability to deploy a linguistic approach,
strategic for the domain experts. Additionally, we used causal and extended causal diagrams to analyze the behavior of the designs. Finally, the artifact was analyzed in the simulation design using the system dynamics constructs.

The way of thinking is divided into three parts: problem identification followed by DPSIR, and SWOT analysis. Afterwards, the way of controlling was applied to solve the research problem using linguistics techniques. The way of modeling was prepared using behavioral design, causal modeling, and simulation. The way of working includes the ICT Roundtable process, collaborative engineering and evaluation of the tool. To ensure the validity and reliability of data and the findings, the implementation of this study was evaluated in the real case environment in Zanzibar.

1.6 Thesis outline

The structure of this thesis is divided into nine main chapters. Chapter 1 defines the problem and gives an overview and the nature of my research problem. The chapter includes scope, research questions and the justification of the study. Chapter 2 is thesis conceptualization. The chapter defines key terms and technical jargons used in the thesis. Chapter 3 explores the concept of e-governments and their implementation requirements using DPSIR, where Chapter 4 presents a discussion on the situation in Zanzibar focusing on two aspects: cultural characteristics and SWOT analysis. Domain modeling by using Object Role Modeling (ORM) is in Chapter 5, and system dynamics modeling from the conceptual design to the system dynamics, designs and simulation are in Chapter 6. Chapter 7 discusses cultural perspectives by employing the use of Linguistic approach in the ICT Roundtable setting. Chapter 8 offers an in-depth evaluation of the LART method and its implementation in a real case situation in Zanzibar, culminating in the conclusion in Chapter 9.

1.7 Publications


Chapter 2

Thesis conceptualization

This study was developed from many constructs that represent knowledge within the system and development environment. This chapter intends to describe some terminologies and develop general abstracts on the key aspects deployed in this research to help the coherent reader understanding of the knowledge presented on this work.

The underlying objective of this work is to consider modeling development techniques in order to provide a particular method in problem-solving solutions. Model-driven approach is a primary artifact in software development [234], where a clear and shared understanding of the semantics was given significant consideration. Nowadays, the modeling approach is in most cases used as a method to determine what the business does and the data it needs for better services. However, in system development, the modeling approach is primarily used to assess user requirements [223].

This study deploys modeling approaches, followed by the practical implementation of the proposed model. The model development approach is characterized by both static and dynamic features. The static properties are used to conceptualize the design and magnetic properties to capture the runtime behavior of the plan. Then, both properties, static and dynamic, are linked to practical procedures for development system. A good model is expected to be correct and complete; that is foremost quality in design approach. However, those qualities can only be achieved when the requirements are complete and accurately extracted. Therefore, this chapter aims to describe the overview of requirement elicitation practice where terminologies and abstractions are outlined. Also, the DPSIR framework is defined.

2.0.1 Requirement elicitation

In the system development process, various knowledge exists on intensive processes, from which requirement elicitation process is perhaps the most critical for the success of the software system. Requirement elicitation process is hence used to gain knowledge about user needs [256].
Moreover, there is little guidance available on how to select elicitation techniques for a new software project [256]. Usually, the selection of requirement elicitation techniques is based on the company’s practice or personal experience. In this study, the requirement elicitation exercise covers the essential part about modeling practice. In this regard, the requirement elicitation exercise is used to provide a brief overview of the contextual knowledge of the model being developed. In knowledge representation, contextual development is used to map the real-world needs, and in validation, stakeholders verify whether their needs have been correctly specified by looking at the generated conceptual model [239].

Traditionally, requirement elicitation practice relied on a scenario-based approach [39]. It was done in one to one communication using interviews, questionnaires, and surveys. Consequentially, a collaborative approach, such as focus group discussion and workshop meeting, made requirement elicitation more effective. A collaborative approach is more flexible for its spontaneous reaction and feedback [256].

2.0.2 Scenario based approach

The scenario-based approach is a narrative description of a system to illustrate events of the system behavior. The scenario approach can be described in broader perspectives. Carroll classifies scenarios according to their use in systems development ranging from stories of current use, user-designer communication, design rationale, the imagination of a future design, and behaviors of software design through to implementation, training and documentation [39]. In this study, this approach was used to extract user requirements to be used for modeling and design tasks [150].

The scenario approach is here used to provide a picture of or a story describing unforeseen events. This approach supports reasoning in the design process as well as stimulating modelers’ imagination. It lies between the arguments and reasoning in the specific details or examples. For this study, this approach is organized in two ways: individual and collaborative environments. Surprisingly, in a collaborative environment, this approach opens the doors for detailed discussion and understanding. In the end, it leads to a complete and correct design that can directly strike a useful balance between relevance and rigor in a practical way [294]. This method is common in software engineering and object-oriented design approaches. It results in an informal narrative, from which formatted texts are created, such as use cases.

2.0.3 Modeling approaches

There are two perspectives when modeling a business solution: process modeling and data modeling. Process modeling considers business activities, whereas data modeling considers the data that the business needs to complete its operations.

The data in data modeling approaches such as Object Role Modeling and Entity relationship diagrams are captured from well-defined inputs such as interviews, observation, meetings, or studies of the existing documentation. These fall into
four main types: (1) real world abstractions (2) real world occurrences (3) design abstractions and (4) design occurrences [223]. The process modeling technique is often known as activity modeling. It aims at determining what is being done and what should be done. There are five main concepts used to understand the activities of a business: (1) the activity itself, (2) the event, (3) the source/sink, (4) the data store, and (5) the data flow. Process modeling is represented diagrammatically using: (1) the activity decomposition diagram, (2) the data flow diagram, and (3) the business dynamics diagram. These diagrams represent the business activities of the data they use, and they are mostly devoted to the specification of causal and conditional links between business operations [17]. However, these business operations depend more on certain conditions, where the availability of the data describing system behaviors might also be a challenge. As a result, some details must be omitted during the modeling process to avoid model complexity, inaccuracy and the ramifications of the model [98].

This research used focus group discussion to exhibit real-world perspectives for requirement elicitation exercise. We followed these perspectives to give a complete picture of the issues and thus providing opportunities to derive more deliverables. The real-world occurrence approach tends to be less error-prone than other methods, since it is less reliant on user memory, especially when combined with the real examples [223]. This research used data modeling due to its static feature in querying the domain from conceptual view points, whereas the process modeling can be utilised to present business activities from general to detailed.

2.0.3.1 Object Role Modeling

The Object Role Modeling (ORM) is a method we used in this study to extract user voices from the conceptual level. The method has an ideal feature for developing and validating conceptual data models with domain experts.

Other data modeling methods that exist are Unified Modeling Language (UML) and Entity Relationship Diagrams (ERD). Both techniques are used to extract user details from conceptual level [47]. However, ERD and UML have shown some limitations in previous studies. The ORM is attribute free, whereby UML and ERD are attribute based in conceptualizing a domain [104]. Attribute based modeling is complex and unstable since they focus on data and their interrelationships. Furthermore, the ERD provides no information about the functions that use the data. Therefore, it is not easy to involve users in validation of ERD and UML models.

The UML is an object-oriented approach to facilitate software modeling. The UML technique includes diagrams like use cases, static structures (class and object diagrams), and behavior (state-chart, activity, sequence and collaboration diagrams). However, for the data modeling, UML uses class diagrams from which constraints in a textual language may be added. Although class diagrams have more features for implementation details (e.g. navigation and visibility indicators), the diagrams can be used for analysis or to provide an Extended Entity-Relationship (ER) notation. In addition, the ERD model is used as a basis for the unification of different views of data: the network model, the relational model, and the entity set model. Though both UML and ERD facilitate software data mod-
eling, they are arguably less than ideal for developing and validating conceptual data models with domain experts [101].

2.0.4 Driver Pressure State Impact and Response (DPSIR)

The Driver Pressure State Impact and Response (DPSIR) framework is an interdisciplinary tool for environment analysis. This tool analyzes cause-effect relationships between interacting objects. The DPSIR framework is widely used in the field and has many interlinked components such as environment [38, 80, 293]. It is used to address changes happening and the trends associated with it. It is used to identify priorities and to find the most efficient response measures.

In this study, the DPSIR framework is used to identify components that influence e-government implementation. Then, before modeling took place, the DPSIR framework was exploited to draw attention, where drivers (ICT infrastructure) and pressures (ICT services) are mainly a focal point in setting target goals and maximizing the intended purposes. The DPSIR framework was employed to structure the analysis and the linkages between cause-effect relationships [80]. Dealing with interacting objects and identifying priorities, the implementation of e-government can focus on the most efficient response (government) to attain higher impact (citizen) during project implementation and sustainability.

2.0.5 Conclusion

This chapter presented and defined some terminologies used in this thesis piece. The terminologies are directly linked with the methodologies used in this study. Some methodologies defined here include requirement elicitation, scenario-based approach, Modeling approach, and DPSIR framework. These terminologies were defined for the sake of clarity and enhancing understanding of the discussion presented in the later chapters. The terminologies described here also help to acknowledge and show usefulness and the contribution of other previous studies to the related area of my research. This will help the reader to gain an incandescent light and insight into the core ideas presented and discussed in this thesis. In the following chapter, this thesis explores the concept of e-governments and their implementation requirements using the DPSIR framework.
Chapter 3

e-government implementation requirements

This chapter describes core components that influence e-government implementation. E-government context is made up of five key components: government, infrastructure, services, deployment and citizens. The relationship between these components is linked in DPSIR framework (Driver, Pressure, State, Impact, and Response) that shows causal relations between these components. Understanding of the components that encompass e-government context is a core factor to achieve sustainable e-government implementation.

This chapter answers the research question RQ1: What are core variables for public system implementation, and how do they influence project deployment?

Abstract

The evolving nature of government operations and the evolution of new technology bring alternative ways for a government to serve its citizens. Many government organizations are in a transition state of shifting from human based services into electronic services. An electronic service is a terminology that describes e-government as a whole. E-government is the use of Information and Communication Technology (ICT) in a government to improve information flow and service reliability. ICT technologies provide for a dramatic evolution in economic, health, education, and agricultural applications. Consequently, ICTs allow government administration to strengthen service delivery to its citizens. E-government has been well established in developed countries. However, its implementation in low infrastructure countries is still suffering resistance which impedes its full deployment in the
CHAPTER 3. E-GOVERNMENT IMPLEMENTATION REQUIREMENTS

government organization. Despite various governments’ efforts to emphasize on the use of ICT, sustainability of underlying e-government projects is facing daunting challenges. This is especially the case in low infrastructure countries. This situation negatively influences the maturity of e-government, which is lagging far behind the maturity of developed countries.

Various studies have previously been undertaken to identify root causes of failure of e-government projects, such as user satisfaction, cultural differences, digital divide, and government policy problems. As a result, frameworks, models, and processes have been developed specifically to ensure successful e-government implementation. E-government component relationships form a dependent bond in the e-government implementation context. However, the importance of this fact is not always recognized by researchers. This study proposes a conceptual framework for e-government implementation in a low infrastructure situation. The framework integrates its constructs from the DPSIR model (Driver, Pressure, State, Impact, and Response), the e-government maturity model, the Technology Acceptance Model (TAM) and the SERVQUAL model to obtain a sustainable e-government implementation. Furthermore, the framework identifies five critical success factors (infrastructure, service, deployment, citizen, and government) in e-government implementation. Mapping the DPSIR concepts to the critical success factors for implementation leads to the proposed framework, having infrastructure as driving force, service as pressure, deployment as state, citizen as impact, and government as response. The framework can be used as a basis for e-government implementation. However, the internal organization of the implementation process at the administrative level should be well organized to engage both government officers and the citizen as end-user. This chapter suggests that using the ICT Roundtable process can increase user engagement and successful usage of e-government application.

Keywords: e-government, Sustainability, low infrastructure, DPSIR model

3.1 Introduction

E-government is the use of Information and Communication Technology (ICT) in a government to improve information flow and services [191, 290]. The evolution of ICT use in government operations intends to address transparency, accountability and openness in public sectors. ICT is the instrument to achieve the advantages of e-government. E-government has been well established in developed countries. However, its implementation in low infrastructure countries is still suffering resistance to achieve its full deployment in the government organization [145]. Infrastructure is a broad term that defines the basic facility related to economic performance [258]. Low infrastructure countries are those countries with limited fundamental facilities such as in the areas of communication, transport and electricity. The infrastructure itself makes a dramatic contribution to the social development; that is why many developing countries are lagging far behind in achieving economic development goals [33].

Despite various governments’ efforts to emphasize the use of ICT to its offices,
sustainability of e-government projects is facing daunting challenges. About only 15 percent to 45 percent of information system projects in industrialized countries were successful by 2001 [111]. This situation negatively influences the maturity of e-government [109], which is lagging far behind the e-government maturity of developing countries [71]. In this study, the term e-government sustainability is defined as the integration of new and existing practices to improve and deploy ICT technology usage for a long time period. Sufficient resources, human capacity and effective system design are the key factors that contribute to sustainability of projects [145]. Many organizations have been motivated to sustain the use of electronic systems in government organizations. Benchmark measurement is one strategy used to evaluate and compare the development of e-government operations of different countries. The use of these benchmark measurements have appeared in reports such as the United Nations e-government reports [264, 265, 290] and the ITU (2009) report on measuring the information society. Similarly, the sustainability of e-government implementation has been highlighted since the beginning of the last decade and places more emphasis on implementing the 2030 United Nations agenda. In this study, the DPSIR concepts are used to meet the sustainability challenges. The DPSIR framework is a useful tool to shape a sustainability strategy in a large context [80]. The DPSIR framework is used to bridge the gap between the use of ICT to improve government and governance (e-government) and the use of ICT to foster sustainable development known as ICT for Development (ICT4DEV).

Several models have been developed in the literature to facilitate the success of new technology adoption. Understanding of the process by which new technology is adopted becomes a continuous process since innovations always emerge to solve social problems. Literature shows that, Technology Acceptance Model (TAM) [61], Diffusion of Information model (DOI) [224], SERVQUAL model [200] and Theory of Planned Behavior (TPB) [9] are frequently used models to get an insight into understanding opportunities and barriers of e-government service deployments. These models try to conceptualize the complex behavior of e-government deployment processes. DOI theory describes the individual decision, the adoption of information gathering and process uncertainty reduction to evaluate new technology [224]. However, DOI theory was tested, and only three factors were most supported by empirical studies [8]. Technology Acceptance Model (TAM) evaluates user belief with respect to information technology use [61]. The technology use starts from the intention to use any technological service and afterwards becomes the behavior. The TAM model underlined that perceived usefulness that is related to system performance and perceived ease of use of technology increased the system use behavior. Empirical analysis of TAM model reveals that it is the parsimonious model widely used in electronic applications [270].

In addition, individual behavior of accepting electronic system use is related to the quality of services. Measuring quality of electronic services provides clear insight into citizen perspectives on using them. SERVQUAL model is a model that evaluates the quality of service [200]. Service quality can be described by two terminologies: functional attribute and technical attribute. The functional attribute describes how the service is being delivered, and the technical attribute describes
what service is being delivered, but these two attributes are difficult to separate. They can only be distinguished by user perception and expectation. Consequently, SERVQUAL model is the model that is also used to measure service in five dimensions: tangibles, reliability, responsiveness, assurance and empathy [200].

Moreover, understanding user behavior and service characteristics cannot be enough to enhance e-government development. There is a need to understand the current situation of electronic use and deployment in a given country-state. The maturity model reflects the innovation of ICT and electronic use growth of particular states and regions. There are many e-government maturity models such as Layne and Lee [155] and, Watson and Mundy [283]. Indeed, the Layne and Lee model is the most cited model. Layne and Lee construct the model into technological and organizational perspectives from simple to complex, and from sparse to complete. The maturity model identifies four dimensions: 1) Catalogue (information); this dimension provides online information about the services; 2) Transaction; the organization provides interactive communication that creates active citizen participation; 3) Vertical integration; links a local system to higher levels of government of similar functionality; 4) Horizontal integration (sharing); in this stage the integration combines heterogeneous systems and shares common information to achieve one-stop shopping centers.

There exist some studies that have a potential contribution to e-government sustainability for developing countries. Moens proposes the ICT Roundtable process to overcome the sustainability problem, especially for project development in developing countries [179]. He argues that using the ICT Roundtable approach stimulates sustainability and scalability of ICT innovation processes. This approach perceives technological infrastructure and ICT equipment explicitly and hence is an adequate metaphor of internal organization during the e-government implementation process. Aagesen et al, on the other hand, designed a model for cross-country infrastructure service and suggested that, governance, method and guidelines, infrastructure components, services and citizen are components that work together to enhance e-government implementation [3]. The model was designed to compare cross-country business processes, hence architecture, methods, standards and guidelines were major concerns. Lenk and Roland consider e-government implementation in four perspectives; citizen (named addressees), process (named re-organization), cooperation and knowledge. In their study, they restrict themselves to the basic components of e-government [158]. We think that the contribution of government in terms of policy and regulation to achieve a successful implementation is an obvious extension.

The literature review of e-government development and sustainability found a number of research themes that have been repeatedly discussed. The theme includes citizen, government and infrastructure [122]. Many researchers try to find better solutions by using different approaches, yet no method has been proven to guarantee a sustainable solution, especially for low infrastructure countries. In this study, a conceptual framework for sustainable e-government implementation is proposed; our proposal exploits the strengths from the TAM model, the SERVQUAL model, the e-government maturity model, e-government benchmark measurements and the DPSIR model. The framework centers on sustainability
3.2 Design motivation

Relevant studies were critically examined and analyzed to provide an appropriate solution for the e-government sustainability problem in low infrastructure countries. Infrastructure, citizen, service, deployment and government were chosen based on literature that shows their importance and their contribution to e-government deployment [4, 24]. In-depth analysis from various models revealed that Technology Acceptance Model (TAM), SERVQUAL [200], maturity model [156] and e-readiness benchmark measurements [31, 50, 265] are relevant for this research. TAM and SERVQUAL models describe characteristics of citizen and services; maturity model is related to deployment attributes and the DPSIR model is used to formulate causal relationship between components. Table 3.1 illustrates a design approach of this research.

3.3 The proposed conceptual framework

The framework takes into consideration the Information and Communication Technology (ICT) for sustainable development in a broad context for both government and citizens. The framework employs DPSIR to enhance effective use of ICT to bring changes in the social and economic development of a country. It describes component interconnection and relationship for sustainability. The existing challenges, such as efficient relationships, inclusiveness and collaboration behavior in implementing sustainable e-government services [69], have motivated the development of this conceptual framework. The proposed framework, therefore, combines some existing theories and frameworks that have been proven by empirical data. Variables applied to the proposed model are culled from multiple frameworks that have previously been shown to have impact on some of the sustainability aspects of e-government project implementation. The proposed design employs the DPSIR concept to enhance the component relationship in order to correct the existing gap. By combining various strengths of existing models, our goal is to offer a framework that inherently promotes sustainability in e-government projects implementation, especially for countries with low ICT infrastructure. The proposed framework (see Figure 3.1) represents five prominent components: government, citizen, deployment, service, and infrastructure. The arrows between the components describe causal relationships. In the following sections, we present and discuss the elements of the framework.
3.3.1 ICT infrastructure

ICT Infrastructure consists of physical facilities and equipment to carry out e-government activities. The term ICT infrastructure classifies the economic activities that are related to Information and Communication Technology. It includes communication channels and all available ICT equipment, both hardware and software [161, 130]. ICT Infrastructure is the fundamental need of an e-government implementation that keeps e-government applications up and running. Its importance has appeared in several studies such as the SERVQUAL model [200] and benchmark measurement for e-government readiness [264, 245]. It is considered as a tangible attribute in e-government measurements. ICT infrastructure is referred to as the ‘driving force’ (D) in the DPSIR framework. The infrastructure has a critical role in enabling and delivering e-government services.
3.3. Services

A service is sharing of information or data between government agencies, departments or organizations. It is widely used to support e-government activities by improving communication, data access and data sharing. In an electronic environment, services can be accessed electronically instead of face to face. The design of service attributes is based on the SERVQUAL model. The model describes how the quality of responsiveness, reliability and security are among core factors that are perceived by the user in judging the quality of the service [200]. The infrastructure may affect the quality of services expected by users, although the poor quality of services may also reduce the effectiveness of infrastructure use [161, 149]. Service reliability, responsiveness and security are the core factors of service quality and e-government success [253]. This attribute corresponds to the DPSIR attribute

Figure 3.1: Conceptual framework for e-government sustainability
3.3.3 Deployment

The deployment element fits with the DPSIR model as the ‘state’. In the proposed framework, it describes the status of e-government development within an organization and country at large. Information, transaction, integration and sharing are maturity stages that are represented the most in literature [156, 211]. The maturity model stages describe the deployment component in the proposed framework. Based on the DPSIR model, the state does not have direct impact on the framework components. Still, it represents the collective influence of ICT infrastructure, government, citizen and service towards e-government deployment stability.

3.3.4 Citizen

Citizens are the primary stakeholders of e-government activities [237, 41]. Consequently, their acceptance of an e-government project plays a vital role in e-government success [122, 169]. The citizens are the ones who perceive e-government advantages [197]. Engaging them into the development of e-government services creates an atmosphere of active participation in electronic use [241]. Service and ‘infrastructure’ influence citizen behavior in electronic use. In this chapter, usefulness, ease of use, and trust represent citizen acceptance criteria, categorized as the DPSIR ‘impact’ attribute (I).

3.3.5 Government

Government is a statutory body to control in a country or state [34]. Its primary role in e-government implementation is to ensure the proper legal framework for e-government operation is in place. Policy, plans, strategies and regulations are government communication tools in e-government implementation and sustainability. Government preparations and decisions towards technological changes have a significant impact on the adaptation of emerging technology [51, 211, 232, 264]. In the proposed framework, government is categorized as the DPSIR ‘response’ attribute (R) that controls infrastructure, services, deployment and the citizen. The legal framework should cover every component in the framework for sustainable e-government development [51, 232, 264]. The government can do more to promote e-government sustainability, such as risk management research to reduce numbers of e-government project failures [232, 258]. Therefore, the government is an intermediary coordinator through legislation and regulatory regimes.

3.4 DPSIR theory and causal relationship

This study adopts the DPSIR (Driver-Pressure-State-Impact-Response) framework [80]. DPSIR is a causal framework that we use to describe the interactions between e-government elements. The DPSIR framework has a significant influence on social and economic development. The framework is very prevalent and has
3.4. DPSIR THEORY AND CAUSAL RELATIONSHIP

been used widely in many applications including biodiversity, climate change and sustainable development, because of its transparency and simplicity [38].

Furthermore, the DPSIR framework is a flexible framework that can support decision-makers to make better decisions. According to DPSIR, the driver attribute (D) is a development activity that corresponds to changes in life and fulfils human needs. Sometimes, human activities can put pressure (P) on the environment. The pressure caused by society may lead changes in state. The state (S) is the changes in quality and functions on the environment. The impacts (I) affect well-being due to environmental changes. Finally, the response (R) is an action taken to adapt to the changes. The response from individuals, social groups or government seeks to control D or P [80].

DPSIR has been used diversely to overcome sustainability issues [293]. The DPSIR framework is a proper tool for this purpose because it will help to create the link of e-government components in sustainability implementation. Causal relationships of the DPSIR model enhance the communication between stakeholders (government, citizens). Including the DPSIR concept in the proposed framework in this chapter will ensure the integration of existing and new processes to deploy electronic service use for an extended period and the success of e-government projects.

3.4.1 Causal relationships of framework components

The proposed framework describes five interlinked components that embrace e-government sustainability in the DPSIR perspective: ICT infrastructure, service, deployment, citizen and government. The framework shows direct links from the government to infrastructure, service, deployment and citizen. Their relationship is noted as a response, such that government reaction is significant to e-government implementation and sustainability [3]. Figure 3.1 shows four main relationship combinations that enhance e-government implementation. The primary relationship is government-infrastructure-service-deployment-citizen; followed by government-service-deployment-citizen, then Government-deployment-citizen, and finally Government-citizen relationship.

The government, as a component of the framework, reacts to all other components as a response caused by the technological and human challenges. Consequently, e-government implementation requires the citizen to be involved in every government relation (infrastructure, deployment and service). All four relationships described in the above paragraph emphasizes the needs for citizen involvement for sustainable e-government implementation. More emphasis should be placed on government and citizen relationship. This relationship is bidirectional, which requires collective agreement during the decision-making process of e-government implementation [178, 241]. The proposed framework realizes infrastructure as the foundation of e-government implementation. It is a component that relates to all e-government components. The infrastructure has a direct relationship with the service component because it is a host to support and run electronic services.
3.5 Model implementation strategies

The proposed framework was designed specifically for low infrastructure countries. Low infrastructure countries are far behind the developed countries in e-government development [290]. The framework will be used as a tool to analyze the e-government implementation and development changes during execution. The majority of developing countries who are UN members have a necessary infrastructure [290], enough to be used as a starting point to full e-government deployment. A useful strategy for success is to have a plan that shows an overall sketch of the implementation divided into workable phases, which is simple and low risk; to learn from previous challenges; and to apply the achievements to enlarge the project [195]. The Delta Nigeria, step 2 mentioned “think big, start small and progress fast” [195]. Utilizing the available infrastructure can help to improve the current e-government situation very quickly, as smart strategy promotes success [130].

Service consists of all activities designed by government for its citizens. Stakeholders from different backgrounds (education, economy, and physical ability) are expecting standard functions more or less than traditional services from the government. There exist some challenges for this achievement concerning requirements and stakeholder satisfaction at an individual level [290]. However, these challenges can be minimized when stakeholders are involved in the development process. In enhancing active involvement during the development process, some tools have been used like ICT Roundtable by Nic Moens [178]. This tool can be used to achieve acceptance criteria, while quality of the product is preserved [149, 295].

The infrastructure is characterized by high responsiveness, reliability and security measured at the back office workflow [211]. Indeed, citizens are the ones who perceive service quality. A successful back-office workflow leads to e-government service deployment observed directly from citizens and users of a system [130]. The deployment reflects the current phase of e-government maturity. E-government maturity is the progressive growth of e-government in the country from the lower level to the higher level of ICT use in a government. It defines the states into information, transaction, integration and sharing of government services. The deployment of the e-government development process allows benchmarking of the states of the services on a time basis. However, the environment in which e-government operates increases in complexity as advanced use of ICT increases, and the collaboration within and beyond public sectors also increases. In achieving the maturity stage of e-government use, stakeholders from different government offices should be involved as well as the use of advanced ICT tools [140]. Furthermore, coordination within government organizations, ICT infrastructure consolidation and standardization, collaboration of e-government partners, e-government marketing and global business development should be emphasized.

This chapter proposes a framework for e-government implementation by demonstrating the causal relationships for components that influence implementation. These components are government, infrastructure, service, deployment and citizen. The framework structure has emphasized a significant relationship between government and citizens. Taking into consideration all five components for e-government
3.6. CONCLUSION

Implementation can lead to sustainable government service delivery. Moreover, deployment and citizen components react to the results of e-government implementation. Their reactions have a direct impact on e-government exploitation. These components are essential parameters to achieve e-government implementation success. Furthermore, the ICT Roundtable approach is a useful approach to handle internal e-government matters.

3.6 Conclusion

The use of electronic services helps to increase efficiency and to reduce the cost to the government. Several frameworks have been developed, such as Technology Acceptance Model, Diffusion of Information model, SERVQUAL model and Theory of Planned Behavior (TPB). These frameworks quantify particular components of e-government implementation and sustainability. This study proposes a framework that highlights components’ inter-relationship for e-government implementation and sustainability. The framework describes how government, infrastructure, service, deployment and citizen are constituent parts of an electronic government implementation process. The relationship between elements with corresponding attributes in this framework allows flexibility in an e-government implementation process that also stimulates e-government sustainability. This chapter also extends the DPSIR framework to a new perspective of e-government implementation. The DPSIR was used to enhance ICT use for e-government development and sustainability.
Chapter 4

The situation in Zanzibar

This chapter consists of two parts. The first part describes the characteristics of the target country, Zanzibar, about the introduction of e-government. Zanzibar is not only the target country of the intended platform for the application, but also a responsible country to design, develop and maintain its own e-government application. Thus, we describe the cultural aspects of Zanzibari’s using Hofstede framework to characterize national and organizational cultural elements. The second part of this chapter describes the country readiness for e-government introduction. We use SWOT analysis for this aspect.

Section 4.1 partly answers the research question **RQ2**: How to characterize the cultural identity of a country and of an organization in general, and for Zanzibar in particular?

Section 4.2 answers the research question **RQ3**: What is the current condition for e-government implementation in Zanzibar?

4.1 Cultural issues

The introduction of new technology in any environment is always challenging. The main concern is about the nature of technology and its originality, particularly for receiving community and its traditions. In developing country’s perspective, most of the technologies are inherited from developed countries. These countries have different cultures, organizational setting and resources. This trend is the main reason of the exiting gap between the information system design and local users. As a result, many information system projects were established, but only a few have been entirely successful [111]. For this study, understanding cultural behavior is an advantage for project implementation and success.
CHAPTER 4. THE SITUATION IN ZANZIBAR

4.1.1 Cultural characterization

Cultural challenges increasingly are essential for researchers, especially in the introduction of ICT. Their due consideration in the early stages of project development brings about a mutual understanding required for a successful designed solution. These challenges are regularly visualized during the social interaction and communication relationship. The interaction between public and authority, the individual contact in a social group, and the way of dealing with uncertainty and ambiguity are some instances of communication between different groups. The Hofstede model [91] is a broadly accepted model for understanding cross-cultural communication. This model uses the following six dimensions: (1) power distance, (2) collectivism versus individualism, (3) feminity versus masculinity, (4) uncertainty avoidance, (5) long term orientation versus short term orientation and (6) indulgence versus restraint. These dimensions are used in several fields as a paradigm for studying cultural identity and for getting a quantified impression. The following paragraphs introduce them in brief.

**Power distance** focuses on the unequal distribution of power between members of the society, and the extent of this inequality is visible and perceived. A high power distance indicates a hierarchical structure where superiors and subordinates are existentially unequal. This inequality gap can be seen in the workplace, where the power is centralized in the hands of a few, and it might prevail over rights of others.

**Collectivism versus individualism** dimensions explores societal attitudes between *I* and *we* behavior. The family and society relationship in a country with a collectivistic culture are staunchly loyal. As a result, the interests of the group prevails over the benefit of the individual. On the other hand, in the countries where individualism prevails, individual interests hold more of collectivism and believe in harmony and consensus as an ultimate goal in society [91].

A *masculine* society is driven by competition, achievement and success, while a *feminine* community measures success based on the quality of life. The feminity versus masculinity dimensions is sometimes referred to as *tough versus tender*. In contrast to the feminine society, a masculine society has distinct gender roles. Also, countries scoring higher on the masculinity dimension tend to have an active manifestation of cultural values.

**Uncertainty avoidance** defines how society handles uncertainty about the future. A country with low uncertainty tolerance creates robust mechanisms to control the future rather than waiting for it to happen. Nations with a high uncertainty avoidance tend to be intolerant to unusual behavior, whereas those scoring low on this dimension tend to be more reluctant with practice than the principle.

The **long term orientation versus short term orientation** dimension measures the way society considers past experiences in dealing with current and future challenges. Societies with a high short term targets tend to have a normative orientation. They prefer to maintain local traditions and norms and view societal changes with suspicion. A society with high long term orientation uses a pragmatic approach and encourage modern education as a mechanism for future preparation.
**4.1. CULTURAL ISSUES**

*Indulgence versus restraint* defines human life gratification. The indulgent society allows relatively free gratification in enjoyment and fun, where the restrained society is strictly gratified on social norms.

Using the data from Hofstede website we compare the scores on these dimensions for some countries, including Tanzania and Zanzibar in particular [74]. From Figure 4.1, it can be deduced that the power distance dimension in developed countries tend to score lower and have a high score on individualism. The other dimensions show more variation between developed and less developed countries.

![Figure 4.1: Comparing some countries](image)

The scores for Tanzania (and thus also related to Zanzibar) on the Hofstede cultural dimensions, obtained from [73], are summarized in the following table:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>power distance:</td>
<td>70</td>
</tr>
<tr>
<td>individualism:</td>
<td>25</td>
</tr>
<tr>
<td>masculinity:</td>
<td>40</td>
</tr>
<tr>
<td>uncertainty avoidance</td>
<td>50</td>
</tr>
<tr>
<td>long term orientation</td>
<td>34</td>
</tr>
<tr>
<td>indulgence:</td>
<td>38</td>
</tr>
</tbody>
</table>

According to these data, Tanzania has a high score on power distance and a low score on individualism. On the other cultural dimensions, Tanzania has an average rating. These characteristics can explain the essential similarities in the typical social behavior of Zanzibari people. In high power distance country, open discussion about policy development seems less likely (see [136] and [238]). Besides, a collectivistic society has strong relationships between its fellow members. This characteristic shows the tendency for maintaining traditional culture [116]. Eventually, Tanzania score uses short term orientation and restraint. This is influenced by its political structure supported by social norms and culture [266, 60].
4.1.2 Organizational culture and governmental influence

According to the online business dictionary, the organizational culture is defined as:

*The values and behaviors that contribute to the unique social and psychological environment of an organization. It includes an organization's expectations, experiences, philosophy, and values that hold it together, and is expressed in its self-image, inner workings, interactions with the outside world, and future expectations. It is based on shared attitudes, beliefs, customs, and written and unwritten rules that have been developed over time and are considered valid (see [284]).*

Organizational culture is a system of shared values, beliefs and principles which govern organizational members to perform their jobs. The organizational culture is highly influenced by national culture and acts on the way the organizational members think and work for their organization. Organizational culture is maintained not only in the mind of its members, but also in the spirit of other stakeholders such as customers, suppliers, authorities and the press. Hofstede [117, 91], and in website [75] described the organizational culture by the following six dimensions:

1. **means-oriented vs. goal-oriented**: this dimension positions an organization on how employees identify with *how* (means-oriented) versus *what* (goal-oriented).

   Focusing on *how* tends to encourage people to avoid taking risks. On the contrary, the focus on *what* prepares people to take risks to achieve the goals of the organization. This dimension, therefore, is related to the effectiveness of the organization and the way organization performs its activities.

2. **internally driven vs. externally driven**: this dimension measures employees perceive their task in the external world.

   Externally driven employees tend to restrict themselves on satisfying the customer needs pragmatically. Internally driven employees tend to focus on ethics and honesty to try to do what they think is best for the customer in particular and the world at large.

3. **easy-going work discipline vs. strict work discipline**: This dimension measures the amount of internal structuring, control and training in an organization.

   An easy-going culture allows for improvisation, which is essential when surprises may occur. Strict discipline is required when the organization needs a tight control. In such a culture, employees are cost conscious, punctual and serious.

4. **local vs. professional**: In a local organization, employees feel connected to their boss and organizational unit; they identify themselves by their profession. In this environment, there is an active social control for the employee to act accordingly. Such employees tend to be short-term directed and internally focused in terms of the organization.
5. **open system vs. closed system**: this dimension indicates how open the organization is for newcomers. In an open system, newcomers are welcomed, but a closed system is more averse to them.

6. **Employee-oriented vs work-oriented**: this dimension is most related to the management philosophy for the organization.

   In an employee-oriented culture, the organization takes responsibility for employee welfare, and thus staff members may bring personal problems hindering their performance. In a job oriented culture, the employees experience intense pressure to complete the job irrespective of their welfare.

7. **employee-oriented vs. work-oriented**: this dimension is most related to the management philosophy for the organization.

   In an employee-oriented culture, the organization takes responsibility for employee welfare, and thus staff members may bring personal problems hindering their performance. In a job oriented culture, the employees experience intense pressure to complete the job irrespective of their welfare.

During the various stages of the development process, different organizational cultures may be required. For example, during the modeling phase, means-oriented culture may be more effective, while during the coding period, a goal-oriented culture has more potential. Also, when introducing new technology, newcomers may be required. An open system then is more beneficial. However, we discuss this concept in detail in the next section.

The extent to which an organizational culture is possible depends (also) on the general characteristics of the people, as described by the cultural Hofstede dimensions in the previous subsection. For example, the **means-oriented vs. goal-oriented** dimension correlates with power distance. A country with a higher power distance are more successful when following a process orientation approach. The organizational culture of Zanzibar has been described in [238] as hierarchy and clan-based ad-hocracy with market culture. So far there do not seem to be studies of the Hofstede organizational cultural dimensions in Zanzibar (or Tanzania). For the purposes of this chapter, it is sufficient to have a reasonable impression of these dimensions, since our purpose is on studying the effects of these dimensions on the project development process. In this chapter, we depict Zanzibar as a means oriented (process based) and local (parochial) organizational culture, while on the other organizational dimensions Zanzibar has a middle score.

### 4.1.3 A characterization of Zanzibar

It is essential to give a brief overview of the government structure that has a direct influence on e-government success to understand the key stakeholders in e-governments in Zanzibar. Tanzania is formed of two countries - Tanganyika and Zanzibar. According to the World Trade Organization (WTO), Tanzania is on the UN list of least developed countries [262].
Zanzibar is a semi-autonomous part of the United Republic of Tanzania. Zanzibar consists of 2 islands: Pemba and Unguja (see Figure 4.2, obtained from Google Maps). According to the census of 2015, Zanzibar has a population of 1.3 Million [42]. Its geographical location has played a significant role in its history and cultural heritage, with considerable influence from colonialism [289]. The colonization influence is still predominant for Zanzibar; demographically. Zanzibar is described as a multi-cultural nation, with various ethnic groups from African, Arab, Indian and European nationalities [160, pp.71]. Total of 236 Shehia within ten districts distributed in 5 regions [252]. Zanzibar’s primary industries are spices, raffia, and tourism. The political instability, however, makes the country vulnerable [128].

The Revolutionary Government of Zanzibar consists of the Revolutionary Council and the House of Representatives. The paramount role of the Revolutionary Council is to advise the President of Zanzibar. The house of representatives of Zanzibar is a legislative organ in Zanzibar and has the function of legislating, oversight and presenting legal matters [215]. The House consists of 81 Seats from which fifty members are elected from their constituencies; ten members are appointed by the president, twenty members are individual seats for women and attorney general. Zanzibar government implements three tire authorities from central government to the local authority. The local authorities have a direct connection with the community. UNDP reported that Zanzibar has a total of 236 shehia within ten districts distributed in 5 regions [263]. Zanzibar’s primary industries are spices, raffia, and tourism. The political instability, however, makes the country vulnerable [134].

Religion plays an important role in Zanzibar. About 97% of the Zanzibari’s practice the Islamic faith. The remaining part is a combination of Hindu and Christianity. This percentage has a strong influence on the national culture and the development of the country [7].

Apart from political, economic and social factors, education has a massive influence in defining social culture. According to Nelson Mandela, education is the most powerful weapon which you can use to change the world. The various environmental learning factors are a significant cause of social life variation. The knowledge base that is learned and experienced during education is a solid base
during adult life, but after that, it is difficult to adapt to changes. There is no typical educational structure for each child, leading to differences not only in personal behavior but also in how people think of new challenges and how they express themselves about such issues. Besides, national, social and family attitudes are highly significant to the implementation of new strategies such as prioritization and decision making.

In Zanzibar, higher education enrollment, females are outnumbered by their male counterparts. This phenomenon is also visible in the employment sector[159]. This trend is an example of a high gender disparity of socialisation, which can be related to a high score on the power distance cultural dimension and a high score on masculinity in Zanzibar. This finding implies that Zanzibar is a nation of social norms that deals with uncertainty[228]. Its social life is that of collectivism where families live as one community, and they look after each other [132]. These scores are upholding stereotyping notions of masculinity to an enormous burden of care for the women and delimit jobs involvement [165, 60, 25].

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4.2 E-government and readiness analysis

E-government is considered as a new model of administration and management in the government sector. In the implementation of e-government applications, governments are seeking efficiency, effectiveness, and improvement for data quality. Subsequently, the governmental administration and the general front end services dominate the application arsenal. However, applications of ICT towards policy development and customer involvement are not entirely explored. There are more benefits for government activities to be linked to companies, citizens or even public officials in focus for further research and strategies on e-government. Though national priorities influence the growth of e-government implementation.

The development of ICT systems has tremendously changed the way governments interact with the public to deliver their core services. This advancement has caught the attention of not only software developers and consultant industries, but also an increasing number of researchers in policy institutions, and the public administration. As part of the enthusiasm on ICT in government, best practices and maturity models have been used to guide and benchmark e-government developments on the right track. Maturity models comprise not only ICT technology infrastructure but also ICT skills, government policies and plans. Other external entities, such as citizens and business organizations, are also essential components
in e-government evolution.

Various studies have proposed how to adopt ICT at the societal, organizational, and individual levels [103, 129]. Although assessing government readiness for strategic e-government implementation is an essential element in defining strategies, milestones and formulating implementation structures. Despite maturity models being used as tools to measure the growth of ICT in a government, country readiness is the most critical benchmark for planning e-government initiatives. The readiness analysis gives the general picture to understand the current resources and how those resources can be used as a starting point of e-government deployment.

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4.2.1 Maturity model

Various studies have described the maturity of e-government services [109, 135]. The maturity models range from three to six phases, based on technological complexity [126]. Layne and Lee are one of the few examples that have been cited frequently by various research communities. This model helps in analysing the level of electronic service use. It also helps to address the current practices and to identify challenges and obstacles that affect the improvements in the e-services provided from a society perspective. The four phases maturity model describes the evolution of e-government services from information, interactive information, transaction and data sharing. The information is the initial phase of e-government deployment, while data sharing is the highest [211].

Phase 1: Information

The first phase of e-government is information. It is all about accessibility of the information and relevant processes provided by the government agency. The primary objective of this phase is to put the information online to reduce administrative burden, decrease administrative cost and improve access to the services. When information can be accessed at anytime and from everywhere, it helps to increase transparency and enhance democracy. Online information should be relevant to the actual activities, and it must be up to date. An example of information that the government can disseminate is health and safety advice, rules and regulations, news and consultation papers, business yellow pages, geographical data, economic data, and more.

Phase 2: Interactive Information

The interactive information phase defines two-way communication between gov-
4.2. E-GOVERNMENT AND READINESS ANALYSIS

4.2.1.1 Preparation

The Information phase, described in phase one, is slightly improved; the interactive information is accessible and responsive to the users. The users here refers to both citizens and businesses. In this phase, users can download forms, upload documents, send emails and search from databases. Interactive information is more efficient and effective since a large part of information processing is controlled online. However, if payments or signing documents are required, then physical presence should be done to complete the process.

Phase 3: Transaction

This phase introduces online transaction, and it features previous phases (phase 1 and 2). The implementation of this phase needs more skills and technology of using ICT in government. In this phase, information personalization is implemented, and data security is increased to protect the remote transaction. This phase supports online tax payments, visa and passport application, licence application, online voting and many more.

Phase 4: Data sharing

Data sharing is the connection phase. It accumulates the previous phases (phase 1, 2 and 3) and connects government ICT infrastructure to form enterprise architecture. The enterprise architecture can optimize the IT resources (hardware and software) to reduce cost and improve information flow. A government can share information based on citizen rights defined in data protection and data privacy law. Sharing of data creates significant savings in public administration, ease procedures and reporting burden to the nation. [16, 211, 131].

4.2.2 Readiness analysis towards e-government implementation

Readiness analysis is an important starting point to understand the current situation for e-government initiatives. Besides, from the maturity framework, the SWOT analysis helps to predict the next step for e-government development progress. In this section, we discuss the position of Zanzibar for its readiness to introduce e-government. To achieve this, we perform a SWOT (Strength, Weakness, Opportunity and Threats) analysis in Zanzibar context, and then discuss the confrontation matrix. The confrontation matrix is the element of the SWOT analysis that combines internal and external factors.

4.2.3 Strengths and weaknesses

Since 2009 when the National ICT Broadband Backbone (NICTBB) was started there have been an enormous changes in the use of ICT in Zanzibar and Tanzania. This change was due to the effectiveness and reliability obtained by the International connection through undersea cable operated by SEACOM and EASSY. This implementation enabled Zanzibar and Tanzania mainland to start e-government initiatives [202, 187]. In Zanzibar, the government has made considerable efforts as preliminary steps for e-government initiatives [254] strategically, to establish effective use of ICT technology for both; private and public organizations [89, 192, 193].
Zanzibar government considers e-government as a vehicle to facilitate the implementation of its national development plan. Hence, government relevant plans include ICT policy formulation and implementation, enhancing the use of ICT in all sectors together with capacity building on the use of ICT. A successful introduction of e-government is highly dependent on a mature ICT infrastructure. The use of ICT was prioritized and emphasized in the Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP II) 2010-2015 also known as MKUZA II. MKUZA II is a tool that Zanzibar government deployed to realize country’s national development plan and Millennium Development Goals aimed at improving living standards and strengthen good governance. In this policy document, ICT is viewed as a significant issue in several places. This ambitious view on ICT is a strong point referred to as SP1.

Building an ICT infrastructure for e-government implementation is a government asset since the isles of Unguja and Pemba in Zanzibar are fully interconnected with fiber cable [254, 59]. The installation of the fiber cable in Zanzibar has increased data and voice traffic volumes, high security and promising data transmission at minimum cost, compared to traditional microwave transmission. At the moment of writing, the entire country has access to a fast Internet connection by fiber cable. Government has also started to provide services in both governmental and non-governmental sectors. For example, organizations that have discovered the opportunities and advantages of using the Internet include; The State University of Zanzibar (SUZA), Mnazi mmoja Hospital, Ministry of education, Office of The Chief Government Statistician, Zanzibar Broadcasting Corporation (ZBC) etc. This strong point is referred to as SP2.

Furthermore, the government has established an e-government office as a center dedicated to e-government projects and online service activities. The establishment of the center in Zanzibar simplifies e-government project implementation since all related issues, such as system security, control and monitoring, are placed at one stop center. We refers this strong point to SP3.

A District Health Information System (DHIS) has been established to record information for both public and private healthcare units in Zanzibar [164]. Health data is collected from the Primary Health Care Units (PHCU) to the Referral Hospitals; data are managed at the ministry level and used for decision making, planning of activities and monitoring of healthcare delivery. This project was designed by endless efforts from both facilitators and public health providers in various computer training and workshops that have been conducted (see [27]) to equip target users with computer literacy skills.

There are some electronic systems such as the Integrated Financial Management System (IFMS) that controls and manages public finances. The IFMS is typical stores financial information at the ministry of finance in Tanzania. The system strengthens the capacity of the country from the ministry level to departments and agencies. This system aims to improve expenditure management, though it is dependent upon private company to manage the system [1, 65]. For this analysis, the DHIS is used to represent other systems. If electronic systems run for more than five years, it is considered as a strong point referred to as SP4. The project was developed and funded by the University of Oslo, Norway. When
4.2. E-GOVERNMENT AND READINESS ANALYSIS

the project is funded by external agents, it is considered a weak spot and we refer it to WP1.

Rapid technological growth has an impact on both infrastructure and surrounding people who are affected by it. On the side of the infrastructure, it leads the country to the technological evolution in which the infrastructure is not fully prepared. This is weak point WP2. Surrounding people such as citizens, government and non-government officers may not have the skills to use ICT technology, and this is WP3.

4.2.4 Opportunities and threats

The submarine cable is a single point of failure. When broken, repair may be complicated. Internet access then is hindered, especially in some rural areas, since Zantel, the leading telecommunication company, has a weak coverage to these areas [292]. Breaking the cable is a threat and is referred to as TP1.

E-government implementation is not a new technology, many developed and developing countries have already experienced different scenarios as described in [79, 290]. There are reference sites for learning good practices. This opportunity is referred to as OP1. The openness of e-government creates a room for two-way communication between government and citizens. Rules and rights are open to everybody increasing transparency and service delivery. This opportunity is referred to as OP2.

Various professionals are available online for training people; learners may obtain a degree from many universities around the globe without attending class physically. With internet connection, individuals can engage with online studies in various institutions and universities that provide free online professional courses. The opportunity is known as OP3.

E-government reduces administrative cost and provides efficient service delivery. It reduces corruption, which is a critical challenge in many public sectors and improves the quality of leadership [144]. The use of e-government creates an opportunity for poverty reduction in developing countries. This opportunity is called OP4. On the other hand, the use of e-government needs very high consideration of data security without violating the trust of the majority. This threat is referred to as TP2.

Depending on how they perceive e-government and priority settings, Government officials may hamper the introduction of e-government. This is a threat, referred to as TP3. Furthermore, the exponential growth of technology enforces society to enter the digital evolution. The community should understand new concepts, such as information sharing and control practice. Unreadiness to adapt the changes is threat TP4.

4.2.5 Confrontation matrix and analysis

The confrontation matrix combines internal (strengths and weaknesses) with external factors (opportunities and threats). Table 4.1 indicates the relevancy of internal factors for external factors. We analyze internal factors with the external fac-
tors available in Zanzibar to have sustainable development towards e-government implementation. Particular combinations of strong points and opportunities are:

1. Policy SP1 - International OP1: Having government emphasis on the use of ICT to every sector available in MKUZA II and Zanzibar vision 2020 is an opportunity to have successful implementation. Moreover, the government has introduced the ICT subject to be taught from primary level to university education [216].

2. Connection SP2 – Communication OP2: Strong connection of Zanzibar districts and regions through fiber cable creates an opportunity for communication availability over the country. Government services can be accessed at minimum cost.

3. Department SP3- Cost Reduction OP4: Central services are required to be available 24/7 basis. The central office creates an opportunity to minimize running cost since there is no need to have duplicate resources of the same functions. Also, the centralised services help to enforce standard security policy over the country.

4. DHIS SP4 – International OP1: The success of DHIS project builds a substantial opportunity to implement other electronic projects.

The following combinations of weak points should be considered:

1. Dependency WP1 – Single point failure TP1: The government should formulate the future plan to handle any infrastructure failure. This plan is very important for Zanzibar that experiences electricity blackout for up to three months [106].

2. Infrastructure WP2– Security TP2: Infrastructure security is a threat to the e-government implementation system. Infrastructure implies physical and

<table>
<thead>
<tr>
<th>SP1</th>
<th>Policy</th>
<th>xx</th>
</tr>
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<tbody>
<tr>
<td>SP2</td>
<td>Connection</td>
<td>xx</td>
</tr>
<tr>
<td>SP3</td>
<td>Department</td>
<td>xx</td>
</tr>
<tr>
<td>SP4</td>
<td>DHIS</td>
<td>xx</td>
</tr>
<tr>
<td>WP1</td>
<td>Dependency</td>
<td>xx</td>
</tr>
<tr>
<td>WP2</td>
<td>Infrastructure</td>
<td>xx</td>
</tr>
<tr>
<td>WP3</td>
<td>Basic training</td>
<td>xx</td>
</tr>
</tbody>
</table>

Table 4.1: Confrontation Matrix
cyber security.

3. Basic Training WP3 – Adaptation TP4: The primary users of e-government system are citizens. If the society does not accept, the implementation won’t be smooth and may fail. People may reject the order if they do not have knowledge of using it [157]. Government should provide ICT training, workshops and seminars to the people and the stakeholders involved.

4.2.6 Conclusion

We use SWOT technique to analyze the current situation for e-government implementation that can help to predict the next step of the e-government deployment process. Zanzibar has many reasons to change from the current manual mode of service delivery to the electronic mode of service delivery to speed up economic transformation in the country.

To understand the existing situation helps to plan better implementation strategies. This analysis has highlighted various weaknesses and threats, but also explore many opportunities and strengths. Current weaknesses and threats should be considered to reduce implementation difficulties and enhance the sustainability of e-government implementation. Moreover, the opportunity and strengths is a stepping stone to achieve implementation expectations. Technological evolution conveys challenges, but lessons from other experienced countries are instrumental in reducing the implementation snags.

Considering strengths, opportunities, weaknesses and threats for e-government projects stimulates sustainability of e-government systems. This analysis reveals that, there is a tremendous opportunity for Zanzibar to adapt and employ e-government services.
Chapter 5

Domain modeling

This chapter describes a stepwise approach for domain modeling technique. This technique exemplifies Linguistic structure to construct domain knowledge. Using Object Role Modeling (ORM), the e-government conceptual model was extracted from the requirements document in Zanzibar case domain.

This chapter answers the research question RQ4: How can we model the conceptual structure of a complex domain by using natural language approximations?

Abstract

E-government implementation has received extra attention as a platform to strengthen country’s development. International organizations such as the ITU and the United Nations provide strategic guidance to overcome the challenges of ICT use. Researchers are contributing to support e-government implementation using models and theories. Yet, the development of ICT use in developing countries is still very low.

This chapter extends the DPSIR-based e-government conceptual framework into the direction of implementation strategies. The main focus is to improve stakeholder involvement during requirements engineering to improve on the successful implementation of ICT projects. There are two primary purposes of using Object Role Modeling (ORM): the first purpose is to develop semi-natural language (controlled language). This language is understandable for both domain stakeholders and system analysts. The second purpose is to develop a standard description of the application domain in this language. The result of the developed application domain is used to construct quantitative simulation tool, to be used by policy makers.

Keywords: Conceptual data modeling, Object Role Modeling, Manual service, Digital Service, DPSIR.
5.1 Introduction

Over the last decade, many efforts have been made to improve the use of Information and Communication Technology (ICT) in developing counties. International organizations such as the International Telecommunication Union (ITU) and the United Nations have been providing strategic guidance to overcome challenges of ICT use. Capacity building has been used as a strategic means to share ICT knowledge through the national and international community [229]. Yet, the development of ICT use in developing countries is still deficient.

Many projects are established, but few of them are successful [108]. As a result, the development of ICT deployment does not meet the expected goals, especially in developing countries. Currently there is a vast difference in ICT setting in developing countries compared to the world average. Data shows that internet penetration in developing countries is 7% of the households compared to the 46% world average [228]. Studies also show that failures of ICT project development are caused in particular by insufficient customer requirements and project specification [257, 180]. Also, requirements engineering is mostly ignored in the event of e-government solutions [11]. Both findings are strongly related to insufficient stakeholder involvement during the initial phase of project implementation [72]. As a result, the projects do not conform to requirements and lead to slow down e-government development efforts [291].

Stakeholders involvement has a significant influence on the success of any government project [72, 180]. Citizens, governments, ICT infrastructures, deployment and services are correlated components that have an essential contribution to e-government implementation. Using the DPSR (Driver, Pressure, State, Impact and Response) framework, those components exhibit a strong dependence of causal relations for e-government implementation and sustainability [141]. In addition to that, designing, deploying and evaluation of correlated components helps to understand e-government context especially during the initial stage [291].

In this chapter we focus on the improvement of stakeholder involvement in requirements engineering. We extend the e-government based conceptual DPSIR framework [80] into the direction of implementation strategies by defining a conceptual framework and a related conceptual language. We apply Object Role Modeling (ORM) [118, 102] for this purpose, since main goals of Object Role Modeling is (1) to develop a semi-natural language (controlled language) that is understandable for both stakeholders and system analysts and (2) to create a common description of the application domain in this language. The so-called information grammar describes this common language; the resulting report is called the requirements document. However, many modeling approaches have been deployed to support e-government development. Yet the need to find a better method to reduce project failure is still needed. Our intention is the application of the ORM model to construct quantitative simulation tools to be used by policymakers.

When focusing on some particular point of view defined by some policymakers, we can introduce a conceptual base for the resulting conceptual subspace [268]. Then we extend the causal relations coming from the overarching DPSIR model with more concrete causal relations. These causal relations describe the quantita-
tive behavior of the dimension of the conceptual base. In the System Dynamics approach, the causal relations describe relations between the partial derivatives of the various dimensions.

The layout of this chapter is as follows - a literature review provided in Section 5.2. In Section 5.3 we describe the theoretical basis deployed in this study; we go into more detail about modeling since this is the primary research method to be used in this chapter. Section 5.3.5 presents the informal domain description as the requirements document for e-government. The e-government conceptual model follows in Section 5.4. We conclude this chapter in Section 5.5.

5.2 Literature review

Various dimensions may be considered in achieving a successful e-government deployment. Based on these dimensions, multiple models have been developed for e-government. For a better understanding of e-government implementation two main approaches may be considered; (1) (retrospective) models developed to learn from the failures of existing projects [171, 212, 278], and (2) (prospective) models developed to give guidance to the implementation process [12, 185, 49]. Both approaches have a significant impact on e-government implementation and success.

Lessons learned so far indicate that conceptualization is a dominant factor for successful e-government deployment. The conceptualization method aims to provide precise and unambiguous representation of the real world into a design representation. The quality of conceptual design depends on the quality of the requirements analysis. Similarly, the quality of conceptual model is influenced by the quality of the conceptual modeling method [181]. Both requirements and modeling approaches contribute to obtaining a better conceptual design. In ORM conceptual modeling, the requirements analysis process is structured using a semi-natural language approach. This approach results in a shared understanding between the domain expert and the system analyst in providing a correct and complete requirements document of the application domain [103]. Other modeling methods such as Unified Modeling Language (UML) and Entity Relational Database (ERD) have been used mainly to build online applications that describe the database schema of computer system [242]. However, ORM modeling is more stable compared to other approaches with its unique feature of using fact-oriented notation. The fact-oriented approach creates a communication link for both technical and non-technical stakeholders.

The ORM modeling describes how its underlying conceptual space is organized. However, its implementation in e-government development in general is not yet practical despite being used in many complex applications. For example, it has been used to build an urban meteorological model for estimation of possible wind acceleration along canyons [227]. Tulinayo combines ORM modeling with system dynamics methods to evaluate the hospital management process of pregnant women during the dilation stage from admission to discharge [259]. Similarly, Sebuggwawo combines two meta-models (Rules, Interactions and Models (RIM) framework and multi-criteria decision analysis (MCDA) method and link these
models as a blueprint to analyze and evaluate the deep structure of collaborative modeling using ORM design [244].

Besides, other models were developed to add strength to e-government implementation. In their studies, Altameen and others developed a model for successful e-government implementation [12]. The model considers governing factors, organization factors, and technical factors in e-government implementation. Governing factors influence people’s decision to adopt e-government initiatives. Organization factors objectify machinery and engineering during organization setup; technical factors include the infrastructure tools and applications required to enable government agencies to participate in e-government adoption. A model describing the dynamics of government service delivery has been proposed in [3]. This model focuses on technology affordance, political direction, provided services, administrative interpretation and regulations. Then, this model conceptualizes the need for government, particularly for the legislative process and its underlying politics.

Moreover, maturity model has been used to understand e-government development. Napitupulu and Sensuse have used success factors to evaluate the maturity of e-government implementation [185]. They use analysis approach to explore e-government in different dimension: exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) was used to explore resources (input), activities (process), values (output) and benefits (outcome) factors. However, the maturity model supports the understanding of the current situation in e-government implementation. Yet, complete and correct requirements are the only panacea of ideal design. Furthermore, Choi et al. use design-reality gap analysis to assess e-government implementation in developing countries [49]. The framework explores success and failures of e-government implementation. They introduce the Strategy, Technology, Organization, People and Environment (STOPE) framework in combination with Analytic Hierarchy Process (AHP) to bridge the gap between theory and practice, and apply their approach on the Indonesian procurement system. Based on the e-procurement case study they conclude that ICT infrastructure, legislation, leadership and best practices are the critical success factors in e-government implementation. Accordingly, it is equally important to understand the success factors for the sake of e-government implementation success.

Similarly, Mbale and Staden developed the model HAE, which adopts bottom-up approach, stands for health, agriculture and education (HAE) and used it to assess factors relevant for the initial phase of e-government implementation [171]. HAE model was used to evaluate developing countries based on a typing of government sectors, to analyze the eligibility and readiness of establishing an e-government system. It was found that a balanced distribution of the basic needs in both urban and rural areas is an essential strategy during e-government implementation. This model describes the theoretical aspects to understand e-government implementation issues. Rawas uses Actor Network Theory (ANT) to understand information system research, underlining local and global network mobilization in the utilization of information systems, and claim that this helps when solving e-government problems [212]. Vuksic et al. use a theoretical framework to examine multiple factors influencing e-government implementation in Croatia [278]. The model helps to understand the relationship between goal, objective and the context.
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of the project. Hence, it can be quite reasonable to analyze project implementation risks. These models are developed to support e-government implementation. However, they differ in their implementation focus. Our proposed model focused on the sustainability aspect in which end user is a key player for e-government services.

5.3 Theoretical basis

In this section we first discuss the backgrounds of conceptual modeling in general and using Object Role Modeling in particular. Then we present the requirements document that will be used in the next section to construct a conceptual model for e-Governance.

5.3.1 Modeling

An application domain comprises a particular point of view and some part of the real world that has our special attention. Sometimes the application domain also is referred to as the universe of discourse (UoD) [103]. We may be observers of this UoD, or be part of this UoD, but our goal is to be able to understand the application domain and make motivated statements about this domain. Following [85], we assume two roles during the modeling process: the domain experts and the system analysts. The domain expert has extensive knowledge of the application domain but is unaware of formal methods, while the system analyst is an expert in applying formal methods but is unaware of the application domain details. During modeling, a common semi-natural language is defined by the domain expert and the system analyst. A query about the application domain, formulated in this common language, is answered by domain experts from their knowledge of the application domain. This matter are referred to as the informal semantics of the common language. The system analyst answers the query from the data that has been recorded about this application domain. This is called the formal semantics of the common language. The crucial activity for modeling is the definition of a common language by domain expert and system analyst such that informal and formal semantics of this language agree with a high level of certainty.

The modeling process starts with a UoD description communicated by the domain expert that is sufficient as a first mental model, describing all relevant aspects that are considered suitable by this stakeholder. Then this initial model is analyzed by the system analyst into a first formal model. Such a description is written in formalized natural language (also referred to as controlled language). The aim is to find an equivalent description of that domain written in the formal language associated with the modeling technique [250, 103]. In the ORM approach, a format for controlled natural language is prescribed such that the description can be seen as a formal model. As a consequence, the domain expert and the system analyst can use the same language description both as structured natural language description in the model at the same time. We refer to this document as the requirements document. According to Parnas and Madey, a requirement is anything necessary to fulfill particular concerns [201]. Requirements may be described in
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terms of the domain language. The requirements document is seen by [201] as a communication tool used to describe the environment of the information system as a set of quantified statements that are of concern to the users of the system.

After this first step, the system analyst and domain expert have an ongoing discussion in which (1) the system analyst validates choices made by asking the domain expert questions that can falsify this choice or (2) by asking questions to explore some aspect of the description further so far. This process leads to modifications of the requirements document. The process stops when both domain expert and system analyst are satisfied (from their point of view) with the resulting report.

The requirements document can be seen as a bridge between the informal application domain and a formal model. As such, the requirement has to satisfy some properties. Firstly, it should be complete and make sure that (1) each relevant statement in the UoD can also be expressed in terms of the formal model, and (2) each formal statement can be interpreted uniquely in the UoD [250]. Secondly, it should make this bridge in a correct way. The requirements document to be a correct and complete description of the UoD is the responsibility of the domain expert. The responsibility of the system analyst is that the requirements document is correct concerning the modeling technique.

5.3.2 Conceptual modeling

Conceptual modeling involves capturing various aspects of the real world, and representing them in the form of a model that can be used to communicate about the application domain. It focuses on capturing and representing human perceptions of the real world to describe the physical and social world for understanding and communication [151, 249, 279]. ORM modeling is done by analyzing sample sentences that are generated by domain experts to describe their application domain [85]. These sample sentences are processed by system analysts to extract the elementary sentences that define the information grammar. The modeling method uses simple natural language sentences that are comprehensible for both the non-technical domain experts and the technical system analysts. As a consequence, this approach improves stakeholder involvement during requirements analysis and project specification. As a result, these requirements analysis method is more stable than other modeling approaches such as ER modeling [105].

5.3.3 Object Role Modeling (ORM)

Object role modeling (ORM) is a fact-oriented approach to modeling and querying information at a conceptual level [118, 102]. It is an attribute free approach which structures the conceptual model directly from natural language sentences. This characteristic makes the design to be more stable compared to other Object-Oriented (OO) or Entity Relational (ER) modeling [105]. For example, Unified Modeling Language (UML) modeling has weak support for constraints, and it can be ignored or duplicated in more than one objects. The OO approach can be used in implementation but not in the analysis of the system [196].
5.3. THEORETICAL BASIS

In ORM, an application domain (also referred to as universe of discourse) is modeled as a so-called information grammar that describes the basics of the conceptual language used in that domain. An ORM diagram is a graphical representation of that grammar. The information grammar not only describes the structuring of the information, but also describes constraints on how the structure may be populated. In formal terms, the information grammar may be seen as the signature of a first-order logic theory [123], together with a set of axioms, derived from the population rules. We refer to such a logic theory as Object Role Calculus (ORC) [118]. The associated logic theory is a basis of formal reasoning about the domain that is described by the information grammar. Proof assistants such as the Coq Proof Assistant [95], may help policy makers in the analysis of the domain.

5.3.4 Domain specific languages

Domain Specific Languages (DSL) has been introduced to narrow the gap between the application domain and its implementation [83]. Therefore such languages must satisfy the following conditions [198]:

1. Conceptual proximity: the domain concepts must be proximal to their corresponding language concepts

2. Representational proximity: the representation of concepts in the application domain is proximal to the representation in the domain specific language.

Domain specific languages are commonly represented by a meta-model that describes the relevant concepts in the application domain and their relations. In our approach, the meta-model is described in ORM format. Xtext has been introduced as a formalism to describe meta-models [82], that is the basis for a Java framework via Eclipse. In [137] the transformation of ORM into Xtext is described.

5.3.5 The requirements document for e-government: the Zanzibar case

Zanzibar (Unguja and Pemba Islands) launched an e-government project in 2013 [254]. The project was designed to encourage government offices to increase efficiency through the use of information and communication technology. This project centered on the adoption of advanced communications to deliver services between Government to Government (G2G), Government to Citizen (G2C) and Government to Business (G2B). The establishment of this project is an outcome of strategic plan implementation of Zanzibar Strategy for Growth and Reduction of Poverty (ZSGRP II) 2010-2015. The project aims to improve economic growth and quality of life. The ZSGRP II is a tool that the Revolutionary Government of Zanzibar (RGoZ) uses to deploy and realize the Millennium Development Goal. The tool comprises strategies that help RGoZ to strengthen good governance and improve living standards. The tool recognizes the high contribution of ICT use to achieve national development goals. Having legal ICT framework, proper infrastructure and competitive business strategies influence social and economic development.
The e-government project involves laying on the fiber optic cables, followed by connecting the cables. Finally, the project culminates in the construction of an e-government data center in Zanzibar [254]. In Zanzibar, laying down the fiber cable is now complete. Currently, many government and non-government offices are using a fiber connection. RGoZ is the owner of the fiber network infrastructure and its accompanying equipment. However, the government has signed a contract with Zanzibar Telecommunication Company (Zantel) for technical support provision and assistance. RGoZ has accomplished the operation of the fiber cable network, and a joint agreement with Zantel telecommunication network to provide fiber network service was agreed. Equipment such as Point of Presence (POP) and Network Operation Center (NOC) have been installed, monitored, configured, upgraded, and repaired. Failure to operate equipment properly results in equipment response failure towards electronic requests. Each equipment records the date and type of operation performed. Zantel follows the existing maintenance plan such as preventive, corrective, adaptive and operational to enhance quality service.

Currently, government offices have responded actively to the ZSGRP II plan. The use of electronic services in government offices is increased, especially in administrative work. For example, the Ministry of Health uses District Health Information System (DHIS) to record information for both public and private health care in Zanzibar [164]. As a result, office staff use ICT technology to produce statistical analysis and health bulletin reports each year with less effort compared to previous manual recording. Other systems that also exist are the system to manage social funds, system for finance and accounting, to name but a few. These information systems help to maintain back office records, yet there is a gap for citizen systems that can react to their requests.

Citizen services can be responded to by both staff (human base request) or by automation using ICT tools (electronic request). A service performed by a staff is a human service. For this type of service a citizen should follow the service to the located office and send or receive a request physically. In recent days, however, the citizen can use ICT tools to send and receive a service electronically without any staff interaction. There is another service called electronic services. Using electronic services helps to reduce administrative work and improves service efficiency. Conversely, human-based requests increase processing and handling time. Changes in processing time affect the number of administrative staff required for a particular service. As a result, the budget of administrative services fluctuates. In conclusion, time is an essential factor in measuring an employee’s performance. The government can use this factor to estimate the total number of staff required for a specific service. The total number of requests received per day describes staff working hours and operating cost covered by the government.

Infrastructure maintenance and future development is a critical threat. The infrastructure should be upgraded and maintained to meet the needs of current and future demands. The fiber cable is described as a core e-government activity. Sustainability of e-government activities requires an allocated budget to enhance the implementation of the plan. Failure to maintain the existing investment of fiber cable may result in a considerable loss to the government and community in general. The described threat has been experienced by the State University of
Zanzibar (SUZA) at Tunguu campus. SUZA was among one of the government organizations that benefited from fiber cable network at Vuga and ZITOD campus. Unfortunately, the road maintenance at Fuoni road damaged some fiber lines which resulted in unexpected network failure at SUZA, Tunguu campus. Currently, Tunguu campus uses their old communication (microwave radio signal) which is slower than fiber cable signal. However, encouraging more private companies to invest in the existing fiber network could be considered as a source of fund generation and an excellent opportunity to share operating costs for e-government sustainability.

Introducing new technology to the community requires citizen capacity to operate the underlying equipment. Citizen capacity refers to the knowledge of using electronic services. Citizen awareness and readiness is a crucial phase to overcome the technological challenges in e-government deployment. The community is the primary stakeholder of e-government activities. Therefore, the citizen’s acceptance of new technology increases the use of modern technology. Technological change is not a new practice in Zanzibar municipality. Raising awareness among citizen users has been experienced and supported by both government and non-government offices. Various pieces of training and workshops have been conducted to equip the citizens in various technological problems. For example, computer training and seminars have been undertaken to empower health officers to manage the District Health Information System (DHIS) [27].

Transparency, openness and accountability that featured e-government implementation may create government officials hampering e-government development efforts. Many developing countries follow the hierarchical leadership structure. This structure creates an abstraction layer between implementers and leaders that limit e-government development efforts initiated by low-level officials. However, motivated leaders may also get bogged down by bureaucracy and stifling their initial efforts[170]. Taking this into consideration as a threat may reduce risks of e-government project failures.

5.4 The e-government conceptual model

Our application domain, as described in Section 3.5 is about e-governance. In this section, we introduce a conceptual language to explain this application domain. In this application domain we distinguish (1) citizens, (2) organizations (such as companies), and (3) governmental offices as major actors. These actors interact by (4) services as actions to be exchanged between the actors. Finally we consider the enabling factors, being (5) the skills that citizens are supposed to have and (6) the infrastructure supporting the handling of services in an ICT automated way.

5.4.1 Citizens

Citizens are the individual entities in our application domain. Formally, a citizen is anyone who has been registered in the considered country, thus having a personal identification. The following elementary sentences describe the properties that are relevant in our application domain for our purposes for citizens:
1. Citizen is identified by Citizen-ID.

2. Citizen has an Address.

3. Citizen is employed at an Organization.

4. Citizen has completed Training.

5. Citizen uses Equipment.

The following properties provide knowledge about the skill level of the citizens, and the tools that they have some access. In their interaction with the government, citizens require services that are offered by the government. In our modeling process we want to keep track of service requests when they were issued and handled, the kind of request and relevant details related to the request. A service request is identified by the requesting citizen, the type of service and the time stamp of this request.

6. CitizenRequest: Citizen requests Service at Time.

7. CitizenRequest has Properties.

8. CitizenRequest was replied at Time.

9. CitizenRequest was concluded at Time.

5.4.2 Organizations

An organization is any grouping of citizens that are recognized as a legal entity by the government. Consequently, each organization is assigned an Organization-ID that uniquely identifies that organization.

5.4.3 Governmental offices

Government organizes its activities via a hierarchically organized office structure. An office is an organizational unit dedicated to specific professional activities. For our purposes, it is sufficient to register the services that are handled by offices as follows:

1. An Office is identified by Office-Nr.

2. Office is sub-office of Office

3. Office organizes Service.

It is also be relevant to record the cooperators of each office. A staff member is a citizen who is being employed by a governmental organization. Hence a staff is characterized as follows:

4. Staff IS citizen being employed by Organization ‘Government’. Staff members have a special identification Staff-ID.
5. Staff is identified by Staff-ID.

6. Staff works in Office.

7. Staff has FunctionType.

8. Staff is paid Salary.

9. Staff is hired for Nr-Hours.

Finally, about the office structure:
   For this application domain it is important to distinguish between technical and administrative staff. The following specializations of Staff is introduced:

10. TechnicalStaff IS Staff having FunctionType ‘technical’.

11. AdministrativeStaff IS Staff having FunctionType ‘administrative’.

Technical staff is responsible for the management of the equipment in the office, enabling the proper operation of the office, including the monitoring of the services. The administrative staff, on the other hand, are responsible for the operation of the office equipment. Therefore, both the staff groups and their responsibilities are recorded:

12. TechnicalStaff manage Equipment.

13. AdministrativeStaff operate Equipment.

The following sentence defines the function of the staff with the role of a manager:

14. OfficeManager IS Staff having FunctionType ‘manager’.

### 5.4.4 Services

A service is an action or help of public needs that are provided by the government to both citizens and organizations [182]. Service may be anticipated by the government or by a citizen or organization. Services are defined by the government, and are uniquely labeled by a special service identification.

1. A Service is identified by Service-ID.

2. Service has Name.

It will be convenient to introduce a generic term for citizens and organizations:


Services that are delivered by humans (in the traditional way) is distinguished from those that are being delivered via modern ICT. Services that are delivered automatically by ICT equipment are recorded, and use that relation to partition the services as follows:

4. Service is delivered automatically.
5. DigitalService IS Service being delivered automatically.


7. ManualService has ManualRequest

8. DigitalService has DigitalRequest

In an e-government situation it is to be expected that digital services replace manual services.

5.4.5 Skills

An important issue for successful implementation is the skill level of citizens since they are the basis for using the infrastructure that is to be built for e-government [225]. The assumption here is that, the government strategy is to offer training to the citizens to obtain the required skills. Each training offered is assigned to its training identification. Each training also has associated training objectives. Typically, a country has its system to describe skill levels.

1. Training is identified by Training-ID.

2. Training trains for Skill.

Next, it is relevant to record who is (officially) offering the training, and who have successfully completed training. It must also be clear as to who is supposed to master the skills offered in training:

3. Training is offered by TrainingInstitution

4. Training has been taken by Citizen.

Note that the mastering of skills may be recorded by rigorous administration, but in practice it is more likely that this relationship is maintained (more efficiently) on a statistical basis. Of course, the government implements some form of quality assurance, for example by an accreditation system for training institutions and by requiring independent examinations. Quality issues are not considered in this chapter.

The information obtained from the Zanzibar case domain is used to calculate as to what extent the citizens meet the skills required for service. By using the address information, helps to identify what areas are not presented in mastering specific skills, and therefore are not yet open for digital services.

5.4.6 Infrastructure

In this section, we consider the infrastructure required for a successful implementation of e-government. From this situation about implementation two issues can be noted here. Firstly, we propose the equipment needed for processing a services. Secondly we consider the connecting infrastructure that enables the equipment to communicate with each other.
Equipment is composed of hardware (the service actor) and software (the service program). Typically, hardware and software are offered as separate products. The advantage is that both hardware and software can have a more or less independent evolution cycle. For example, the introduction of a new computer type is not a problem as long as it can run the available service programs. Services can be improved, or new services may be introduced, as long as they can run on the (supported) hardware. Therefore the government has a list of approved hardware configurations, and record what services can be run on each configuration:

1. Equipment is identified by Equipment-ID.
2. Equipment is described by Hardware Configuration.
3. Equipment can run Service.

The ability to access the digital communication network is seen as a basic service that is required from all approved equipment. Similar to the recording of the skills offering and mastering, equipment providers and owners are also recorded.

4. Equipment is offered by Company.
5. Equipment is owned by Customer.

As we remarked for the skill mastering relation, the equipment owning connection also may be maintained (more efficiently) by statistical methods. Concerning the connecting infrastructure, we assume the country has been divided in regions. It is recorded how regions are connected with each other. The quality (e.g. the connection speed) is also recorded.

6. Address is located in Region.
7. Connection: Region is connected to Region.
8. Connection has Quality.

So a region is disclosed for e-government if (1) it is connected with a service managing region and (2) the overall of that connection is sufficiently high.

5.4.7 Model summary

Figure 5.1 shows a graphical representation of the information grammar developed in the previous subsections. It is an ORM model representing the scenarios taken from the Zanzibar study described in Section 5.3.5. The proposed conceptual model describes the concepts and their relations that are relevant for implementation strategies in a government to provide better public services. The model identifies citizens, organizations, government offices, services, citizen skills, and infrastructure as inner elements in e-government implementation.
5.5 Conclusion

Through our modeling process, we have contributed to the understanding of e-government implementation. In our approach we primarily focus on stakeholder involvement by describing the result of a communication protocol between domain expert and system analyst.

The resulting information grammar (the conceptual model) can be used for various purposes. Traditionally, the ORM approach is used to build high-quality information systems. Our goal, however, is to use the information grammar as the base for a conceptual language that allows formal reasoning about the application domain in semi natural language. The information grammar can also be seen as a domain specific language. Exceptional support is available to generate special tools, for example a parser for the domain specific language.

Our interest is in the conceptual language, ORC, for example. The conceptual language supports formal reasoning about the application domain and its dynamic behavior. Next chapter we describe conceptual bases for the conceptual model introduced in this chapter and then focused on a first-order model to describe the changes of the conceptual base as the accumulation of changes via the various dimensions of the conceptual base. The conceptual base and its causal relations can then be transformed into the system dynamics formalism to allow for simulations that are helpful for policymakers to validate intended decisions.
Chapter 6

System dynamics modeling

In the previous chapters, we have seen the domain modeling technique that builds a conceptual scheme of the domain. In this chapter, we are going to start from the conceptual modeling scheme to the system dynamics model simulation. From conceptual modeling design, we use causal technique to extract potential behavior. Then, we simulate the behavior using system dynamics concepts.

This chapter answer the research question RQ5: How can the modeling approach model the dynamics of complex systems?

Abstract

System thinking has become an effective strategy when dealing with complex systems. Such systems are characterized by mutual interactions, causality and inter-dependency between system components. A typical example is cooperation between governmental organizations and stakeholder interaction. The complexity of developing an e-government system suggests a more fundamental approach, where the roles of domain expert and system analyst are separated. This chapter focuses on the following: is (1) to propose a linguistically-based systematic approach to the construction of models for the dynamics of complex systems, and (2) to propose extended causal diagrams. Our research methodology is based on Design Science. We start from a conceptual language developed for the application domain at hand and use this to define the dynamic factors. Then, we show how the resulting extended causal diagram is transformed into a framework for system dynamics. We have demonstrated this approach by using a basic form of an e-government as a running example. The proposed approach can be used a basis for a systematic stepwise introduction of e-government in Zanzibar. Besides, this method is useful for modeling any complex system, especially for the description and evaluation of intended policies.

Keywords: Complex systems, Conceptual modeling, System Dynamics, Extended
6.1 Introduction

E-government has emerged as a means of service delivery improvement, enhancing public sectors by participating in a new knowledge landscape. However, the ability to develop countries to reap the full benefits of e-government is very low, and it faces many challenges in its implementation.

The e-government concept has originated in developed countries. These countries are significantly different from developing countries in many aspects such as economy, infrastructure and culture. E-government implementation is not a process that can simply be inherited from one country to the other. It needs a distinctive study of the case domain to understand the requirements better. Domain understanding creates room to utilize the benefits and to extract the most potential holes that need to be repaired at the earliest opportunity. In that case a system thinking approach [13] is an optimal approach since it creates a way of unfolding a complex domain by making it more comprehensible. This approach can be used by policy makers to enhance strategic decision making.

The system thinking approach is defined as a construction of selective abstractions of reality, known as mental models, that help us to derive decisions that inform our actions to get the meaning out of what we are experiencing [221]. Mental models have been used for many years especially in Artificial Intelligence and Psychology. Later, they have become a useful tool in both qualitative and quantitative analysis [287].

According to Richardson [220, 252], System dynamics (SD) is a computer-aided approach to policy analysis and design. It has been introduced as a technique to build simulation models. These models are used to visualize the effects of intended policies. Even if this may have a small impact on policy implementation, it can help get a quick impression of the impact of expected policy changes [226].

A drawback is that building an SD-application is not an easy task, especially when a complex application domain is involved see example in [233]. It consists of 2 steps. The first step builds a causal network that shows the relevant (dynamic) factors and how they influence each other. The second step expands causal networks with a set of recurrence relations that describe the progress of the system time stamp. This chapter intends to explain this building process in a systematically by separating domain-specific activities (such as modeling and evaluation of the results) from more technical steps.

Building a causal network can be simplified by using semi-natural language techniques to relate the (more abstract) modeling concepts with (more concrete) domain-specific descriptions. First, the goal is to describe the language used by experts from that domain as a controlled language. This language allows the domain experts to be involved in the modeling process.

A rigid approach to conceptualize an application domain is Object Role Modeling (ORM). ORM aims at building a grammar that describes a simplified (structured) yet semi-natural version of that domain language. ORM formally defines
the structure and meaning of that language. Consequently, the domain description is understandable within the application domain and understandable by the system builders.

Traditionally, ORM is used to build information systems, from information grammar a relational database structure is easily derived. However, information grammar can also be used as a first order logic system that can be used to build a formal reasoning system. The information grammar describes the elementary sentences that are valid in the associated application domain. From these sentences, other sentences may be formed. Object Role Calculus (ORC) [115] and ORM2 [101] are examples of such generic systems for constructing sentences. In formal terms, the information grammar may be seen as the signature of a first-order logic theory [124], together with a set of axioms, derived from the population rules. The associated logic theory is a basis for formal reasoning about the domain. Proof assistants such as the Coq Proof Assistant [18] may help policy makers.

The primary goal of this chapter is to provide a systematic and structured method to analyze inter-dependency in the context of the conceptual scheme, and to build a simulation tool by which government is supported to get a quick and well-founded impression of the effects of their various managerial choices. We use the Object Role Modeling (ORM) approach to generate the information grammar in its graphical representation as a conceptual scheme to be used as a basis for reasoning about the application domain. We follow the SD-approach to find relevant dynamic factors and how they influence each other. In causal reasoning, such an influence can be positive definite, negative definite or none of these both.

Causal diagrams allow for qualitative reasoning about (the effects) of system dynamics. This reasoning is only effective when loops are involved since they describe the inherent system options for self-reinforcement and self-stabilization. But even then reasoning based causal diagram is rather week. In this chapter, we propose an extension of causal diagrams to improve their expressive power that makes their expressive power slightly better. We also discuss how the expressive power may be further extended in a semi-quantitative way by extending influences with a strength and a velocity indicator.

We describe causal reasoning itself more systematically based on the selection of target factors that the policy makers want to optimize and introduce the active diagram for these factors. We give some properties of Extended Causal Diagrams (ECD) and show rules by which an ECD can be transformed into an SD-structure. This structure then has to be enriched with quantitative expressions that define how a new system state is calculated from the previous state.

The layout of this chapter is as follows. This chapter has two parallel storylines. After a literature review in Section 6.2. We continue with the first storyline on theory of causal reasoning. In Section 6.4, we introduce extended causal diagrams (ECD); provide its syntax and semantics, provide some modeling guidelines and describe causal reasoning. We continue the theoretic line in Section 6.6 with the transformation of the ECD into system dynamics.

The other storyline uses the e-government example to demonstrate the techniques described in the theoretical storyline in this chapter. In Section 6.3 we
discuss the Conceptual e-government scheme that we use. Then in Section 6.5 we focus on a particular managerial goal for e-government, and show how the ECD is systematically derived for this case. Then in Section 6.7 we use the transformation rules from Section 6.6 to transform the ECD into an SD-structure. We use the Sysdea tool to develop a simulation tool.

We summarize this chapter in Section 6.8 with conclusions.

6.2 Literature review

Several methods have been proposed to extract complex application domain in a relatively easy way. These methods are used to represent complex problems in a normative approach. Failure to understand domain problems and incorrect interpretation of the case domain may cause technical failures of the proposed solution. The proper interpretation is important for a relevant modeling design. There are three dimensions to characterize a modeling method: the theoretical, the methodological and the domain method [92].

The domain approach focuses on the understanding of the physical system that connects causality changes to normative knowledge. This system is often related to dynamic phenomena. Domain modeling characterizes the behavior of a mental model in a system thinking context. A term model was used in this study to describe a product used to represent a system of interest. The model becomes a tool when it has a salient feature to study behavior of the actual system. A mental model is defined as the representation of the external system that conceptualizes historical, existing or projected system aspects [66]. Historically, mental models were used for many years, especially in Artificial intelligence and psychology. They have become a useful tool to be used in most areas where both qualitative and quantitative analysis is being manipulated [287].

There are many ways to elicit mental models. The causal diagram is the most suitable conceptual diagram to represent dynamic characteristics [153]. But, concept mapping, cognitive mapping and causal mapping are the most popular approaches, especially when making a strategic design [231].

The causal diagram is a modeling technique used to promote understanding of nonlinear behavior of complex systems [203]. This type of diagrams is used to explore the dynamic behavior of a system [119] but also extract empirical data using auxiliary experiments and observations [203]. Besides such data science applications, causal diagrams are nowadays also used in modern applications to make the utility of large data sets more potent [99]. Indeed, it can be used as analysis tool without need for simulation experiments [226]. The impression of causal diagramming shows some limitations in presenting the entire case domain in a realm of system dynamics [32]. Causal modeling prevails variables and influences in a form of feedback loops but, it cannot elucidate the detailed information of the model such as stock, flow and implicit influence. For the case of stock and flow representation, causal diagram deploys system dynamics techniques to illustrate the details [219], but, for implicit influence, this has not yet explored. Besides, the analysis using causal diagrams is not that simple; it requires not only understand-
Concept mapping has been used in many applications to support qualitative reasoning. It is primarily used to express and organize knowledge in various levels of complexity. Concept mapping was used to analyze complex situations such as climate change [213]. However, exploiting this approach may cause some restrictions in modeling, but, it cannot separate structure from behavior and thus puts more focus on influences than effects. It is convenient to assess conceptual knowledge, especially in embedded technology-based environments [285].

Another technique is cognitive mapping. Cognitive mapping is a method to represent personal constructs in a form of note taking. It uses chunks of 10-12 words as nodes to disclose concepts and their relations concerning the problem at hand. This technique is mainly used to improve problem understanding or to explore the opportunity of some particular theory. It structures a problem and analyzes it to make sense of details in the form of assumptions, actions, possibilities, strategies and goals. However, the cognitive mapping method does not provide sufficient information. Thus it is combined with other research methods such as observation and interview to increase the validity of findings. It is mostly used for qualitative data analysis [6].

Causal mapping is a technique that captures expert knowledge about the application domain using linking strategies of what people think and how they act. It represents domain knowledge more descriptively in a way that it articulates many ideas from both individuals and groups. It is a way of knowledge representation use high level of variable abstraction. Thus, it is mostly used to investigate managers decision [5].

The main reason of selecting causal diagrams over other methods is the results of the model. The causal diagram emphasizes on the dynamic behavior during the modeling, specifically on the use of cause and effect relations. This technique focuses on feedback loops and loop effects of the design. On the other hand, cognitive mapping investigates the constructs that need extra details from interview or observation to understand a particular knowledge. Using constructs in variable construction reveal a definitive version of the facts which is more or less relevant to qualitative analysis. Again, the causal mapping technique concentrates on the strength of the link relationship that most positions the construction process to a subsequent analysis technique such as statistical analysis [30] or Bayesian network methods [183].

Due to the wide extensive use of causal diagrams in policy analysis, it is used in many applications to overcome policy resistance. For example, Homer and Hirsch deploy causal diagram modeling to understand public health risk behavior in hospital context, including environments, resources, and delivery system [120]. Furthermore, Shotaro and Daniel have improved the knowledge of the complex logistics in the food supply chain by investigating the behavior in the food industry, specifically in poultry production and processing [176]. Also, the causal diagram used with other modeling methods such as Object Role Modeling [259] and cognitive mapping [121] to enhance decision making.

These works show various approaches for data collection, system design and
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integration of the data in the system. A common feature is however that the actual work is usually done by a domain expert (e.g. social scientist, environmental scientist) who is then delivered to a computer modeler to integrate the data and ideas in the model that should be developed. This one-way communication may cause hard-to-trace inconsistencies between the various steps in the chain (from theory to meta model, from meta model to data collection, from rough data to interpreted data, from data to model and so on). Moreover, a lack of two-way interaction may result in missed opportunities, e.g. more efficient data collection or more explicit theory.

The quality of conceptual design is influenced by the quality of the conceptual modeling method [181]. A good model should satisfy a number of conditions. According to Zwart et al. the most important conditions are: (1) the communication principle, followed by stating that the primary intention of the model is not to model the structure of the application domain but to model the structure of communication about the application domain by its participants; (2) the 100% conceptualization principle, states that the model covers all the aspects of the user communication, but nothing more, see also [188]; (3) the redundancy free principle which requires only elementary concepts to be modeled; (4) the unification principle which ensures that all constructs can be populated; (5) the substitution principle which states that the elementary sentences can be regenerated; (6) the generic principle which requires a balance between generality and specificity; and finally (7) the minmax principle stating that the model should be a minimal grammar to accept the sentences provided by the domain expert (also referred to as Ockham’s Razor), and yet maximally expressive (by adding abstractions when they are likely to be profitable) [296]. Secondly, the quality of the model is highly influenced by the modeling process and its participants. Frederiks and van der Weide give an overview of the process and the required competencies of its participants. They describe this process from two roles; domain expert and system analyst, and competencies required from each role. They added that, these competencies ensure a successful modeling process [85].

Using a natural-language based approach also helps to validate the constructed model. A formal model of an informally described application domain cannot be proven correct, but can only be shown as incorrect. This is called the falsification principle (Popper, [207]). A model is seen as plausible when enough efforts have been to falsify the model. Showing that a model is plausible can be more effective when all stakeholders share a common language that is understandable for them from their point of view. We argue that the ORM approach uses a semi-natural language (also referred to as controlled language [87]) approach for this purpose. The system analyst detects a model flaw when the domain expert refers to a construct not(yet) present in the current state of the information grammar. The system analyst also actively tries to find inconsistencies by performing semantic checks. A semantic check typically is a question from the system analyst to the domain expert in the form: does the following query have the following result?”. The domain expert bases the answer to the query on domain knowledge while the system analyst uses the formal techniques of the modeling method to calculate the answer.
6.3 Modeling process

In this section we describe the conceptual model that used to demonstrate a non-trivial application of the Extended Causal Diagrams technique that we introduce in the next section. The process used to develop the conceptual modeling in domain modeling technique was described in Chapter 5. The development of this model aims to understand domain context for successful implementation of any system development. The model describes the case domain that is used in Sections 6.5 and 6.7 to extract a framework for the causality to (positively) influence e-government implementation to provide better public services.

Refer Figure 5.1 for graphical representation of the model. This model was designed using the ORM modeling approach, see [103, 81]. It describes the concepts and their relations as far as they are relevant for implementation strategies in e-government to provide better public services. The model categorizes these concepts into three groups: actors, actions and enabling factors. Citizens, organizations (such as companies) and governmental offices are the actors in this conceptual model. The citizen is anyone who has been registered as an inhabitant of the country considered. Citizens are consumers but also deliver work force. An organization is any legal entity registered in the country considered. Organizations are the producers and in need of work force. A governmental office is uniquely identified and named by its dedication of specific professional activities, supported by relevant staff specialization.

It is the task of the government to enable effective and efficient interactions between its citizens and organizations. Government guarantees a legal, safe and productive environment to align the demand and supply. Services are the main instrument of government to steer and support this process.

In our model, a service is any activity provided by government to citizens and organizations. Traditionally, services are delivered manually, where people interact with other people at specific locations and specific time. Manual service delivery typically is slow and costly. However, digital service delivery can improve the delivery of services considerably. For interaction, the interactors are not required to be at the same place at the same moment. Also, digital service delivery allows a high-speed handling of the required communications [286].

On the other hand, digital service delivery enables the government to implement its service delivery much more efficient at a much lower cost. The result helps the country to improve its international position and to participate increasingly in international trade. To use digital service delivery, the citizens need to have access to the electronic highway for digital interaction. Hence, citizens need to be trained to have the appropriate skills, but also need to have the required tools (computer, internet connection, etc). The same applies to organizations, but usually, they are one step ahead of citizens in this respect.

A government may thus consider several strategies to improve acceptance, access and usage of ICT. In this chapter we consider the following initial information aiming for modeling. We restrict ourselves to the following scenarios:

1. Improving the infrastructure (power supply, internet connections, etc.). The quality of the infrastructure is a critical success factor for a successful intro-
duction of digital services. However, improving infrastructure is a slow and costly process.

2. Improving the overall skill level of citizens. Government may strategically want to improve skills by offering new courses. In general, education not only is costly and slow, but probably the most critical success factor. Special courses may be cheap and fast when they are used to fill a specific skill gap.

In the next section we introduce Extended Causal Diagrams (ECD) as a method to define causality that play a role in the context of the options considered. Then, in Section 6.5, we apply this technique to determine the causality that plays a role in the e-government context described in this section. After that, in Section 6.6, we describe how an ECD is systematically transformed into a System Dynamics model (SD). This model is applied in Section 6.7 to obtain a SD model for this e-government case. This model then is prototyped in a concrete SD tool to show some simple simulations.

6.4 Causal reasoning

A conceptual model provides a static description of the underlying application domain. A conceptual model may be extended with behavioral aspects. We follow the approach as developed in [260]. In this approach, and causal diagrams are used to develop system dynamics models.

A conceptual base is typically the result of a particular focus on the application domain [268]. The conceptual base, in terms of the conceptual model, provides the dimensions that describe the states of the (considered part of the) application domain. Since a conceptual model such as ORM defines a semi-natural domain language, this (quantitative) focus can be most conveniently described in terms of ORM conceptual language. The significant advantage of this approach is that the definitions made can be understood and verified by (non-technical) domain experts.

The proposed conceptual base consists of those concepts that span the state space for the focus in question. The elements of the conceptual base (also referred to as dimensions) are in this chapter referred to as substantial variables. Each state of the application domain is represented as a population of the conceptual base. The value of a substantial variable is the number of elements (the size) of its associated population.

Besides the substantial variables, there also is a dashboard of characteristics defined in terms of the conceptual model. Dashboard variables are typically described in terms of computation over the underlying conceptual model. They correspond to functions that quantify some aspects of the application domain in terms of the underlying conceptual model. Both the substantial and dashboard variables are the variables of the causal diagrams.

A complete quantitative description of real life applications tends to be very complicated since such systems usually can be indicated as complex dynamic systems (see [230]). Causal reasoning provides a qualitative first-order approximation
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of the dynamics of the considered system. A first-order system description is an approximated (linear) description of the system in which only first derivatives play a role. This system means that only the (partial) derivatives \( \frac{\partial B}{\partial A} \), where \( A \) and \( B \) are dimensions, are considered. This derivative indicates how changes in variable \( A \) influences the value of variable \( B \).

6.4.1 Causal diagrams

Causal relations describe elementary causal influences between variables (see for example [247]). In causal diagrams, these relations can be binary only. A causal relationship between variables \( A \) and \( B \) indicates that a quantitative change of variable \( A \) leads to a quantitative change in variable \( B \). This relation corresponds to the partial derivative \( \frac{\partial B}{\partial A} \). Causal relationship may be accompanied by a polarity indicator (positive or negative) to qualify the effect of the associated causality.

1. A positive causality indicates that \( \frac{\partial B}{\partial A} \) is positive definite, meaning that \( \frac{\partial B}{\partial A} > 0 \) for all \( A \). This causality is denoted as \( A \xrightarrow{+} B \), see Figure 6.1(a). Consequently, (1) an increase in \( A \) leads to an increase in \( B \), and (2) a decrease in \( A \) leads to a decrease in \( B \).

2. For a negative influence \( A \xrightarrow{-} B \) the derivative \( \frac{\partial B}{\partial A} \) is negative definite, meaning that \( \frac{\partial B}{\partial A} < 0 \) for all \( A \), see Figure 6.1(b). In this case, (1) an increase in \( A \) leads to a decrease in \( B \), while (2) a decrease in \( A \) leads to an increase in \( B \).

3. The absence of a polarity indicator shown in Figure 6.1(c), indicates that the derivative \( \frac{\partial B}{\partial A} \) is neither positive definite nor negative definite, or, \( \frac{\partial B}{\partial A} > 0 \) for some value of \( A \), and \( \frac{\partial B}{\partial A} < 0 \) for some other value of \( A \).

\[
\begin{align*}
A \xrightarrow{+} B & \quad A \xrightarrow{-} B & \quad A \rightarrow B \\
(a) & \quad (b) & \quad (c)
\end{align*}
\]

Figure 6.1: Direct causal relations

Arrows in the causal diagram correspond to elementary causal relations between the corresponding variables and are used to describe dynamic aspects of the application domain. Arrows may be combined into paths, to show non-elementary causal effects. The polarity of a path is obtained from the polarity of its components. If all arrows on the path have a polarity indicator, then the polarity of the path is positive if the number of negative polarities on the path is even, and negative otherwise.

Cycles are most important paths in causal diagrams. A cycle is a closed feedback system. Each variable in a cycle (also) is influenced by itself. There are two special types of causal loops. A balancing loop is a cyclic path that has a negative polarity indicator, whereas a reinforcing loop is a cycle with a positive polarity indicator [247]. These particular kinds of loops allow to reason about influencing the underlying application domain in terms of causal effects in a semi-quantitative
way: they give the policymakers opportunities to stimulate growth effectively and to create stabilization.

If a factor in a reinforcing loop increases, then, there are no other influences, this leads to an unstoppable increase of all other factors in the loop. For policymakers, such loops are most useful to start a self-reinforcing development. Note that the policymaker wants to use another factor to stop the resulting growth explosion at some appropriate moment.

Balancing loops are different. The increase of a factor in a loop leads to the decrease from the causal effect of the loop. Balancing loops enable policymakers to build self stabilizing systems.

### 6.4.2 Extended Causal Diagrams (ECD)

Usually it is difficult to separate linearity and non-linearity [204]. The first derivative approach of causal diagrams is meant to approximate the behavior of the application domain in a linear mode. Non-linear behavior is added to fine-tune a linear model for a more appropriate description of the application domain behavior. Higher-order derivatives describe non-linear behavior.

The Extended Causal Diagram (ECD) is an extension of the traditional causal diagram as described in the previous subsection. In ECD’s we also consider how the influencing of a variable \( A \) by variable \( B \) can change by modifications in variable \( C \). This corresponds to the following higher order derivatives:

\[
\frac{\partial \frac{\partial A}{\partial B}}{\partial C} = \frac{\partial^2 A}{\partial C \partial B}
\]

This causal relation is denoted as \( C \rightarrow [A \rightarrow B] \), see Figure 6.2(a). Note that this allows the system analyst to add more application domain semantics into the ECD than would be possible when the situation from Figure 6.2(a) would be ‘flattened’ into the scheme in Figure 6.2(b).

![Figure 6.2: Indirect influence and its flattened version](image)

6.4.2.1 Formal syntax

The formal syntax for extended causal diagrams assumes the syntactic categories `SubstantialFactor` of substantial variables and `DashboardFactor` of dashboard variables as described in the introduction of this section. Then extended causal diagram extends these to the syntactic category `CompoundFactor`. Using this category, the
syntactic category CausalRelation is extended. Also in this case the causal relationship may have a polarity indicator. The resulting grammar is graphically illustrated in Figure 6.3.

1. CausalRelation :: SubstantialFactor, LeadsTo, SubstantialFactor
   | SubstantialFactor, Influences, SubstantialFactor
   | DashboardFactor, Influences, DashboardFactor
   | SubstantialFactor, Influences, [~, CausalRelation, ]
2. LeadsTo :: \[\rightarrow\] | \[\Rightarrow\] | \[\iff\].
3. Influences :: \[\rightarrow\] | \[\sim\rightarrow\] | \[\Rightarrow\].

![Figure 6.3: Graphical syntactical overview](image)

We will use the generic notation \( A \rightarrow B \) to denote either \( A \rightarrow B \), \( A \Rightarrow B \) or \( A \Rightarrow B \). Likewise, we use \( A \iff B \) to denote either Flow\([B \Rightarrow A]\), \( A \Rightarrow B \) or \( A \Rightarrow B \). Note that this definition of causal relations allows for higher order constructs such as for example: \( D \iff [C \leftarrow [A \rightarrow B]] \).

### 6.4.2.2 Special cycles

As an example, consider the Extended Causal Diagram in Figure 6.4. We have a reinforcing loop \( A \rightarrow B \rightarrow C \rightarrow D \). The policy maker has the option to influence the reinforcement strength via the factor \( E \). Increasing \( E \) enhances the reinforcement effect of the loop, but the opposite effect is obtained by decreasing \( E \). A special
case is when the influence by $E$ causes the effect of the causal relation $B \rightarrow C$ to become zero.

![Figure 6.4: Cycle in ECD](image)

New kinds of cycles can be defined in ECDs. The general format is $A_n \rightarrow [A_{n-1} \rightarrow \ldots [A_1 \rightarrow A_0] \ldots]$. An example of the most simple case $B \rightarrow [A \rightarrow B]$ is shown in Figure 6.5(a). In this case, the causal relation $A \rightarrow B$ is balanced by $B$.

![Figure 6.5: Implicit cycles in ECD](image)

For example, let $A$ corresponds to the factor *Population* and $B$ to the factor *Food*. More food leads to an increasing population $Food \rightarrow Population$ but an increasing population has a decreasing effect on the strength of this causality:

$Population \rightarrow [Food \rightarrow Population]$

Another special case is a situation like $A \rightarrow [A \rightarrow B]$, see Figure 6.5(b). In this case, an increase of factor $A$ leads to an increase of factor $B$. But at the same time, this increase has an effect on this causality. For example, in an educational situation where courses are offered to the public and citizens register for courses, we have the causal relation that is offering more courses lead to an increase in course registrations. However, offering more courses may also confuse citizens when making courses. This would be described by

$Training \rightarrow [Training \rightarrow Registration]$

### 6.4.2.3 Semantics

Next we focus on the semantics of these constructs. First we consider substantial variables. Substantial variables have associated a population of instances. The size of the population of variable $A$ is denoted as $n(A)$. The causal relations $Flow[B \rightarrow](A)$, $A \Rightarrow B$ and $A \Rightarrow B$ indicate that instances from variable $A$ move to variable $B$. Consequently, the variables $A$ and $B$ must correspond to type-related concepts in terms of the underlying conceptual model. Suppose we would introduce dashboard variables $n(A)$ and $n(B)$, then the semantics of causal
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relations \( \text{Flow}[B \to](A), A \xrightarrow{\pm} B \) and \( A \xrightarrow{\pm} B \) are defined as \( n(A) \to n(B), n(A) \xrightarrow{\pm} n(B) \) and \( n(A) \to n(B) \) respectively.

With each causal relation \( C \) we associate a derivate \( \mu(C) \), defined inductively as follows:

**Induction base**

1. \( \mu(A \xrightarrow{\pm} B) = \frac{\partial n(B)}{\partial n(A)} \) when \( A \) and \( B \) are substantial variables.
2. \( \mu(A \xrightarrow{\pm} B) = \frac{\partial n(B)}{\partial n(A)} \) when \( A \) and \( B \) are substantial variables.
3. \( \mu(A \xrightarrow{\pm} B) = \frac{\partial B}{\partial A} \) when \( A \) and \( B \) are dashboard variables.

**Induction step**

4. \( \mu(A \xrightarrow{\pm} C) = \frac{\partial \mu(C)}{\partial n(A)} \) when \( A \) is a substantial variable and \( C \) a causal relation.

The semantics of causal relations are defined as differential inequalities as follows. Let \( C \) be a causal relation, then:

1. if \( C \) has a positive polarity indicator, then \( C \) expresses the differential inequality \( \mu(C) > 0 \), where \( f > g \) is a relation between functions that indicates that for all arguments the value of \( f \) is larger than the corresponding value of \( g \).
2. if \( C \) has a negative polarity indicator, then \( C \) expresses the differential inequality \( \mu(C) < 0 \), where \( f < g \) indicates that the value of \( f \) is smaller than the corresponding value of \( g \).
3. if \( C \) has no polarity indicator, then \( \mu(C) \) can take both positive and negative values. This is denoted as \( \mu(C) \approx 0 \), where \( f \approx g \) means that for some argument the value of \( f \) is different from the corresponding value of \( g \).

Summarizing, the semantics of an Extended Causal Diagram \( \langle F, C \rangle \) consists of a set of variables \( F \) with a differential inequality equation for each causal relation \( C \in C \).

Our feeling is that the extra features of ECD compared to CD suits better the description of logistic growing behavior (see for example [52]). For example, the ECD consisting of variables \( x \) and \( y \) with the causal relations \( x \xrightarrow{\pm} y \) and \( x \xrightarrow{\pm} [x \xrightarrow{\pm} y] \) leads to the system of differential inequalities

\[
\mu(x \xrightarrow{\pm} y) > 0 : \ y'(x) > 0 \\
\mu(x \xrightarrow{\pm} [x \xrightarrow{\pm} y]) < 0 : \ y''(x) < 0
\]

which can typically describe a plateau function like \( y = \frac{1}{1+e^{-x}} \) as is easily verified (see Figure 6.6). But other solutions are also possible. Suppose for example that the domain for variable \( x \) is restricted to \( (0, \infty) \), then \( y = \ln(x) \) also satisfies this system of differential equations.
An Extended Causal Diagram can be made more explicit by quantifying the differential equations. In Section 6.7 we discuss the transformation to a system dynamics diagram as an example.

6.4.3 Further extensions

In the traditional approach to causal diagrams, the diagram does not indicate a time fragment of the causal effects. The effect of a causal relation may be immediate (i.e. effective after a very short time) or may be long-term (i.e. effective with a larger delay). For example, a causal relation that is conveyed by traditional publishing on chapter is not as fast as information exchange based on modern information technology. We will not discuss this issue in this chapter.

In this (traditional) approach to causal diagrams, it is also not possible to describe a varying strength of causal relations. For example, improving the factor conditions may lead to a stronger effect of the causal relationship that describes the relationship between the factor material and the factor product. This is what we add to obtain Extended Causal Diagrams.

We assume the following properties for causal relations. The causal relation $A \rightarrow B$ is called *fast* if the effect of a change in $A$ in changing $B$ happens in a sufficiently short time. The causal relation $A \rightarrow B$ is called *weak* if this effect on $B$ is below some threshold. The notions of *sufficiently short* and *weak* are to be determined by the domain expert.

We extend these definitions to paths as follows:

- A path is called fast if all its constituent causal relations are fast. In all other cases the path is not seen as fast.
- A path is called weak if all its constituent causal relations are weak. In all other cases the effect of the path is not seen as weak.

This extension allows us for the reasoning following steps to estimate the cumulative effect of two cycles $P_1$ and $P_2$ having the factor $A$ in common. For example,

1. if $P_1$ is reinforcing and fast while $P_2$ is balancing but not fast, then the accumulated effect is a plateau-effect (see Figure 6.6): a positive change in
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A the first lead to reinforcement that later is muted by the balancing effect from $P_2$.

6.4.4 Constructing guidelines

The construction of an Extended Causal Diagram from a conceptual model for a given focus roughly consists of the following steps.

**Step 1** - Determine the substantial variables that are necessary and sufficient to span the state space of the focus.

**Step 2** - Introduce the dashboard variables that characterize properties that are relevant for the focus.

**Step 3** - Identify the elementary causal relations between the factors.

In the next section we discuss some cases to demonstrate this transformation procedure.

6.4.5 Causal reasoning

The extended causal diagram allows policymakers to reason in a semi-quantitative way about the underlying application domain. We discuss several aspects of this reasoning. We see an ECD as a labeled directed graph $G = \langle V, E, \lambda \rangle$, where the nodes ($V$) are the factors of the ECD, the edges ($E$) the connections and $\lambda$ a function assigning the polarity indicator to each edge.

Firstly, policymakers want to distinguish between independent and dependent factors. The other (dependent) factors can be influenced via these elementary factors. So the independent factors provide the managerial basis for the policy makers. Formally, a node without incoming edges is an independent factor. Let $\text{base} (G) \subseteq V$ be the basis of graph $G$, the set of independent nodes.

Secondly, the policymakers will want to indicate a (set of) factor(s) as target factor(s). Their policy is to optimize on the target factors. Then the ultimate success of their policies is measured in terms of these target factors. In our example, the factor $\text{DigitalUser}$ is chosen as the (single) target variable. Let $T \subseteq V$ be the set of target variables.

We call the restricted ECD diagram $G$ to the target variables $T$ the active diagram, denoted as $\text{active} (G, T)$. This diagram consists of all vertices $v$ such that there is a path from $v$ to some target variable. Only the edges encountered on such paths are part of the active diagram, and the labeling function is the restriction of $\lambda$ to the active labels.

Thirdly, policymakers want to detect the balancing and reinforcing loops in the active diagram. These loops provide special opportunities for uncontrolled growth and for stabilisation.

In the next step, the policymakers detect all control paths in $\text{active} (G, T)$. A control path connects an independent factor with a target factor. The polarity of a control path indicates how this path contributes to ultimate goal in terms of the target factors.
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After these steps, the policymakers have to find their best options by selecting the most effective control paths. For each control path it is essential to estimate:

1. The strength of the causal effect of the control path;
2. The time frame required by this control path to become effective;
3. The investment costs associated with this control path.

The proposed tool help the policymakers to make a price/performance analysis, based on which the best control paths are selected.

6.5 The e-government application

In this section we demonstrate the procedure described in Section 6.4.4 to derive an Extended Causal Diagram in a systematic and structured way from the description of a focus in the context of an underlying conceptual model.

In Section 6.3 we have described a conceptual model for the successful implementation of e-government and defined as the focus of attention the stimulation of citizens to use the digital services that are offered in the context of e-government. Our primary goal in this section is to extract all possible opportunities, threats and other related variables that affect e-government implementation, and to investigate what causal relations exist between these variables.

ORM is a language-based conceptual modeling technique. We can, therefore, use the associated semi-natural domain language (referred to as Object Role Calculus, ORC) to define these variables such that (non-technical) domain experts can easily recognize (and validate) the variables chosen.

My analysis involves several steps. The first step is fundamental. It only focuses on viewing the number of citizens using manual services (manual users) and the number of those using digital services (digital users). In the second step, the effect of education is considered, while the third step focuses on the impact of infrastructure. The rationale for this is that to be using digital services; a citizen needs to have sufficient skills and sufficient tools.

After these steps, we have a complete causal overview of the focus area. This Extended Causal Diagram then is used in Section 6.7 to construct a simulation tool.

6.5.1 Step 1: basics

Our goal is to keep track of the number of users that use digital services and those using manual services. This goal is presented in Figure 6.7. Keeping a record of how these figures develop over time helps in understanding the e-government development progress. This goal is analyzed via the steps described in Section 6.4.4 to extract the relevant variables for the extended causal diagram being developed, and their causal relations.

To achieve this goal we restrict the e-government conceptual model (see Figure 5.1) to those object types that are associated with manual and digital use of services. This conceptual scheme does not define manual and digital users by themselves. But, they can be defined in terms of concepts within this conceptual scheme. Digital users are described as citizens who use electronic tools. They are
recognized by sending service requests using electronic tools. Manual users are citizens who do not use electronic tools. They are identified as citizens making requests to manual services. The relevant subscheme is highlighted in Figure 6.8.

Using the semi-natural language defined by the ORM scheme, we may introduce the following new concepts as follows:

- **DigitalUser** IS Citizen involved in Request for DigitalService.
- **ManualUser** IS Citizen BUT NOT DigitalUser

By introducing the object types **DigitalUser** and **ManualUser**, we have presented a conceptual base for the object type Citizen (since each citizen is in either state). These new object types are the factors for the extended causal diagram under construction (see Figure 6.9). In this example we do not consider the death rate of the population. The assumption is that both manual and digital users are proportionally influenced by birth rate factor of a population. Furthermore, we assume new born citizens are categorised as manual users. Manual users are transformed into digital users when they start to use digital services. External factors can influence this transition positively or negatively. For example, offering training programs and improving infrastructure affect this transformation. We will come back in the next steps. The effect of these steps is the flow of instances from **ManualUser** to **DigitalUser**. This flow is refined later.
6.5.2 Step 2: adding education

In this step, education is added as a means to stimulate the use of digital services, or, to stimulate the transition from ManualUser to DigitalUser. The motivation is that having the relevant skills promote citizens to involve in digital service practices. The conceptual scheme from Figure 5.1 records the trainings that have been taken by citizens, and the training that is completed. The relevant scheme fragment is displayed in Figure 6.10.

Citizens first register for a training; then it is recorded when they successfully complete the training. For our purposes, we focus on the following new states for citizens. First we consider those manual users who have registered for the training. Such citizens are referred as CitizenStartTraining. After successfully completing a course, such citizens are trained, and ready to become digital user. This citizen is referred as TrainedCitizen. The flow from ManualUser to DigitalUser from Figure 6.9 is now redirected via CitizenStartTraining and TrainedCitizen.

We introduce a factor RegistrationRate to control the registration process for trainings (the flow from ManualUser to CitizenStartTraining): the more untrained citizens, the more citizens start training. Also, the more training is being offered, the more citizens register for training. However, when the number of training provided becomes too big, citizens get confused, and this will negatively influence citizens to enroll in training.

Furthermore, we assume a factor SuccessRate that controls the probability that a citizen after registering for training also completes that training successfully. The intended effects of promoting digital service usage are caused by training that...
has been completed. As a consequence, the quality of training (the SuccessRate) is an essential factor. This factor can be described as the ratio of starting users who are successful.

Citizen and training factors lead to the introduction of the following extended causal diagram:

1. CitizenStartTraining IS Citizen start Training.
2. RegistrationRate IS COUNT Citizen start Training BUT NOT completed Training / COUNT Citizen BUT NOT completed Training.
3. TrainedCitizen IS Citizen completed Training.
4. SuccessRate IS COUNT TrainedCitizen / COUNT CitizenStartTraining.

From the application domain the following causal influences are obtained. A higher offer of training leads to an increase in subscriptions for training. On the other hand, an overload of training is offered also confuse people, and therefore have a negative impact on starting a training. The more training programs are offered, the more people enroll. By increasing the success rate of courses, this effect increase the number of citizen trained. More trained citizen will (1) negatively influence the number of citizens starting as manual user, (2) positively influence starters to become digital users, and (3) encourage the transition from manual to digital service usage. This leads to the ECD as displayed in Figure 6.11.

6.5.3 Step 3: adding infrastructure

The next significant factor for successful implementation of e-government is the infrastructure that is required for the digital services. This section restrict infrastructure to the connectivity by which citizens are connected to the Internet. Figure 6.12 display relevant concepts for this step.
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From the domain expert perspective, connectivity is defined as the number of citizens who are connected to the Internet; citizens living in a region that is connected to another region may be considered connected. Reformulating this definition is the conceptual domain language leads to:

Connection IS COUNT Address located in Region being connected to

Furthermore, the domain expert explains that the average connection quality can be used as the overall quality indicator for the network of that country:

ConnectionQuality IS AVERAGE Quality of Connection

These both factors influence manual and digital users and their transition as indicated in Figure 6.13.

6.5.4 The Zanzibar case

Figure 6.13 represents study focus on e-government implementation process from Zanzibar case domain. This example highlights important focus for policymakers to apply strategic decision in government services.

Zanzibar is a semi-autonomous Island with a population of 1.3 million [21]. In forecasting the development of e-government adoption, citizen behavior is a core factor to predict changes. Citizen behavior reflects a proportion of the population in accepting changes especially in ICT adoption. These behaviors were very much accepted and proved as an intrinsic driving force in any adoption process. This chapter has come into consideration of adoption factors that contribute the transformation process. The details of these factors have been described in Bass model. The Bass model use mathematical constant coefficient to present the influence of innovation [20].

These factors help to estimate the pessimistic picture of the transformation process from manual service to digital service. They represent the internal and external influence for every transformation step. Figure 6.13 shows three transformation steps CitizenStartTraining, TrainedCitizen, and Digital users. Where citizen adoption behavior contributes to the realization of transformation process. Each transformation step needs to estimate the number of citizens who get influenced by external communication and those influenced by internal communication. These
6.6 Transformation to system dynamics

Typically, a causal diagram is a first step in the development of a system dynamics (SD) model. In the system dynamics model basically the causal relations of the causal diagram are quantified. These quantifications then are the basis for a simulation tool. Such tool helps the policymaker to quickly and conveniently see the effects of their decisions on the target factors by (for example) manipulating the independent factors. Quantification of the causal relations requires a level of detail and precision that adds extra complexity to the modeling of the application domain.

In this section we define the basic SD constructs, and define the semantics of a SD scheme. A system dynamics scheme is constructed from 2 kinds of variables: (1) stock variables are similar to substantial variables in ECD, and (2) exogenous variables corresponding to dashboard variables in ECD. Sinks and sources are special kinds of stock variables, that represent the environment of the SD-scheme. Two kinds of arrows connect these variables. A flow is a connection between stock variables representing the flow of instances; the other connections are called links representing causal relations. Links start in a variable (exogenous and stock), and lead to another exogenous variable, or to another flow or link. The source of arrow $f$ is denoted as $\text{src}(f)$ and the destination $\text{dst}(f)$. See Figure 6.14 for the
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Graphical representations. For this purpose, an SD is similar to an ECD except for naming conventions. However, construction rule 5 (see Figure 6.14) is not possible in system dynamics. We nevertheless assume this construction rule, and use the technique of flattening (see Lemma 6.6.2) repeatedly until no longer possible to transform a construct generated by applying construction rule 5.

Figure 6.14: Dynamic modeling constructs

There is a special stock \( \bigcirc \) that represents the environment of the system. Input via a flow from this special stock corresponds to the birth of instances in the system, output to this special stock corresponds to the death of instances. We call a flow external if either \( \text{src}(f) = \bigcirc \) or \( \text{dst}(f) = \bigcirc \); this will be denoted as \( \text{ext}(f) \). A flow cannot have both \( \text{src}(f) = \bigcirc \) and \( \text{dst}(f) = \bigcirc \).

The main difference between ECD and SD is that the SD is used to quantitatively describe the behavior of the system by explicitly quantifying the arrows. In contrast, the ECD restricts itself to a qualitative description of influential aspects. System dynamics assumes time to be discrete rather than continuous, and represents time as a set \( T \) of equidistant points of (real) time. Let \( \Delta t \) be the size of an elementary (real) time step. For convenience these points in time are consecutively numbered. Then the semantics of the behavior of a SD are described by equations that express how the state of time \( t + 1 \) is evaluated from the state at time \( t \).

The state of the SD at time \( t \) is described by assigning a value \( \text{Val}[X](t) \) to all its elements \( X \), both variables and connections. We describe the value function for stock variables and exogenous variables differently.

Stock variables get a special treatment in the description of the behavior semantics (see also Section 6.4.2.3). At each point in time \( t \) a stock \( S \) stores a set \( \text{Pop}[S](t) \) of instances of the associated conceptual type. Instances may be moved via a flow to another stock. The value of a stock \( S \) is defined as the number of
instances \( \text{Val}[S](t) \) in the stock. Consequently we have:

\[
\Delta \text{Pop}[S](t) = \sum_{f: \text{dst}(f) = S} \text{instances coming from} \ f \ (f) - \sum_{f: \text{dst}(f) = S} \text{instances disappearing via} \ f \ (f)
\]

In terms of the value function:

\[
\nabla \text{Val}[S](t+1) = \sum_{f: \text{dst}(f) = S} \text{Val}[f](t) - \sum_{f: \text{src}(f) = S} \text{Val}[f](t)
\]

where \( \nabla \text{Val}[S](t+1) = \text{Val}[S](t+1) - \text{Val}[S](t) \) is the increment of the value function at time \( t+1 \), and \( \text{Val}[F](t) \) the number of instances coming from flow \( f \) at point of time \( t \). As a consequence, the change of total number of instances at each point of time equals the number of new instances (of any type) minus the number of disappearing instances (of any type).

**Lemma 6.6.1  conservation of instances**

\[
\sum_{\text{Stock } S} \nabla \text{Val}[S](t+1) = \nabla \text{Val}[\emptyset](t+1)
\]

**Proof:**

By applying the definition and reversing the summation order, we get:

\[
\sum_{\text{Stock } S} \nabla \text{Val}[S](t+1) = \sum_{\text{Stock } S} \left( \sum_{f: \text{dst}(f) = S} \text{Val}[f](t) - \sum_{f: \text{src}(f) = S} \text{Val}[f](t) \right)
\]

\[
= \sum_{f: \text{\neg ext}(f)} (\text{Val}[f](t) - \text{Val}[f](t))
\]

\[
+ \sum_{f: \text{src}(f) = \emptyset} \text{Val}[\emptyset](t) - \sum_{f: \text{dst}(f) = \emptyset} \text{Val}[\emptyset](t)
\]

\[
= \sum_{f: \text{src}(f) = \emptyset} \text{Val}[\emptyset](t) - \sum_{f: \text{dst}(f) = \emptyset} \text{Val}[\emptyset](t)
\]

\[
= \nabla \text{Val}[\emptyset](t+1)
\]

since links that are not internal correspond to an internal move of instance, and therefore have no contribution to a change in the number of instances in the system.

The tap symbol used in the graphical representation of a flow (see Figure 6.14) indicates a regulation that controls this flow. The regulating effect of flow \( f \) is influenced by its incoming links (if any).

If link \( f \) itself has no incoming links, then its value is simply defined as its base value: \( \text{Val}[f](t) = \text{Val}[\text{src}(f)](t) \). Let \( g \) be an incoming link for \( f \), or, \( \text{dst}(g) = \)
 CHAPTER 6. SYSTEM DYNAMICS MODELING

$f$, then this base value \( \text{Val}_{\text{src}(f)}(t) \) will be influenced by \( g \). We use the pair \( g : \text{Val}_g(t) \) to denote this influential factor. Let \( \text{Inputs}_f(t) \) be the set of all influential factors for link \( f \) at time \( t \):

\[
\text{Inputs}_f(t) = \bigcup_{g \rightarrow f} g : \text{Val}_g(t)
\]

The base value and the influential factors of the incoming links of \( f \) are aggregated by the aggregation function \( \text{aggr}_f \) associated with \( f \) to obtain the resulting value \( \text{Val}_{\text{dst}(f)}(t) \):

\[
\text{Val}_f(t + 1) = \text{aggr}_f(\text{Val}_{\text{src}(f)}(t), \text{Inputs}_f(t))
\]

Similarly, we assume an aggregation function \( \text{aggr}_E \) for incoming links of exogenous variable \( E \). Then we have:

\[
\text{Val}_E(t + 1) = \text{aggr}_E(\text{Val}_E(t), \text{Inputs}_E(t))
\]

where \( \text{Inputs}_E(t) \) is the extension of the inputs-function to exogenous variables. In the remainder we will use \( X(t) \) as a shorthand notation for \( \text{Val}[X](t) \). Furthermore, aggregation functions will assume some ordering of the incoming links, allowing to simplify the definition of aggregate functions.

![Figure 6.15: Sample scheme](image)

**Example 6.6.1**

Consider the sample scheme fragment in Figure 6.15, consisting of the variables \( A \), \( B \) and \( C \) and the links \( f \), \( g \) and \( h \) with the following aggregation functions:

\[
\begin{align*}
\text{aggr}_f(x, y) &= x \cdot e^{-y} \\
\text{aggr}_g(x, y) &= x \cdot \ln(y)
\end{align*}
\]

Then we get:

\[
\begin{align*}
f(t + 1) &= \text{aggr}_f(A(t), g(t)) = A(t) \cdot e^{-g(t)} \\
g(t + 1) &= \text{aggr}_g(C(t), h(t)) = C(t) \cdot \ln(h(t)) \\
h(t + 1) &= C(t)
\end{align*}
\]

Finally we consider exogenous variables \( E \) without incoming links. Such variables are sensors that obtain their value from an inspection \( \text{insp}(E) \) of the associated application domain. Therefore, for such variables we have \( \text{Val}_E(t) = \text{insp}(E)(t) \).
Next we consider the flattening procedure as described in Section 6.4.2. The semantics of the links in Figure 6.2(a) are described by:

\[
B(t+1) = f(t) \\
f(t+1) = \text{aggr}[f](A(t), g(t))
\]

The semantics for Figure 6.2(b) are:

\[
B(t+1) = \text{aggr}[B](f(t), g(t))
\]

So the fragments from Figures 6.2(a) and 6.2(b) are equivalent if the function \(\text{aggr}[f]\) from Figure 6.2(a) is identical to \(\text{aggr}[B]\) from Figure 6.2(b). Consequently we have the following lemma:

**Lemma 6.6.2** (flattening) The fragments \(C \rightarrow A \rightarrow B\) from Figure 6.2(a) and \(C \rightarrow B; A \rightarrow B\) from Figure 6.2(b) are equivalent.

This lemma shows that the use of construction rule 6 in Figure 6.14 can be avoided.

### 6.7 A simulation tool for policy makers

Using the conceptual scheme from Figure 5.1 as a framework for reasoning about the application domain, in Section 6.5 we defined the relevant factors for our focus of attention, and their causal relations. This resulted in the Extended Causal Diagram displayed in Figure 6.13. In Section 6.4.5 we gave an impression how an ECD can be used to do qualitative reasoning.

In this section we extend the ECD with a discretization approach and quantitative rules as described in Section 6.6, leading to a quantitative description of the application domain via a set of recurrence relations. Specific tools have been developed for such system dynamics models. Usually, these tools differ (slightly) in the way that the model is graphically represented. Some well-known platforms are Vensim ([70] and Sysdea ([282]). In this study we will use the Sysdea online platform. Sysdea is a commercial software for modeling how items change over time. This software enhances the overall functions of the system and manages the continuing performance of significant changes over periods. The software can display a time chart for each item in the model, which makes it easy to visualize the model behavior quickly.

#### 6.7.1 The transformation

Figure 6.16 shows the transformation rules that transform ECD scheme as shown in Figure 6.13 to system dynamics scheme Figure 6.17. The transformation aims to quantify the ECD diagram using system dynamics techniques. In general, the quantification process has opened a way to simulate the behavior of the system components on a time basis. The process intends to simplify the administration process and helps decision-makers to understand the behavior of the system influences better. Also, the realization of the ECD scheme into a simulation model
measures the dynamic feature that need to be monitored in e-government implementation. The transformation process results system dynamic scheme in web application simulation tool of Sysdea (see Figure 6.18).

Figure 6.16: The transformation rules

Figure 6.17: The e-government SD
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6.7.2 Adding a time step and quantification rules

First we focus on the discretization scale. A fair choice seems to use one month for each time step. Smaller leads to a lower systematic error caused by the approximation of a continuous process by a discrete process. However, a smaller time step leads to more calculations to consider some period. Time step also has an impact on the propagation of errors caused by using an incomplete representation of real numbers.

The quantification rules are straightforward estimates of the intended effect. For example, the factor Births is influenced by the BirthRate \( x \) and ManualUser \( y \) and calculated as the fraction \( x \) of the current population size \( y \):

\[
\text{aggr} \left[ \text{Births} \right] (x, y) = x \cdot y
\]

6.7.3 Experience with the simulation tool

The online use of Sysdea platform allows understanding system behavior behavior quickly. The online simulation enhances the exploration behavior, where each variable can be visualized independently. It enables observing the changes that influence the entire model. Another feature is the sharing property. The model can be shared and modified with other online users without affecting the original model. This feature motivates users to run the model without fear of software installation.

The model itself has adopted the incremental behavior described in ECD construction rules. The simulation results have quantified the variable influence defined in Section 6.5, mainly the influences between target variables and influence variables. Changes of target variables have direct influence on the final results. This feature helps to create awareness to the target variables to meet a long term plan.

Still, the Sysdea platform has some limitations. Some features have not yet been implemented. Nevertheless, the flattening process (see Lemma 6.6.2) was a perfect approach to align an ECD model to system dynamics modeling.
6.8 Conclusion

The method developed in this study considers domain study as an initial part to understand any system. The domain understanding provides an opportunity to realize the existing problems and find appropriate solutions. The process deploys analysis, assessing and identifying of key components to understand the interconnection, causality and mutual interactions of the system. The method can support policymakers to support strategic decisions in those cases where adequate solutions are hard to design.

The introduction of Extended Causal Diagram (ECD) aims to increase the expressive power of Causal Diagrams by adding 2nd order effects and proposes extra dimensions as speed and strength of a causal effect. Using the introduction of e-government in Zanzibar as a non-trivial example, we showcased how to derive a simulation tool in a systematically from a linguistic-based conceptual description of the application domain.

The construction of an ECD diagram does not concentrate on loop formation. Instead, it is striving to understand existing requirements and to transform them into an implementation model. This process transforms domain requirements into a tool that can help decision-makers to make strategic decision. Furthermore, the introduction of influence variables in ECD diagrams provides an opportunity to analyze the case domain without further quantification method.

The causal relations that were identified provide a clear perspective on the predicted causes on system implementation. The formalization of this process leads to a more thorough and deep understanding of the designed system and implementation process. This process provides a full range of relevant variables that we understand on policy decision. The decision that may cause policy resistant if made incorrectly. However, this approach provides a quick solution to the qualitative perspective. We believe that the formalization of this process validates this approach and bring a great contribution to the understanding of causal relations in system implementation. E-government implementation system was used as an example to this method, we assume that this method can be applied in any complex system.

ECD still lack of fine-tuning elements. For example, there is no way to make comparisons between the strength of different causal relations. For example, a policymaker may want to choose for the policy with the strongest effect. Also, the speed of the impact is beyond the expressive power of ECD reasoning. This limitation is problematic when different causal relations need very different periods to become effective. For example, when a reinforcing and balancing loop intersect, then the policymaker can use the reinforcing loop to start development and the balancing loop to stabilize at the required level. But, for example, the situation when the balancing loop is instantaneous while the reinforcing loop is a long term activity, should be treated very differently from the situation where the balancing loop is long term and the reinforcement instantaneous.
Chapter 7

A cultural perspective

This chapter describes the formal implementation of the LART method. We embed the ICT Roundtable approach together with collaborative approach in thinkLet in relationship with cultural characteristics in the requirements engineering process.

This chapter attempts to answer the following research question: RQ6: What is the effect of cultural differences on design and development of ICT projects? How can modeling successfully be applied in a collaborative environment?

Abstract

Modeling is a process of important schematizing characteristics from an application domain into a formal representation. The resulting model not only is a knowledge base for understanding the associated application domain, but also is useful in communicating this domain in its broader sense. Modeling does not take place in isolation but is embedded in a social context where messiness, ambiguity, time pressure and conflicts are impediments to the life of grace. A modeling technique should be able to handle such issues, and therefore depends on both; the cultural characteristics of the people involved and the organizational culture of modeling organization. These dependencies in the end also influence the viability of the proposed solution. Modeling a complex social environment by far is too complex for a single modeler. An involvement approach is more systematic in eliciting knowledge from a group of stakeholders, especially for typical large-scale problems such as the introduction of e-government in Zanzibar. This study presents Linguistic Approach in a Roundtable setting (LART), a modeling technique based on (1) hierarchical decomposition, (2) natural language based modeling and (3) ICT Roundtable for organizing the social interactions. The proposed method is embedded with a Collaborative Engineering approach, and mainly focus on thinkLets as basic collaboration techniques. We discuss these thinkLets from a cultural perspective to demonstrate the cultural fitness of the LART approach during col-
laborative decision making. We conclude that LART reveals an agile nature in which correctness and completeness are stimuli for product acceptance and public ownership. This chapter intends to propose a method to strengthen sustainability and viability in the context of the introduction of e-governance in Zanzibar. The chapter describes an extended case study to validate the usefulness of LART in a practical situation. Keywords: Linguistic approach, Roundtable, thinkLet, Participation approach, Shared understanding, Agile methodology, Object Role Modeling (ORM)

7.1 Introduction

Participation is a well-accepted method to engage the local population in a development project [55]. This approach enables local people to share their perception and to prioritize and appraise issues from their knowledge of local conditions. It is used in developing countries to unlock peoples ideas and to find a realistic solution. Nowadays, it has been used internationally in various perspectives such as conflict management, awareness issues, and development projects [44]. The participation approach tries to substantiate a bottom-up approach, where the participants can contribute to project development from their voices. Ideally, this approach empowers local participants throughout the development process. At the same time, participants can attain an inimitable style to support invention. Quality issues such as individual responsiveness, local ownership, development of internal capacity and practical experience can be obtained along the development process [267, 143].

The ICT Roundtable approach is an emerging paradigm of a participatory method introduced by the International Institute for Communication and Development (IICD) to initiate Information and Communication Technology (ICT) projects in developing countries [128]. The ICT Roundtable approach is an operationalization of the Constructive Technology Assessment (CTA) framework [178] that has Technology Assessment (TA) as a parent structure [222]. A round table setting is a most efficient method due to its effective measure to get public acceptance for difficult problems [57]. Besides these incomparable benefits, the ICT Roundtable process promotes participation equality and spontaneous conservation over other approaches. For this reason, the ICT Roundtable process has been applied to 9 countries in Africa and Latin America for the development and implementation of various ICT projects. The implementation of this approach stimulates other developing countries to apply the ICT implementation strategies in seeking different livelihood opportunities [128, 129]. In principle, the ICT Roundtable approach allows face to face discussion, though the cultural and social attributes tend to have some degree of subjectivity [91].

Since the ICT Roundtable approach is a consensus approach, it indirectly supports conflict and change management [178]. Yet, its limitations usually bring a heated debate in a CTA framework [93]. In practice, conflicts can hardly be avoided especially when transforming a traditional system. Experience shows that the introduction of new technology inherently is prone to conflicts [170]. Hypothet-
ical suggestions to control the environmental situation in a CTA framework did not cover such issues as handling deadlocks and alleviating decision conflicts [178]. But, a hypothetical solution logically corresponds to a facilitation technique and definitely predicts a collaborative development approach [280]. For that purpose, this study proposes the usage of thinkLets to advocate a systematic framework and unified view during ICT Roundtable execution.

The ICT Roundtable process was proposed to support modeling development which brings together both domain expert and system analyst in a roundtable setting. That situation conveys some design challenges on communication pattern with a domain expert. Therefore, the Object Role modeling (ORM) was proposed to structure the communication link and brings a common understanding between domain expert (DE) and system analyst (SA). Particularly, in the use of semi-natural language to comprehend domain experience [118]. Of course, modeling user related approach is not new in participation approach [275]. It has been used in combination with other problem-solving techniques such as modeling and simulation solution [243]. Eventually, many software modeling typologies exists, such as Companion Modeling (CM) and Soft System Methodology (SSM). But, in the social system, uncertainty has to be treated differently, in the sense that following other typology with the diametrically different goal may not reveal desirable results. However, some innovative ideas such as the use of representation scheme in oral or graphical visualization can be inherited to support working environment [46].

In short, following a set of principles for software development, agile methodology is flexible and rapid in response toward changes which stimulates communication pattern for effective learning, and correct requirements document [154]. Since, the agile approach stimulates development process, its influence in the project execution process is well considered in project implementation and specifically for the introduction of e-government system. This agility phenomenon can substantiate complete understanding in the construction of the ORM conceptual scheme using semi-natural language [53]. This approach complies with stakeholder involvement in the use of natural language development in the roundtable discussion.

This study has two contributions, namely, (1) Improve roundtable process execution, this is solely on handling conflicts and anonymous contributors in a roundtable setting. The anonymous contribution supports active involvement in which participants can freely contribute without having to worry about their security. Collaborative engineering stimulates facilitation skills, where stakeholders can exchange information on problems and take collaborative action and decision. In the light of collaborative engineering technique, this improvement was realized, (2) Improve the ORM modeling technique. Using natural language in design process supports shared understanding between domain expert and system analyst in which product can be delivered to meet user requirements. Thus completeness and correctness of the model can be achieved.

This chapter focuses on the questions: what is the effect of cultural differences on design and development of ICT projects and how can design and development techniques respond to cultural differences. This study was conducted as a contribution to the introduction of e-government in Zanzibar.
This chapter is organised as follows. In section 7.3 we will describe a Linguistic Approach in a RoundTable setting (LART). LART is based on three pillars: (1) a natural-language based approach to modeling, described in 7.3.1. In this pillar, we first discuss a natural-language based approach to the modeling process and distinguish the two major roles: the domain expert and the system analyst. The second (2) pillar is a decomposition mechanism for typical large-scale problems such as the introduction of e-government, in 7.3.2. In this pillar we discuss the complexity of the problem at hand, which can be characterized as a public sector project. We see how this complexity can be mastered by making a hierarchical decomposition of the overall task, thereby introducing various intermediate levels of abstraction. This leads to sub-processes, where each level has its own concerns (more or less) independent of the concerns of the other levels. As a result of this decomposition, the organizational aspects of the modeling process become more prominent. The third (3) pillar is the use of the ICT Roundtable method for process organization described in 7.3.3. In this pillar, we discuss the ICT Roundtable approach as a mechanism to effectively organize the modeling transformations with multiple domain experts and multiple system analysts. Then, in section 7.4 we focus on how to efficiently support this approach by a collaborative engineering approach. Next, in section 7.5 we discuss the proposed approach in the aspect of social development, followed by description from the cultural aspects. Then we conclude in section 7.6.

7.2 Literature review

Several studies have shown that various techniques can be used for strategic and successful e-government implementation [40, 158, 155]. But these studies are focused on success factors from a developed countries point of view, which may contextually be very different from developing countries. In both situations, however, change remains difficult to pull off, regardless of the economic situation of a country. Studies have shown that the success rate for introducing new technology, downsizing, and corporate restructuring have had in many cases a disappointing outcome [22]. Only a few organizations have managed the change of the process according to their preferences. This adaptation to change is more challenging for developing countries due to their high bureaucratic structures [88]. A study conducted by [96] describes this problem in concerning corporate work flow [54] as a significant cause for change resistance in government organizations [88]. On the other side, a study conducted by [48] has described cultural and social factors as critical strategic factors in e-government implementation. These factors feature a close relationship between society and services provided by government organization. In a sense that cultural characteristics should be subjective for both developed and developing countries. Because of cultural diversity in organization viewpoint is so dynamic, that can prevail in any country [91].

According to [274], there is no single definition of the Theory of Change (ToC) and neither there exists a generally accepted methodology. In this chapter we use the definition in [77]: *Theories of change are the ideas and hypotheses ('the-
ories’) people and organizations have about how change happens. These theories can be conscious or unconscious and are based on personal beliefs, assumptions and a necessarily limited, personal perception of reality. According to [77], the core elements of the Theory of Change are

1. What is the desired change, why and for whom?
2. Analysis of the system and the current situation: (a) context analysis: social, political, economic, ecological and other dimensions; (b) stakeholder and actor analysis; (c) power and gender dynamics, drivers of change, opportunities for change.
3. Mapping pathways of change: (a) Who and what needs to change in order to realize the longer-term desired change? (b) How do we think the change process might evolve from where we are now?
4. The assumptions underlying our theory of change: (a) What do we assume about the needs, interests and behavior of stakeholders and other key actors? (b) What do we assume about cause-effect relations in the logic of the change pathways?
5. Strategic options: (a) What is the best way for the organization or project to contribute, what should its role be (position, capacity, added value)? (b) What do others do? Is there a need and opportunities for multi-actor collaboration?
6. Strategic planning for the project period (theory of action)
7. Monitoring, evaluation and learning framework and process: (a) How to document the change process? (b) What to monitor and how? (c) Learning agenda. (d) When and how to revisit the ToC and reflect on what works?

Software development methodologies are proposed as a solution for the construction of e-government problem definition [189]. In software development approaches, users are the top focus for the designed product, whereas the e-government is a basic recipe. The waterfall and agile approaches are conventional approaches to software development [273]. The choice of the most appropriate of these approaches is largely determined by industrial support practices and the scope of the proposed solution. The waterfall approach follows a traditional top-down approach in the development process in which there is no room for changes and modifications once the process has started. This is completely different in the agile approach that uses modern technique to overcome competitive market advantages when stakeholder agreement is the most critical factor for the development process [68].

In each software development approach user involvement is prioritized since users can cultivate a greater understanding of complicated matters and decisions, specifically for social development projects [288]. Usually, the stakeholder contribution has two main objectives: (1) knowledge sharing and system understanding [165] and (2) supporting decision making and policy management [152]. Involvement by itself may not completely cover its necessity, and a valuable contribution can only be attained when participants are actively engaged in the development process. Active participation not only enhances shared experience but also builds a strong civil society and public confidence. Therefore, the degree of
participation distinguishes those who espoused and implemented genuine participation, in the effect that interpersonal interest and external influence may limit the scale of actual participation [175].

The participation approach appreciates the value of stakeholder engagement in problem solving processes. It has been used to meet lines of argumentation in both a normative and pragmatic way [214]. The pragmatic approach defines how much knowledge experience and expertise are required to address complex problem, either at favourable or unfavourable consequences. The normative approach relates problems with uncertainty and societal fears. Participation was used as a way to define social problems and issues in societies for which social participation owns authoritative judgment [214]. The participatory approach is widely used in a range of community based, poverty reduction and regeneration projects where local participation is prioritized [44]. This method is beneficial due to the perception that it characterizes bottom-up concepts and prevails construction mechanisms for unconnected components [210]. Primarily, this approach invites the local population to share their knowledge and to prioritize issues in their local environment. The main focus is on handling conflicts of interest, and on collaborative decision making [76]. In general, the participation approach was undertaken in many studies that correspond with research-driven [179] and development-driven [128] findings.

When cultural diversity is concerned, participation approach has an international reputation in areas such as conflict management, awareness issues, and development programs [44]. The most compelling project is conducted in Nigeria under Jigawa Enhancement of Wetlands Project. This project deploys the participation approach to link between public officers, non-government organizations and beneficiaries from natural resource conflicts where rights and collaboration were well established [25]. In addition to that, the same approach has been used for many years for rural communities in Wales and Eire. Hence, this approach has been used in both developed and developing countries as a tool for sustainable development [44]. One example of a participation type is known as the roundtable process. This process is most commonly used to overcome organizational culture, where a bottom-up approach is used in the development of social projects [179].

To the software development process, a model-based development approach is mostly used to add abstraction to the development process. This approach is mainly meant to simplify the problem and to build a clear understanding with customers [174]. Some modeling approaches are autonomous on participation context, such as the Group Model building [163], Companion Modeling (CM) [36] and Mediated Modeling [267]. Usually, modeling development approaches are used in combination with other methods to enhance the development process. For example, Companion Modeling (CM) is combined with both qualitative and quantitative methods to construct natural resource and management system knowledge [78, 36]. Therefore, tools such as interviews and focus group discussion have been used to qualitatively analyze information, and methods such as UML modeling and simulation techniques for quantitative analysis [36]. Furthermore, the involvement approach also adds extra importance to modeling projects in which shared understanding forms another possibility for inefficient development with participatory approaches [146]. Various tools and techniques are used to overcome
those hurdles, such as the semi-natural language approach used in Object Role Modeling techniques [105] and collaborative engineering approach [184].

The ICT Roundtable approach is an emerging paradigm of a participatory method introduced by the International Institute for Communication and Development (IICD). This approach is used to initiate Information and Communication Technology (ICT) projects for developing countries [128]. This approach was implemented in developing countries such as Burkina Faso, Bolivia, Ecuador, Ghana, Jamaica, Mali, Tanzania, Uganda and Zambia [179]. These countries are struggling for sustainable implementation of ICT projects [178]. In overcoming that hurdle, the ICT Roundtable approach has been used to get maximal responsiveness in finding considerable solution.

The ICT Roundtable approach has proven to be an instrument for change in practical operationalization of Constructive Technology Assessment (CTA) framework. This framework used as a stimulator for the participation behavior, and natural transformation of the technology to societal needs. Within a broad range of Technology Assessment (TA) criteria, the CTA framework becomes particularly relevant in three level indicators. These are anticipation, deep learning and reflexivity criteria, specifically for learning and social agenda development [93] because it supports multi-stakeholder as individuals and members of teams or organizations who have the same interest in the realization of the new system. With attention to knowledge sharing and collaboration, the involvement characteristics are firm in a CTA framework. They can be used as a reliable instrument to convince policy makers to support innovative efforts, in results of empowerment and ownership criteria [222].

The CTA framework measures process effectiveness using two criteria, namely, process orientation and output inspiration. The process criterion defines the infrastructure setting relevant for the orientation of the development process and organization mechanism in special attention on transparency and dialogue control. This criterion mainly focuses on the controls against the implementation process, where it defines formal rules in a development setting. This technique needs to hold the development environment and the development approach to maximize the resulting impacts. Furthermore, the output criterion evaluates the effectiveness of the development process. Thus, this criterion can be used as an indicator for measuring the overall impacts of the development process [93]. Under those characteristics, the CTA framework has been proved to be a tool for change and technological control, explicitly for measuring outcomes and impacts to the society, specifically in roundtable process execution. The reproductive effects of the ICT Roundtable method were tested during the introduction of ICT in education in Tanzania [177]. Besides, the technique has been applied in a wide range of development areas such as health and agriculture to seek a sustainable solution in technology intervention [177].

Importantly, the ICT Roundtable process responds to cultural constraints in which stakeholders are engaged to generate new ideas for case scenario development. In ICT, transformational strategies where bottom-up approach is potentially significant for public adherence. Also, it provides an excellent opportunity for local partners to contribute their unique experiences and knowledge. Domain
experience maximizes overall impact in development and ownership authority.

7.3 A Linguistic Approach in a Round Table setting (LART)

In this section we propose a method for project-based system design and development. In this context, we see a project as an organized cooperation between dedicated actors to perform some overall task related to define a common view on the application domain at hand. The cooperation process may be seen as a multi-processor algorithm, wherein the actors are the processors, and the organization describes how the processors can interact (like a motherboard in a computer). The actors represent the different aspects of the application domain. Setting up a project for design and development thus also includes thinking about social aspects. These social aspects include both the (required) interaction between people involved and how the interaction activities are organized to obtain the best possible result. These aspects may (and will) influence, directly and indirectly, the process.

Design and development processes are usually inherited from methods developed in (and for!) developed countries since (still) most technological innovation originates from initiatives in developed countries. Experiences from the past have learned that these methods are not necessarily useful in less developed countries [261, 178]. Many factors have already been identified in the past as critical factors in technology transfer [15]. The factors identified to make a point of need development and the problems caused by infrastructure deficiencies.

For our purposes, the main component of the design and development process is the modeling activity which defines a conceptual agreement between all stakeholders. The resulting model is useful for and central in the other steps of the design and development process. The angle of approach in this chapter focuses on cultural differences in so far as they determine how people are supposed to interact and how processes should be organized.

7.3.1 The modeling process

The intention of (conceptual) modeling is to make a formal description of some informal part of the real world, designated as the application domain or universe of discourse. In model-driven software development, a direct model executor is a tool that brings the model to life [94] for example for fast prototyping. For our purposes, an information system is seen as a direct model executor.

Information systems basically act as systems for communication within an organization. They help the various members of the organization as a center of knowledge to communicate about relevant domain issues, in so far as these members require such information for their daily decisions. Consequently, information systems incorporate social and organizational factors as well [110] that should be considered during the design and development phase.
Modeling is a significant part of the design and development phase intended to obtain a common and shared understanding of intra-organizational communication. A grammar can describe the rules of this communication language. However, different members of the organization may speak different 'dialects'. Then modeling tries to find the smallest and simplest grammar that is sufficiently close to and complete for each of these dialects. The result preferably is formed as a controlled language [87], being a well-defined restricted version of natural language. The information grammar defines the application-dependent part of this controlled language. It describes the elementary sentences that are valid in the associated Universe of Discourse. From these sentences, other sentences may be formed. Object Role Calculus (ORC) [115] and ORM2 [101] are examples of such generic systems for constructing sentences. In formal terms, the information grammar may be seen as the signature of a first-order logic theory [125], together with a set of axioms, derived from the population rules. The associated logic theory is a basis for formal reasoning about the domain. Proof assistants such as the Coq Proof Assistant [19] may help policy makers to check the validity of their intended policies in terms of their political assumptions as recorded by the axioms of the system.

Let $L_d$ be the language being used in the application domain and let $L_a$ be the language generated by the information grammar. During the modeling process, we assume a domain expert to be available who is familiar with both syntax and semantics of $L_d$. Syntax and semantics of this language are not available in a formal way, but are available on request from the domain expert in the form of example sentences and validations of scenario’s presented by the system analyst, who plays the opposite role in the modeling process.

The major problem during modeling is deciding whether the $L_d$ is (sufficiently) similar to the developed language. Since $L_d$ has no formal description, there is no formal way to check this equality. The only option is that the system analyst performs sufficiently many checks by offering validation scenario’s to the domain expert, to reach a sufficiently high confidence about the correctness and completeness of the model derived. Another issue is that a modeler will want to make the model on the one hand as simple as possible (Ockham’s razor), while on the other hand as generic as possible.

Therefore, both parties (system analyst and domain expert) are required to come to an agreement. The responsibilities are distributed over the roles as follows:

1. The domain expert is responsible for relevancy and completeness of the agreement.
2. The system analyst is responsible for correctness, given the specification that was agreed.

Note that this can only be possible when both domain expert and system analyst can fully understand the agreement and can check when suspicious. The system analyst wants to implement the semantics of the agreement as specified by the domain expert, the domain expert wants to test the formal semantics by offering test cases. The result then is assumed to be correct as long as its statements are not falsified during their communication [208]. In section 7.3.3 we discuss
the situation when multiple stakeholders in the role of domain expert and system analyst are involved.

According to the state-of-the-art discussions about natural language and its complexity [56] there is something very special about the brains of human beings that enables them to master a natural language which, in line with ideas the MIT linguist Noam Chomsky, is that the human brains contain a specialized language organ as an innate mental module that is dedicated to the task of mastering a language. In the context of this study, we conclude that this language organ is common for all people, independent of their (cultural) background, and thus can be used as a basis for a common approach. So language can be seen as having this common component as the hardware given by nature. The actual language then can be seen as a cultural asset or software that is to be learned (nurture).

A linguistical approach to the modeling process is not new. Already in NIAM [271, 159] the goal of modeling was defined as specifying the information grammar, which then would be transformed into a relational database scheme in optimal normal form. Nowadays, NIAM has evolved to ORM [103]. In this approach, other western languages other than English have also been considered [133], but, for example, Asian and African languages have not been investigated.

The advantages and challenges of using a natural language have been discussed in [85, 86]. The usage of a semi-natural language technique increases the strength and cohesion of the communication process during modeling activities. It can reduce misunderstanding and misinterpretation of the information that quickly arises when using natural language. Natural languages suffer from inherent complexity when used for two-way communication. A semi-natural language approach can reduce this complexity by combining both formal and natural language to create a shared understanding between domain expert and system analyst. A typical example of semi-natural language communication in daily life is the communication between armed forces and the international communication in worldwide civil aviation. The intention is that each sentence submitted over a radio channel has exactly one meaning and very little chance of misinterpretation. This technique is seen as the easiest way to reduce communication errors in natural language instruction that requires minimal (technical) skills to learn.

In that aspect, language philosophy brings formal cohesion in the development process. It comprehends understanding between stakeholders since they can easily exchange information in a format that is both (sufficiently) informal and formal and has both formal and informal semantics. The involved stakeholders, in their role of domain expert or system analyst are the ones defining this common language. Domain experts assign the language with informal semantics when reasoning about the application domain and while system analysts assign a formal semantics to this shared language. This style of communication is also known as a semi-natural language communication process, and allows the information exchanged to be agreed at the highest level of certainty. Definitely, the conceptual scheme is furnished with semi-natural technique. Such that; the domain knowledge is transformed from informal description to the formal representation. Hence, using a conceptual domain language during the development process creates a communication link for non-technical parties to understand and interpret the formal
procedures, which a fortiori brings active participation during the development process. This approach there is can also accommodate changing requirements, even during the development process, which in any complex system development seems to be unavoidable [281].

**7.3.1.1 Adding behavior**

The modeling development process described in [142] divides the modeling process in the following four phases:

1. Conceptual design, leading to a model of concepts and their relations. This model also is referred to as the information grammar. The information grammar, extended with some general (application independent) linguistic rules, forms the common semi-natural conceptual domain language in which other aspects of the application domain can be discussed in the subsequent stages of the design process.

2. Behavioral design, describing behavioral rules at a conceptual level via Extended Causal Diagrams. Causal diagrams describe how concepts qualitatively influence each other. Note that such a qualitative description is not as complex as a (complete) quantitative description, but can be used as the basis for such a description.

3. Simulation design, using system dynamics to prepare for a (quantitative) model simulation by transforming conceptual entities to Flow and Stock diagrams and by adding concrete rules to quantify the causal relations from the previous step over time; This approach makes it possible to do simulation at a conceptual level.

4. Implementation, realizing the system dynamics design using some tool for system dynamics. In this phase the adaption to a particular tool is realized, making it possible to set up the simulation design independent of implementation details.

The four phases behavior used to extract application domain from conceptual level to the model that can give information. For this study, the four phases behavior used as a tool for analysis and decision making of the application domain for the purpose of successful e-government implementation.

**7.3.1.2 The dialogue document**

A modeling meeting is a structured interaction between its participants, roughly organized in a question-answer style. A spoken message between humans consists of a verbal part (the actual words that form the message) and the nonverbal part (the associated body language). The nonverbal part puts the message in a context that is essential for the meaning of the message. For example, an incomplete (and thus basically incorrect) sentence may be meaningful when associated with the proper body language. Written communication is different, it does not involve a
nonverbal part. As a consequence, the meaning of written communication should not depend on factors that cannot be represented in the verbal part of the message itself. Consequently, written communication is very strict in order to be non-ambiguous.

Since a modeling transformation should result in an unambiguous description, the sentences in which the participants have agreed on are to be represented as written communication in a particular document. That reflects the kind of facts relevant in the context of a domain expert, need to be accomplished by system analyst. This so-called dialogue document is a document under development written during the modeling transformation. In particular, the dialogue document defines the information grammar and is written in the (emerging) conceptual language. It also contains the examples that have been used as a sample (and significant) population of the conceptual structure.

The dialogue document comprehends the domain knowledge described by the participating stakeholders during a modeling transformation. The development of this document links both local stakeholder and stakeholder outside of the selected domain. The local stakeholder known as domain expert or non technical team and external stakeholder comprise technical teams who are also modelers, or experts but also known as a system analyst.

The main factor in the development of the dialogue document is a communication understanding. Two circumstances require special domain expert attention, (1) when the dialogue document needs some addition or other constructs and (2) when the dialogue document needs a major modification due to the introduction of new policies. The first case is easily handled by the modeling technique since the new input can be processed instantly. But, for a major modification a new focus may be required to formulate the new points of view. Generally, domain knowledge is required to understand complex requirements. Consequently, the dialogue document has to be reconsidered from the beginning.

7.3.1.3 The basic modeling algorithm

Basically, the modeling process is a question-answer based interaction about a particular system between the domain expert and the system analyst. The system analyst takes the lead in this interaction and asks questions about the application domain that then are answered by the domain expert. The minutes of this interaction are recorded in the dialogue document.

The process typically starts with the question of the system analyst to provide an initial description of the application domain, preferably by specifying a set of examples, which are then used to find the deep-sentence structure of the sentences used in that domain. What follows next is to build a sample population of the resulting conceptual database. Note that the domain expert provides the system analyst with the informal syntax and semantics of the application domain by way of answering questions, while the system analyst provides the domain expert with the formal syntax and semantics of the information model. The described protocol is summarised in Script 1.
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### Script 1. The binary modeling process

1. Domain expert: present initial description
2. repeat
3. repeat
4. if System analyst: ask next question then
5. Domain expert: provide the answer
6. System analyst and Domain expert: agree on deep sentence structure
7. System analyst: record question and answer in Dialogue Document
8. System analyst: process sentence
10. System analyst: check for completeness and plausibility
11. else
12. Domain expert: ask next question
13. System analyst: answer question from model and sample population
14. end if
15. until Both parties agree: sufficiently satisfied
16. System analyst: do extra quality and plausibility checks
17. Domain expert: do completeness and correctness checks
18. until Both parties agree: sufficiently validated
19. System analyst: construct new agreement

### 7.3.2 Project decomposition

For a large project, task execution can be very complex due to the many issues that can be raised during the decision processes [35] involved. Besides, understanding specific conditions for specific situations also require a great deal of concrete contextual knowledge details. Hence, the decomposition of a complex task into smaller sub-problems can highly simplify decision making, providing higher clarity, consistency, and avoiding ambiguity and inconsistency [168]. On the other hand, decision making can be viewed as a rule-based process or as an action of an autonomous actor [168]. In either situation, a layered approach can highly contribute to optimizing rational decision making.

System development for public use is known to be challenging. An important reason is that multiple stakeholders are involved, each with different goals, needs and values. In [14] the following main project failure factors are identified: (1) organizational power, (2) politics, (3) education, (4) project management issues, (5) ambiguous business needs and unclear vision, (6) security and privacy, (7) finance, and (8) information technology. The project management issues concern the following common causes: (1) underestimation of timeline, (2) weak definition of requirements and scope, (3) inefficient risk analysis and risk management, and (4) unsuccessful monitoring and measurement.

To get a better grip on the management issues, we apply a generic method to split up the problem into smaller subproblems. A standard hierarchy for organizations
is to distinguish the following managerial levels in the context of decision making (see Figure 7.1):

1. the organizational level. It is here where directors operate. They handle such issues as mission, vision and strategy.
2. the process level. At this level managers operate trying to implement the strategy defined by the board.
3. the information level. At this level the required information is provided to support decision-makers. Information analysts are responsible for defining and processing the information channels.
4. the application level. At this level developers and system architects provide the operational aspects of information processing.
5. the infrastructure level. This level connects to the physical requirements context for proper operations.

We use this hierarchy to decompose design and development into various typical abstraction levels. The overall strategy of an organization is defined in the top-level of the pyramid, in a high level language. The modeling transformation processes the requirements specified in this language into instructions for the process level. It also processes the requirements that should be realized by the underlying information level, which then is part of the overall requirements that are to be realized by the part of the pyramid headed by the information level. If any requirements cannot be handled by the process level and if cannot be translated to the lower information level, then external project support is required. The same way these requirements are translated to requirements for the lower application and infrastructure level.

Decomposition of a complex task speeds up the process of system development. It simplifies decision making, not in the least because a layered approach has been proven successful in cases of complex decision making (see for example [205]). Working in a group is mostly used as a mechanism to compel evidence. It is
also considered as part of community engagement and their involvement in decision making process. Common understanding is the most important conception of group development. The use of a semi-natural language-based technique can significantly contribute to the common understanding of the essential concepts of group development.

We assume that the hierarchical structure has some fan-out, for example, normally several departments may contribute to the realization of (different parts of) the requirements of the requiring level above. During the modeling transformation, representatives of these various departments participate in the modeling transformation meetings. The modeling transformation process involves stakeholders both in the role of domain expert and in the role of system analyst. Note that different stakeholders may come from different organizational cultures. Also, in larger projects international stakeholders may be involved, for example in a participatory role.

Figure 7.2: The various languages

Summarizing, each modeling transformation starts with the description as supplied by the higher level in the language \( L_a \) of that level. Consider the modeling transformation that gets its input requirements from level \( i - 1 \) and converts this into a description at level \( i \). Let \( L_a^{i-1} \) be the language resulting at level \( i - 1 \), in which the requirements for the next level have been described. Then at level \( i \) the language \( L_a^i \) is used and developed. This language may be seen as the minimal extension of \( L_a^{i-1} \) such that all concepts required by the system analysts \( SA_1, \ldots, SA_k \) are covered either directly or as an external view on other language concepts. For each system analyst \( SA_j \) (with \( 1 \leq j \leq k \)) this will lead to a so-called internal-external mapping from \( L_a^i \) into \( L_{a_j}^i \). The resulting specification written in language \( L_a^i \) is easily transformed into a requirements document written in the language \( L_{a_j}^i \). Note that \( SA_j \) realizes part of these requirements at level \( i \) and may use the remaining issues of the requirements document as input for a modeling transformation into the next level \( (i + 1) \) see Figure 7.2.

### 7.3.3 ICT Roundtable project organization

The ICT Roundtable process (or RT process for short) was introduced as a specific participatory approach (for example) to innovate in sectoral governance and de-
The method was developed as a project of the International Institute for Communication and Development (IICD, \url{https://iicd.org/}) under auspices of the Dutch Ministry for Development Co-operation. The approach is based on the following principles: system thinking; multi-stakeholder involvement; participation; ownership; dialogue; learning; facilitation and organization; step-wise approach; and networking. The RT process consists of the following three development cycles (see Figure 7.3):

1. preparation and RT workshop; we will refer to this phase as the **modeling phase**.
2. prototype development and implementation; we will call this the **design phase**.
3. embedding or integration within the local context; We will refer to this phase as the **embedding phase**.

![Figure 7.3: Development cycles of ICT Roundtable process ([178])](image)

Following [178], the modeling phase consist of:

1. Preparation. This cycle consists of the following parts: (1) reconnaissante theme, (2) initiation of a steering group, (3) demarcation theme, (4) selection of participating organizations and participants, (5) development reference report and (6) preparatory workshop/seminar for participants.

2. The RT workshop. This cycle consists of the following elements: (1) analysis current situation, (2) scenario development, (3) visioning, (4) analysis of sectoral leverage areas for change with ICT, (5) idea generation, (6) setting priorities, (7) prototype identification, and (8) diffusion of results of the RT workshop.

The round table approach is a special arrangement for interactive group discussion in a multi-stakeholder context. This approach was already mentioned in the Arthurian legend *Le Morte Darthur* written by sir Thomas Malory in 1485, where the round table was used by king Arthur for the meetings with his knights. This setting provides equal opportunities to all participants to contribute their point of view and to scrutinize other's point of view. Consequently, during this process existing hierarchical relationships become temporarily dormant. Each discussion session is led by a round table chair, who is responsible for stakeholder voices and
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discussion formality. Therefore, this approach creates active stakeholder participation, especially when the roundtable chair deploys various facilitation techniques to promote stakeholder engagement.

The ICT Roundtable approach has been developed in the context of participatory system development in developing countries [178]. It assumes a cultural imbalance between the participants of the process. As a result, the ICT Roundtable approach is both aware of and tolerant of cultural differences that exists between its members. It also aware on the level of the product that is being build.

The ICT Roundtable process not only is an instrument to manage the modeling process, but also a strategy to construct a product that adapts the local preferences and conditions. Stakeholder involvement can be seen as a bottom-up approach during the development process, while top-down aspects exhibit organizational challenges. Without a broad stakeholder involvement, the design may lack important requirements not recognized during the design process. Hence the resulting product may suffer from acceptance resistance.

7.3.3.1 ICT Roundtable as a framework for design and development

As discussed in section 7.3.2, a layered hierarchical approach breaks down a complex design problem into a hierarchically structured system of smaller, less complicated design processes. It also defines a stepwise approach to align the design with external environmental factors such as mission, vision and strategy in terms of the options offered by the external environment (such as ICT facilities), represented in Figure 7.4. It shows the top-levels of the organizational pyramid (see Figure 7.1).

![Figure 7.4: Linguistic based approach and domain knowledge construction](image)

As discussed in section 7.3.2, the hierarchy in Figure 7.1 has the abstraction levels (1) organization, (2) process, (3) information, (4) application, and (5) infrastructure. Therefore we have 4 modeling transformations, in which the requirements of the higher level are translated into a model that suits the lower level.
The transformation of level $i$ to level $i + 1$ in this pyramid thus is a modeling activity that transforms those elements of the level $i$ requirements description that cannot be resolved at that level into a requirements description for level $i + 1$. In each of these transformations we can recognize the activities (1) modeling, (2) prototyping and implementation and (3) embedding. We conclude that each modeling transformation can be organized as an ICT Roundtable process with its own unique goal. Each modeling transformation involves only the stakeholder from the parts of the organization (involved at this level) as a necessary but also sufficient participation.

The ICT Roundtable process is a framework for development projects, in which it provides a proper structure for a sustainable solution. This framework defines the development process in terms of process criteria and output criteria. The process criteria define all required features for the development process, while the output criteria define the expected outcome of the process. In this study, the ICT Roundtable process identifies three characteristics for development process criteria: (1) interactive discussion, (2) participation development, and (3) task decomposition. All three characteristics aim to meet the output criteria. The interactive discussion is a core parameter in the ICT Roundtable process. It describes how to include multiple stakeholders into a face to face discussion during the modeling transformation meetings. The formal interactive discussion is described in Script 1 as a protocol for the modeling transformation project. In Script 2 we add the organizational details.

For the participation development, the ICT Roundtable process encourages non-technical stakeholders to participate actively in the process of design and development. As we discussed in Section 7.3.1 a linguistic based approach contributes mainly to communication (and its goal) during round table meetings. Task decomposition as discussed in Section 7.3.2 allows for development executions in small tasks, thus providing more room for modifications and improvements at detailed levels.

The ICT Roundtable process is mainly concerned about the output criteria, although these criteria are a result of the development process in general. The ICT Roundtable process, therefore, measures the success of the development process in terms of (1) the learning outcomes for the organization and its co-operators and (2) the benefits for social life that are obtained during the entire project execution, see Section 7.5.

### 7.3.3.2 The resulting modeling algorithm

In Script 1 the protocol for the modeling process is shown in the case of only 2 participants: the domain expert and the system analyst. In this section we extend this protocol to support a multi-stakeholder modeling transformation in Script 2. We focus on the points of interaction and the role of the ICT Roundtable process.
7.4. COLLABORATIVE ENGINEERING IN THINKLETS

Script 2. Multi-stakeholder approach to modeling transformation

1: Roundtable chair: present the requirements document
2: repeat
3: repeat
4: Roundtable chair: select topic from work list
5: Stakeholders: express point of view
6: Roundtable chair: organize stakeholder’s point of view
7: - find commonalities between the various conceptual description
8: - convert to agreed semi-natural language format
9: - when new linguistic constructs: extend information grammar
10: - update the Dialogue Document
11: Stakeholders: check for missing concepts and constructions
12: Stakeholders: check for completeness and plausibility
13: All: prioritize work list
14: until all parties agree: sufficiently satisfied
15: Stakeholders: do extra quality checks
16: until All parties agree: sufficiently validated
17: Roundtable chair: return Dialogue Document

7.4 Collaborative engineering in thinkLet

According to the International Journal of Collaborative Engineering ([127]), collaborative engineering addresses collaborative decision-making within engineering, whereby multiple interested stakeholders resolve conflicts, bargain for individual or collective advantages, agree upon courses of action, and/or attempt to craft joint outcomes which serve their mutual interests. The modeling transformation, as introduced in the previous section, is a typical example of collaborative engineering. In [147] the thinkLet concept is conceptually described as a critical concept in collaborative engineering.

Modeling transformation meetings may be characterized as being susceptible to tension and conflicts, especially when hard decision agendas are on the table. It can be exciting and energizing sometimes, but it may also hinder team progress. The thinkLet technique is used to attain control over a collaborative working environment making the group development process more effective. It is a tool that provides proper guidance, even in the absence of professional facilitators [28]. ThinkLet deployment also corresponds to cultural characteristics in which involvement is considered a primary course to overcome development challenges. In general, the thinkLet introduction took into account the consideration that working environment such as interactive discussion and knowledge sharing have a great diversity or was never restricted, especially when cultural behavior is paramount, and changes predictions are no longer possible. Therefore, the correspondence for modern technique in development projects is essential to explore remarkable feature for the new invention [247].

According to Kolfschoten et al., the process of collaborative engineering may be conceptualized as the meta-scheme shown in Figure 7.5 [147]. A collaborative
engineering process consists of a set of Participants involved in Collaboration Processes. Each collaboration process has the disposition of a set of typical dedicated interaction procedures, so-called thinkLets. A partial order describes the sequencing of the individual thinkLets. Each thinkLet has associated several Rules. Each rule has associated set of Roles being played by the participants and a set of Actions. A concrete collaboration process is a concrete scheme according to the rules of the meta-scheme. For a graphic representation of concrete schemes, the graphical symbols of Figure 7.6 are used. The activities in a collaborative elicitation process are represented as a rectangle with rounded corner. Those activities are further divided into three fields. The largest field describes the activity, the field on the left is an original pattern instantiated in the activity and the top field is the thinkLet name. This representation helps the facilitator to execute each activity in a logically; activity, pattern and thinkLet. The transitions between thinklets are represented as flow arrow. The flow arrow represents the predecessors and successors of thinkLets. The circles are used to show start and finish of the thinkLet.

Figure 7.5 shows the collaboration scheme for the modeling transformation. This conceptualization is seen as a structured collaborative framework for the requirements elicitation process. This process is executed with many Participants known as stakeholder with two Roles; domain expert and system analyst. The process is executed with a series of thinkLet patterns described below:
1. **Leafhopper** This thinkLet is used to generate detailed ideas on a focused set of topics as a brainstorm activity.

2. **Storytelling** explores extra details from already captured topics.

3. **Dialogue** is used to get a greater understanding of already collected information.

4. **Summary** reviews the information generated from Brainstorm, Storytelling, Leafhopper, and Dialogue thinkLets.

5. **StrawPoll** is used to evaluate certain situations to meet consensus within a group.

6. **MoodRing** allows participants to examine assumptions that get little consensus after evaluation period with StrawPoll, or to track consensus patterns for any issue not discussed and evaluated continuously throughout the discussion.

The selection of the described thinkLet pattern was adopted from criteria described in [29] and [277]. The study by [148] has come out with almost similar selection. Each thinkLet has an essential Parameter for participants exploitation. An example of the parameter for the StrawPoll is the poll and Brainstorming is a concept or question. The Capability has been configured as a procedure of facilitation. Then, the execution requires each brainstorming concept or question to be followed by a storytelling pattern. While the Rule remains salient for each storytelling discussion to be relevant to the brainstorming topic. Once the capability have been provided, then participants are instructed how to execute particular Action, such as add, edit, delete, move and judge. A Modifier is a compound thinkLet that can be reused during the entire process. Therefore, for requirements elicitation, a modifier can be described as three compound thinkLets; Brainstorming followed by Storytelling and then Summarize. Furthermore, the Dialogue can extract further details during a Summary execution. These compound thinkLet can be reused frequently for the entire requirements elicitation process for each Dataset. The dataset can be described as an outcome of the ICT Roundtable meeting.

![Figure 7.6: Symbols to describe the collaborative process](image)

The collaborative processes in LART are modeling transformations that have to be performed by carefully-selected stakeholders. The way of working in LART is described in Script 1 and Script 2. Using thinkLets we may add more details to the various steps to be taken during modeling transformations.

Merely, the LART itself does very little concerning the human organization and communication control. Consequently, improper guidance in a situation of collaborative decision making and misunderstanding between participants. Therefore, the introduction of a collaborative pattern of thinkLet is to provide proper
structuring scheme for information processing during the requirements elicitation process. Hence can fits well with a broad range of cultural background.

Figure 7.7: Using standard thinkLet in LART

Figure 7.7 describes the various activities mentioned in Script 2. We need various thinkLets in developing the Dialogue Document. These thinkLets start the elicitation process in a broad view, where brainstorming can be used to conceptualize in-depth knowledge as well as respond, reflect and elaborate the proposed concepts. Then, the StrawPoll pattern can strictly evaluate the required concept from a list of criteria. For the same purpose, the storytelling can be used to extract extensive information in a form of story narration. Furthermore, the Summary pattern guides the Storytelling blocks into a combined format for a similar Brainstorm question. In particular, the Summary transforms natural language into a semi-natural language representation, which also aims to remove duplicates and irrelevant information. The freedom of choice is also applicable to thinkLet, especially with the Leafhopper pattern. This pattern is more convenient for each participant to the area of interest. It is used to fill missing concepts. Then, the dialogue pattern is an interactive question and answer for more detailed information. Finally, is the Moodring pattern for approval. This structured helps roundtable chair not to fall back in too much simplifying which can lead to a linea thinking. Instead, engage participants in a social transformation without oversimplifying.

The collaboration process deploys formal way to handle the collaborative task in three most critical conditions: (1) Anonymity, (2) agreement and (3) consensus. These conditions are essential for Zanzibar and non-western cultures to support the development process and implementation success. Indeed, privacy and security is a critical factor in a discussion that involves people at different hierarchical levels. Furthermore, the collaboration process would also minimize any form of disagreements and misunderstanding, where the roundtable process itself is arduous to achieve. We claim that the introduction of thinkLet in roundtable process execution can support the development process in preserving privacy and security of contributor, precise control over disagreement and unity during the development.
7.5 LART effectiveness for social development

The effectiveness of LART is evaluated from a general perspective as the way it is compliant with Theory of Change (ToC), and from the concrete perspective of Zanzibar as the way it is tolerant to its cultural conditions.

7.5.1 Compliance with theory of change

Prior research has shown several causes leading to system development failure [14], in relation to development challenges and sustainability. This study conceives a great importance in requirements engineering as a core factor for the success of system development and the project management plan. The overall approach used for the development process tries to make a balance between the alignment complexity and social change. Hence, legitimate aspiration, ambition, action orientation and collaboration can help in adapting development to sustainability.

Accordingly, our key focus is to understand social complexity in multi-stakeholder involvement that can help to identify common ground for action, opportunities and obstacles. This goal is compliant with the Theory of change (ToC), where individuals or organizations are involved in change processes to narrate their change and to have a hypothetical projection of the future. The ToC is primarily intended for describing how and why the desired change is expected to happen. In a particular, there are 8 necessary steps: (1) Clarification of the purpose of the development process, (2) Describe desired change, (3) Analyze current situation, (4) Identify Domains of change, (5) Identify strategic priorities, (6) Map change pathways, (7) Define Monitoring, Evaluation and Learning priorities and process, and (8) Use and adaptation of ToC.

ToC thinking can take part in the inception phase for different purposes at all stages of the project, programme or initiatives. ToC is most useful when tailored to suit a particular purpose [77]. For example, ToC can investigate the outcomes of the introduction of e-government in Zanzibar over the short, medium and more prolonged period. It can be used to find who and what needs to change, where and in which way the desired change become possible. However, the actual implication of the ToC for this study can be extended to a complete conceptual design process, as the initial phase for the introduction of e-government. For the requirements analysis process, ToC goes well with the first three steps. The remaining steps continue for the conceptual modeling and analysis methods described in [142].

This development process examines the social development approach and technological perspectives to adhere to the agile development approach. The proposed development process promotes customer satisfaction, whereas local ownership, networking and acceptance are core parameters of the designed product. Moreover, is a way to integrate different groups to generate knowledge into a practical implementation [240]. We focus on a long term sustainability plan, in which the legitimate participation is very much crucial in building local ownership more firmly for a particular community. This approach stimulates the learning process for participants as they can learn from peers [23].
7.5.2 The case of Zanzibar

Our target application is the introduction of e-government in Zanzibar. Two points are very relevant: (1) governmental software development is rather complicated, (2) conventional methods for design and development have been developed and tested in countries with a western culture. According to the Hofstede dimensions ([91]) there are 2 significant cultural differences between developed and developing countries: (1) developed countries tend to have a power distance score significantly lower than in developing countries, (2) developed countries tend to be significantly more individualistic than developing countries. The other dimensions seem to be varying independently of the dichotomy between developed and developing countries.

Zanzibar, as Tanzania has a hierarchy and clan-based adhocracy with a market culture; the country has a process and local (parochial) based organizational culture, while on the other dimensions (means/goal oriented, internally/externally driven, easy going/strict, open/closed, employee/work oriented) Zanzibar has a middle score. Husein Shaaban describes Zanzibar’s whom afraid to take risks of innovation [238].

Another issue that makes the introduction of e-government complex is the impact it has on major economic factors. For example, e-government improves communication. As a consequence, farmers do not rely on intermediaries to find the best price for their products. Intermediaries strongly benefit from the information gap between farmers and food processing companies. So when farmers are better informed, they have a positive effect on the income of the farmers, but a negative effect on the income of the middlemen. The resulting social consequences lead to strong opposition on the one hand and reliable support on the other hand.

Since e-government involves people from all layers of the population, it is essential to have a well organized bottom-up (see Section 7.3.3) procedure during design and development.

However, in the ICT Roundtable groups, it may be expected that power distance issues play a role in the project meetings. As a result of the hierarchical decomposition as described in Section 7.3.2 the power distance between members in each ICT Roundtable project teams is less, small enough for the successful functioning of these teams. A limited number of participants is strengthened by the fact that the project teams become more democratic and understandable for all members.

Considering the cultural characteristics of Zanzibar, we summarize as follows. Any power distance issues that would hinder the design and development process, are diminished by the hierarchical decomposition that we described in Section 7.3.2. Being collectivistic can facilitate the project meetings making them more useful. Special attention is to be paid to the chair, in order to make the organization more global than local and to be more goal-oriented. The chair can also encourage to being non-defensive about the introduction of new technology [238]. Following the LART technique to formulate stakeholder voices and decision making in the development process would have a significant impact on the design under construction. Notably, on the sense of public ownership, the LART technique is
an essential tool and protection for the sustainability of the designed product.

Currently, Zanzibar has many applications that used as a communication link between Government to Citizen (G2C) and Government to Business (G2B). However, these applications are partially executed in electronic means. Next chapter evaluates the LART method for G2C services. Two offices were selected; (1) Zanzibar Revenue Board (ZRB) and (2) Zanzibar Business and Property Registration Agency (BPRA). Hence, the LART method can be evaluated in particular aspects of cultural behavior and hierarchical decomposition in a multi-stakeholders involvement from both government and public users.

7.6 Conclusion

In this chapter we presented a method that fits cultural differences in the design and development of ICT projects. Next, we evaluate the LART method to the selected e-service delivery related to Government to Citizen (G2C) services from both ZRB and BPRA offices.
Chapter 8

Evaluation for LART method

This chapter demonstrates the implementation of the LART method in a real case environment. The modeling technique, especially the ORM modeling, was tested for a particular case of an e-government system in Zanzibar as a distinct whole. Two workshops were conducted to explore a real picture of what occurred, involving stakeholders from associated government offices and dedicated to public services. All necessary modeling steps were applied to the actual case of our choice. This way, we got an in-depth experience to judge the compliance of the model in actual implementation practice. The LART method, therefore, stimulates the mutual understanding, especially for Zanzibari’s culture using a hierarchical decomposition approach.

8.1 Introduction

Evaluating research is usually done during or after its design process [206]. When designing a new method, its evaluation requires real users, artifacts and research activities to demonstrate the intended purpose using the naturalistic or artificial approach [269, 206]. The intended features of the design method LART have been listed in Section 1.2.1. This chapter intends to check whether these features are met by describing how the method behaves in a realistic environment for which LART was developed (see Section 8.2).

In the naturalistic approach, the researcher studies issues in three natural settings: user, artifact and task, while the artificial approach is lacking some or all three of these natural settings [251]. Evaluation in a natural environment maximizes hidden opportunities of the proposed method through the interaction of people, organization and information technology [114]. As a result, the usefulness and applicability in system implementation can be improved since the validation revealed the weaknesses in theory or artifacts and the need for its refinement and reassessment [276, 114].
For practical reasons, we have chosen to restrict ourselves to the validation of the requirements elicitation process. The motivation for this choice is that the requirements elicitation is the phase where a design project gains its stability [37]. Not only are the requirements elicitation process used to discover and balance stakeholders needs, but it is also a critical phase in the project development life cycle. We applied the LART method to a real case situation to assess and refine the proposed method as the design science requires [276].

For the naturalistic approach to evaluation, several techniques exist (see [64]). In our situation, we selected the following methods: focus group discussions, questionnaires and observations. These techniques led the evaluation exercise to unanticipated, but significant issues, such as disagreement on focus groups and lack of personalization for the questionnaire.

We analyzed the resulting data using the inductive approach. This approach refers to a procedure for analyzing qualitative data to derive concepts, themes or a model through interpretations made from the raw data and guided by specific evaluation objectives [255]. There are other qualitative analysis strategies such as grounded theory [45], discourse analysis [90] and phenomenology [246]. The grounded theory is most similar to the inductive approach but differs on the coding process. The inductive approach does not explicitly separate the coding process into open coding and axial coding. We used the inductive approach to condense the raw data into a summary and to establish a link between evaluation objectives and these summary findings derived from the raw data [255].

We conducted the validation exercise from two perspectives, the single-level and multi-level collaborative ICT Roundtable discussion (see section 8.4). A single-level approach is an ICT Roundtable discussion that involves only participants of the relevant experience and with the same administrative power. The multi-level approach included participants of different education, experiences and levels of administrative power. The evaluation of the LART method in both the single and multi-level perspective enhances modeling exercise leading to system sustainability. To focus on these perspectives, especially during the assessment of the LART method, aims to discover the effectiveness of the LART method through various patterns, such as cultural characteristics and education levels. We found that the single-level and multi-level perspectives exhibit distinct cultural characteristics. Therefore, the hierarchical decomposition is aligned to attain successful collaborative modeling. The LART method shows participatory experience and face to face discussion through ICT Roundtable approach; thus, using qualitative methods, the proposed approach can be correctly validated.

The single-level ICT Roundtable was conducted at the Zanzibar Revenue Board Office (ZRB) [217, 167]: the office responsible for revenue collection, business operations. ZRB is also responsible for offering high-quality services to taxpayers. ZRB has improved its administrative services using modern Information and Communication Technology as a critical attribute in its electronic governmental system. Their Customer Service Department is equipped with an extensive system known as the Motor Vehicle Registration System. This system incorporates three subsystems for respectively the administration of customer driving license, vehicle ownership, and vehicle registration [217]. The validation took place in the subsys-
Hierarchical decomposition is a composite attribute in the LART design process. Therefore, the multilevel collaborative model was deployed to find how the LART would fit. The multi-level collaborative ICT Roundtable discussion was conducted at the Business, Properties and Registration Agency (BPRA) office [218] at the following three levels: operational, technical and middle-level officers.

A primary goal of this evaluation exercise was to measure the applicability of the LART in its real design context. This exercise exploits the collaborative model for different organization levels. Special consideration was put into the suitability of the method to support specific cultural and social behavior.

The major conclusion of the validation is that the linguistic component in the LART method indeed stimulates mutual understanding between domain experts and system analysts in the situation of a clan culture like in Zanzibar. We found that the execution of the LART method is more effective at single-level organization hierarchy, especially for clan culture, because, it gives the opportunity to hear everyone’s voices, and hence minimizes authoritative decision making. Clan behavior exhibits unity and consensus, therefore the timidity is unlikely to be encountered.

The rest of this chapter proceeds as follows: Section 8.2 describes the validation approach in more detail, in which tools and techniques used for the validation exercise are presented. In Section 8.4 we present our impression of the two workshop sessions. The results of the validation exercise are presented in Section 8.7, followed by the discussion of the results in Section 8.8 and the conclusion in Section 8.9.

8.2 The validation approach

This study uses a combined approach to assess the LART method. The techniques used associated with the naturalistic approach are as follows: 1) focus group discussion, 2) structured questionnaire, and 3) observation. Formal procedures were followed to align those methods with the specific internal rules in the governmental offices involved. This procedure happened due to the availability of government officers for the second workshop.

Following the internal organizational rules, it was required to use one-to-one discussion for the requirements elicitation exercise, followed by validation of the requirements document in a roundtable setting involving all participants. This adaptation of the LART method did not affect its essential ideas.

Initially, the exercise was guided by a plan prepared in advance, describing the required participating stakeholders, our validation goal, and a basic layout for its procedure. The validation goal distinguished the following two main parameters: (1) the linguistic component, and (2) the ICT Roundtable setting. This plan was then used as a guide and map for the evaluation exercise.
8.2.1 The linguistic component

A linguistic approach is used in the LART method to stimulate mutual understanding between two parties, in this case, domain experts and system analysts, by using semi-natural language. In this parameter, we measured the LART method on how it creates a communication link and understanding between these parties. With this parameter we also checked how well a domain expert could understand the formal procedure to construct and understand semi-natural language sentences in the ORM format.

Our assumption is that this parameter can be estimated by considering involvement and mutual understanding, based on the fact that both involvement and mutual understanding have a significant influence on social projects. This assumption also is based on the fact that privacy issues and conflicts are core parameters in a system development process. For this reason, the linguistic approach parameter also gives an indication on how well the method adapts to the cultural identity of both participants and the organizational culture.

8.2.2 The ICT Roundtable setting

The ICT Roundtable setting exhibits the involvement approach by considering participation at various organization levels. This was measured in two contexts: focus group discussion at a single-level and a multi-level combination. We assume that this parameter can be estimated by considering engagement, privacy and conflict.

8.2.3 The techniques used

Focus group discussion, a questionnaire and observation were collectively used to evaluate the main parameters.

8.2.3.1 Focus group discussion

A focus group evaluation is defined by [248, 209] as a discussion between six to twelve participants, discussing a certain topic, under the direction of a facilitator whose role is to promote active interaction.

This study exploits the focus group discussion to extract domain details that can be used for modeling. A total of 2 focus group discussions associated with two distinct systems from the ZRB and the BPRA office respectively, were conducted. The participants in both group discussions were different, except for the facilitator. The first group consisted of officers with similar managerial responsibilities, and thus can be seen as a single-level group. This group had 7 participants: 4 domain experts, 2 participants representing modeling and information technology expertise, and the facilitator (being the researcher of this study).

The other group combined officers with different managerial responsibilities, thus being a multi-level group. This group had 11 participants: six domain experts, four experts in system analysis and design, and the facilitator (being the researcher of this study).
Each focus group discussion was organized in three sessions, introduction, requirements elicitation and discussion. The introduction illustrates a summary of the topic concerned. Special attention was on proposed method procedure being followed and the techniques being used. The requirement elicitation exercise was used to extract the details of the selected domain. During the discussion, questions and answers were exploited to reveal the anonymity level from a cultural perspective. Due to the availability of the participants from the BPRA office, the requirements elicitation session was conducted on a separate day, and used the results during focus group discussion.

We used roundtable settings to guide us on cultural behavior discovery during the execution of the LART method. As an involvement method, the LART method aims to align cultural and social behavior during the development process. Our intention was to see how we can support mutual understanding between domain experts and system analysts during the design process.

8.2.3.2 The questionnaire

For each workshop we used questionnaires to obtain answers on specific questions. The target respondents for a questionnaire were the participants of the workshop. The questionnaire was designed for both domain experts and system analyst experts. Both open-ended and closed questions form a total of six questions for each questionnaire. (see Appendix .1 for domain experts and Appendix .2 for the system analysts).

The questionnaire was used as a tool to measure organizational issues as well as mutual understanding between the participants. This tool preserves anonymity to some extent, thus respecting the privacy of the participants. Each participant is free to express expertise and insights [84]. For this study, this tool was purposely used to investigate privacy and security associated with cultural behavior. Of course, since the number of participants is minimal, the opportunities for anonymity are somewhat restricted.

8.2.3.3 Observation

The observation method was applied to monitor the workshop exercise at large. Observers are computer experts. Observers examine the workshop achievement while at the same time looking for undefined behavior. For this task, dedicated observers were selected from the domain experts and asked to follow the group discussion solely. The observers are not supposed to participate in the discussion itself, giving them a better opportunity for making observations [139].

The observation method is usually used as a means to generate new ideas. It allows the researcher to study situations that were not conceived in advance [139]. In our approach, the naturalistic observation was used as a tool to observe the social setting in the group that may not be visible to a general audience, and thus gives the opportunity to provide detailed descriptions and to improve interpretation [139]. Engagement and understanding between stakeholders during the face to face interactive discussion under ICT Roundtable settings was a particular point of concern.
8.3 Performance measures

The objectives of the LART method are summarized in four parameters: involvement, mutual understanding, privacy and conflict handling. These parameters for project-based system design and development are analyzed from two parts: the developer’s part as a system analyst, and the user’s role as domain experts.

8.3.1 The questionnaire

Our intention was to express the LART responsiveness from the following objectives:

- Check if a cooperative link between Domain Expert (DE) and System Analyst (SA) is created during the process.
- Check if the DE finds it hard to express the application domain in the semi-linguistic style from ORM.
- Check if the SA finds it hard to understand the requirements in this semi-linguistic style.
- Check if the linguistic approach provides a basis for mutual understanding between DE and SA.
- Check if the DE can validate the ORM Information Grammar.
- Check if the decomposition method as proposed is found to be suitable.
- Check if the thinkLets are found useful.
- Check if privacy and conflict management can be supported in an ICT Roundtable setting.
- Test if national culture is aligned with the proposed method.

From these objectives the following questionnaire was extracted to evaluate the LART method:

1. How well does the LART method create a link between System Analyst and Domain Expert?
2. Do the Domain Experts validate the Object Role Modeling scheme?
3. Do you think the Roundtable approach is improved with thinkLet?
4. Can you formulate formal sentences from your case domain?
5. How relevant is the LART method in cultural behavior for multilevel cooperation?
6. Do you think the LART method will help to handle cultural issues for sustainable system development?
7. Was it difficult to express your views?

These questions were scaled with a combination of Likert scale and Yes/No measurements. The Likert scale measured with three categories: excellent, acceptable and needs improvement, or easy, moderate and difficult, where acceptable and moderate is a neutral response. These measurements were restricted to collect essential information covering the method evaluation exercise. Besides, every question was designed with an open link for participants to contribute outside of the closed designed range. Then, using the inductive approach the collected data was
8.3.2 The data analysis approach

The collected data were analyzed using the inductive approach. Inductive analysis refers to the approach that primarily uses detailed information of raw data to achieve 'universalistic' result through interpretation. The primary purpose of the inductive approach is to emerge the findings to the significance theme inherent from raw data that applies in all instances [255]. This approach provides a simple and straightforward solution in the context of focused evaluation questions. It establishes concrete links between the method and the summary findings derived from the raw data.

8.4 The workshops

The workshop organization followed the formal procedures for any governmental organization in Zanzibar. Letters of invitation were distributed according to prior details of the respected officers. The participants were divided into three categories: (1) domain experts; the ones who directly interact with end-users and who provide public services; (2) experts and key informants, those with basic knowledge on modeling in general. Experts are observers of the LART method execution and are validators of the method; (3) the system analyst, being the researcher of this study.

Both workshops consisted of the following main tasks.

1. Introduction to the LART method. During this task, the presenter used local language to stimulate understanding. The introductory presentation encouraged active participation that made participants feel comfortable and involved. Participants obtained basic knowledge on modeling, specifically on Linguistic and ICT Roundtable approach.

2. Requirements elicitation task. During this phase, we agreed to work on a selected part of the domain system. The domain experts described the domain, and the system analyst recorded the details.

3. Roundtable discussion and formal sentence transformation. In a roundtable setting, participants described their domain, then transformed their descriptions into a semi-natural language format and presented the result using graphical representations.

4. Validation of the transformed domain description. Domain experts checked for missing and incorrect information.

8.4.1 Workshop 1: vehicle registration

The first workshop was considering the Motor Vehicle Registration, which is a complete system in the Government to Citizen (G2C) application in Zanzibar. This
system consists of the following subsystems: (1) vehicle registration, (2) driving license and, (3) change of ownership. Our focus was on the vehicle registration subsystem.

The workshop was designed for 2 days. We spent a total of three hours on each day. The first day was used to execute two main tasks; (1) introduce the LART method, and (2) the requirement elicitation exercise. In a roundtable setting, a focus group discussion was used to collect the requirement from the vehicle registration system. The second day was used to (1) transform the requirement document to formal sentences and (2) validation of the formal sentences.

The following domain description was used as an initial description of the way of working in the context for which this subsystem is designed:

A customer arrives at the ZRB office with a certificate of competence. For the driving license service, the customer can upgrade an old license, renew an expired license, require a duplication for a damaged card or fresh license application. Each license is issued in a licence class such as A, B, C, D etc. in which the age group of the applicant is a main factor.

For a first time issue of the driver licence and for a licence upgrading application, the customer should start to take lessons at a qualified driving school. A successful candidate is awarded a certificate of competence issued at Department of Transport. Each certificate has a certificate number and a confirmation number.

A new registration requires one of the following three types of ID: a passport, a Zanzibar ID or a Tanzanian ID. This identifying information will be augmented with a picture taken by a ZRB officer. The registration starts after the payment of the required ledges by the applicant. A customer pays his license for 2, 3 or 5 years. The payment can be completed at the bank or by using a mobile money transfer. For a bank payment the applicant should bring a bank slip to the cashier to approve the printing of the driving license card.

8.4.1.1 Impression from workshop 1

Participants of the first workshop were neither modelers nor technically skilled. Their participation in the workshop was remarkable. They were very active contributors to the process, and showed a good level of understanding in ORM modeling. For example, despite the education levels of the domain experts, they managed to correct and formulate sentences in ORM, as well as contributed to missing details.

The following are examples of sentences extracted from the domain description during the (limited) time of the workshop. The following main concepts (entity types) were found:

- Customer (CustomerName)

  Customer is an entity type identified by CustomerName

  Reference scheme: Customer has CustomerName.
8.4. THE WORKSHOPS

Data Type CustomerName: Variable Length (30)
Customers are distinguished in two subtypes:
- NewCustomer: a Customer not having a Licence
- ReturningCustomer: a Customer having a Licence

• Gender (GenderName)
  *Gender is an entity type identified by GenderName*
  Reference scheme: Gender has GenderName.
  Data Type GenderName: Variable Length (10)

• Address (AddressCode)
  *Address is an entity type identified by AddressCode*
  Reference scheme: Address has AddressCode.
  Data Type AddressCode: Fixed Length (15)

• Birthdate (Date)
  *Birthdate is an entity type identified by Date*
  Reference scheme: Birthdate has Date.
  Data Type Date: Date

• Photo (Id)
  *Photo is an entity type identified by Id*
  Reference scheme: Photo has Id.
  Data Type Id: Blob

• ID (Number)
  *ID is an entity type identified by Number*
  Reference scheme: ID has Number.
  Data Type Number: Unsigned Integer

• Date (Day, Month, Year)
  *Date is an entity type identified by Day, Month, Year*
  Reference scheme: Date has Day, Month, Year.
  Data Type Day, Month, Year:

• License (Nr)
  *License is an entity type identified by Nr*
  Reference scheme: License has Nr.
  Data Type Nr: Unsigned Integer

• Payment (PaymentCode)
  *Payment is an entity type identified by PaymentCode*
  Reference scheme: Payment has PaymentCode.
  Data Type PaymentCode: Fixed Length (0)
• ConfirmationNumber (Nr)
  
  \textit{ConfirmationNumber is an entity type identified by Nr}

Reference scheme: ConfirmationNumber has Nr.
Data Type Nr: Signed Integer

• Certificate (Number)
  
  \textit{Certificate is an entity type identified by Number}

Reference scheme: Certificate has Number.
Data Type Number: Unsigned Integer

• DrivingSchool (Name)
  
  \textit{DrivingSchool is an entity type identified by Name}

Reference scheme: DrivingSchool has Name.
Data Type Name: Variable Length (0)

• ZRBOfficer (PersonName)
  
  \textit{ZRBOfficer is an entity type identified by PersonName}

Reference scheme: ZRBOfficer has PersonName.
Data Type PersonName: Variable Length (30)

From the domain description the following relations between these entity types were extracted:

• Customer has ID
• Customer has Gender
• Customer has BirthDate
• Customer has Address
• Customer has Photo
• Customer gets License on Date
• Customer chooses Payment
• ZRBOfficer registers NewCustomer
• ZRBOfficer takes Photo
• ZRBOfficer prints License
• NewCustomer brings Certificate
• Certificate issued at DrivingSchool
• Certificate is identified by ConfirmationNumber
• ReturningCustomer upgrades License on Date
• License issued on Date

This is presented in Figure 8.1, which is descriptive. The ORM formal sentences listed above can demonstrate detailed information for further steps in system development. Such that the resulting scheme can be used as a starting document for simulation or database design. More details are shown below:

• \textbf{Customer has ID.}
  
  Each Customer has exactly one ID.
  For each ID, at most one Customer has that ID.

• Customer has Gender.
Each Customer has exactly one Gender.
It is possible that more than one Customer has the same Gender.

- **Customer has Birthdate.**
  Each Customer has exactly one Birthdate.
  It is possible that more than one Customer has the same Birthdate.

- **Customer has Address.**
  Each Customer has exactly one Address. It is possible that more than one Customer has the same Address.

- **Customer gets License on Date**
  (1) It is possible that for some License and Customer, that License gets that Customer on more than one Date.
  (2) It is possible that for some License and Date, that License gets more than one Customer on that Date.
  (3) It is possible that for some Customer and Date, more than one License gets that Customer on that Date.
  (4) In each population of License gets Customer on Date, each License, Customer, Date combination occurs at most once.
  (5) This association with License, Customer, Date provides the preferred identification scheme for License/GetsCustomerOnDate.

- **Customer chooses Payment.**
Each Customer chooses at most one Payment.
It is possible that more than one Customer chooses the same Payment.

- **Customer has Photo.**
  For each Photo, at most one Customer has that Photo.
  It is possible that some Customer has more than one Photo.

- For each Customer, at most one of the following holds: that Customer is some ReturningCustomer; that Customer is some NewCustomer.

- **ZRBOfficer registers NewCustomer.**
  For each NewCustomer, at most one ZRBOfficer registers that NewCustomer.
  It is possible that some ZRBOfficer registers more than one NewCustomer.

- **ZRBOfficer takes Photo.**
  For each Photo, at most one ZRBOfficer takes that Photo.
  It is possible that some ZRBOfficer takes more than one Photo.

- **ZRBOfficer prints License.**
  For each License, at most one ZRBOfficer prints that License.
  It is possible that some ZRBOfficer prints more than one License.

- **NewCustomer brings Certificate.**
  Each NewCustomer brings at most one Certificate.
  For each Certificate, at most one NewCustomer brings that Certificate.

- **ReturningCustomer upgrades License on Date.**
  (1) It is possible that for some ReturningCustomer and License, that ReturningCustomer upgrades that License on more than one Date.
  (2) It is possible that for some ReturningCustomer and Date, that ReturningCustomer upgrades more than one License on that Date.
  (3) It is possible that for some License and Date, more than one ReturningCustomer upgrades that License on that Date.
  (4) In each population of ReturningCustomer upgrades License on Date, each Date, License, ReturningCustomer combination occurs at most once.
  (5) This association with Date, License, ReturningCustomer provides the preferred identification scheme for ReturningCustomerUpgradesLicenseOnDate.

- **License issued on Date**
  (1) It is possible that for some Date, more than one License issued on that Date and that some License issued on more than one Date.
  (2) In each population of License issued on Date, each Date, License combination occurs at most once.
  (3) This association with Date, License provides the preferred identification
scheme for LicenseIssuedOnDate.

- **Certificate issued at DrivingSchool.**
  
  Each Certificate issued at exactly one DrivingSchool.
  
  It is possible that more than one Certificate issued at the same DrivingSchool.

- **Certificate is identified by ConfirmationNumber.**
  
  Each Certificate is identified by exactly one ConfirmationNumber.
  
  For each ConfirmationNumber, at most one Certificate is identified by that ConfirmationNumber.

### 8.4.2 Workshop 2: document and property registration

The second workshop involved officers from multi-level positions consisting of low, middle and top-level positions. This workshop was executed at Business, Properties and Registration Agency (BPRA) office. At this office, the operational, technical and company registrars were invited. Operational officers are familiar with the complete work flow of the system process. Technical officers have a more limited view, but are familiar with many important details. These officers are well informed about technical and support activities, while the accompanying registrar understands system functionality from a managerial point of view.

The Business and Property Registration Agency is a governmental organization dealing with online registrations of business entities, business names, online payment, and online information services. This office brings about a substantial improvement in online services operation.

We conducted the second workshop for 2 days. On the first day, we executed the requirement elicitation exercise to obtain a better and agreed understanding of the underlying domain. Due to the availability restrictions of the participants, this exercise was done at the one-to-one discussion. The discussions involved operating officers and one administrative officer. The result of this discussion was a requirements document to be used on the second day. On this day, all participants were involved in a roundtable meeting with the following activities on the agenda: (1) overviewing the requirements document and introduction of the LART method, (2) transforming the requirement document into formal sentences and (3) validation of the formal sentences. The following domain description was used as the initial document for this workshop:

*A document is a piece of paper written purposely to describe an object. To register a new document a customer brings a written document, a proof of ownership and a letter from local government. For identification purposes, a customer must have national ID. Then, a customer pays stamp fee based on the required document type such as Mortgage deed, Sale deed and beneficiary, Contracts (wakf deed\(^1\), lease agreement, statutory declaration, gift or any other). Other fees such as the registration fee and the document preparation...

\(^1\)inalienable charitable under Islamic law
fee are the same for all document types.
The BPRA office approves the document and registers them to be officially recognized as a legal document for justice.
Initially, an applicant is obliged to prepare this document before the registration process starts. This document is designed by an agent such as (1) a consultant firms, (2) a lawyer or advocacy office, (3) BPRA or (4) someone who is knowledgeable

8.4.2.1 Impression from workshop 2

The participants of this workshop, besides their differences in managerial levels, also had different education levels. Some participants are working in an ICT technical department, some are operators (middle education level), and some work in an administrative position (high education level). A few participants of this roundtable setting were not fully involved, while some of them dominated the discussion and others felt uncomfortable to speak. During the form filling exercise, everyone appeared to be able to express their inner feelings from their personal experience.

The following is the result from the second workshop. Note that only a few participants were familiar with and understood the modeling approach, and others were only vaguely familiar. Furthermore, the result is the situation after only one modeling session, where usually many sessions are required to make the description complete and consistent. The following main concepts (entity types) were found:

- **Govt-Letter (.code )**
  
  Govt-Letter is an entity type identified by .code
  Reference scheme: Govt-Letter has .code.
  Data Type .code : Fixed Length (10)

- **Agent (.name )**
  
  Agent is an entity type identified by .name
  Reference scheme: Agent has .name.
  Data Type .name : Variable Length (20)

- **Staff (.id )**
  
  Staff is an entity type identified by .id
  Reference scheme: Staff has .id.
  Data Type .id : Signed Big Integer

- **Document (.nr )**
  
  Document is an entity type identified by .nr
  Reference scheme: Document has .nr.
  Data Type .nr : Signed Integer

- **Customer (.name )**
8.4. THE WORKSHOPS

Customer is an entity type identified by .name
Reference scheme: Customer has .name .
Data Type .name : Variable Length (20)

• ID (.id )
  ID is an entity type identified by .id
Reference scheme: ID has .id .
Data Type .id : Signed Big Integer

• Ownership-Cert (.nr )
  Ownership-Cert is an entity type identified by .nr
Reference scheme: Ownership-Cert has .nr .
Data Type .nr : Signed Integer

• Fee (.cost )
  Fee is an entity type identified by .cost
Reference scheme: Fee has .cost .
Data Type .cost : Money

• Registration (.id )
  Registration is an entity type identified by .id
Reference scheme: Registration has .id .
Data Type .id : Signed Integer

• Type (.name )
  Type is an entity type identified by .name
Reference scheme: Type has .name .
Data Type .name : Variable Length (20)

8.4.2.2 semi-natural language DERIVED from workshop 2

From the domain description the following relations between these entity types were extracted:
  • Customer has an ID
  • Customer brings Govt-letter
  • Customer brings Ownership-Cert
  • Customer has Document
  • Document require Registration
  • Agent design a Document
  • Document is categorized by Types
  • Customer pays Fee for Registration
  • Fee is for Type
  • A Document is approved by the Staff
This is summarized in Figure 8.2. Special rules are:
  • Customer has an ID
126  

CHAPTER 8. EVALUATION FOR LART METHOD

Figure 8.2: The ORM model derived for document and property registration

Each Customer has some ID.
For each ID, at most one Customer has that ID.
It is possible that some Customer has more than one ID.

- Customer brings Govt-Letter.
  It is possible that some Customer brings more than one Govt-Letter and that for some Govt-Letter, more than one Customer brings that Govt-Letter. In each population of Customer brings Govt-Letter, each Customer, Govt-Letter combination occurs at most once. This association with Customer, Govt-Letter provides the preferred identification scheme for CustomerBringsGovtLetter. Each Customer brings some Govt-Letter.

- Customer brings Ownership-Cert.
  It is possible that some Customer brings more than one Ownership-Cert and that for some Ownership-Cert, more than one Customer brings that Ownership-Cert. In each population of Customer brings Ownership-Cert, each Customer, Ownership-Cert combination occurs at most once. This association with Customer, Ownership-Cert provides the preferred identification scheme for CustomerBringsOwnershipCert. Each Customer brings some Ownership-Cert.

- Customer has Document.
  It is possible that some Customer has more than one Document and that for some Document, more than one Customer has that Document. In each population of Customer has Document, each Customer, Document
combination occurs at most once.
This association with Customer, Document provides the preferred identification scheme for CustomerHasDocument.

- **Document require Registration**
  
  Document requires Registration.
  
  Each Document requires exactly one Registration.
  
  It is possible that some Registration is for more than one Document.

- **Agent design a Document**
  
  Agent design Document.
  
  Each Document is designed by at most one Agent.
  
  It is possible that some Agent design more than one Document.

- **Document is categorized by Types**
  
  Document is categorized by Type.
  
  Each Document is categorized by at most one Type.
  
  It is possible that more than one Document is categorized by the same Type.

- **Customer pays Fee for Registration.**
  
  It is possible that for some Customer and Fee, that Customer pays that Fee for more than one Registration and that for some Customer and Registration, that Customer pays more than one Fee for that Registration and that for some Fee and Registration, more than one Customer pays that Fee for that Registration.
  
  In each population of Customer pays Fee for Registration, each Customer, Registration, Fee combination occurs at most once.
  
  This association with Customer, Registration, Fee provides the preferred identification scheme for CustomerPaysFeeForRegistration.
  
  Each Customer pays some Fee for some Registration.

- **Fee is for Type.**
  
  Each Fee is for at most one Type.
  
  For each Type, at most one Fee is for that Type.

- **A Document is approved by the Staff**
  
  Document is approved by Staff.
  
  Each Document is approved by exactly one Staff.
  
  It is possible that more than one Document is approved by the same Staff.

### 8.5 Integrating the workshops

First, we repeat the disclaimer that the results of both workshops are premature, since normally information analysis will take much more than one session.
CHAPTER 8. EVALUATION FOR LART METHOD

This choice is motivated by our intention of validating the handling of cultural differences, and to see what a team of limited size can achieve in just one section.

By having two workshops, we also hoped to get an impression of what differences in different departments can occur in organizational culture as our experimental environment. So we prepared to get conceptual schemes from both workshops with an overlap but not necessarily be addressed in the same way. Comparing both schemes, as an example of overlap, we see in both workshops, there is the entity type *Customer*.

We conclude that both departments have a difference in their (local) domain language. Since LART is multi-level, we can expect such differences to occur. The hierarchical LART will guarantee that at a higher level of these both local schemes will be integrated, see Figure 7.1 and its description in Section 7.3.2. Then it may be decided to accept a language difference, or to make a standard choice for the organization. In this particular case, one would likely consider differently named identifications as undesirable since such ambiguity is likely to lead to confusion. After making this choice, it will be communicated downward to the lower levels of the pyramid.

### 8.6 Results

At the end of each workshop, the participants filled out the questionnaire. The questionnaires were divided into two parts: a part to be filled out by domain experts and a part to be filled out by the system analyst, also referred to as experts. The results from both two workshops are summarized in Table 8.1. This table summarises the domain expert answers on questions one to three. The table shows that all 10 participants understood the LART method from the presentation. Among them, seven participants can formulate a formal sentence from case domain, but three participants could not. Also, seven participants answer yes from the questions that can spot mistakes, while three cannot detect any error.

The results from Table 8.2 show that two participants found it easy to understand the LART method, five participants found this to be moderate, and three participants found it difficult to understand. Question number five of the questionnaire asks if it was difficult for the participants to express their views. This question had four choices; participants could choose more than one answer. Six participants said it was not difficult to express their opinions during a face to face discussion. On the other hand, six participants said they were confident to
Table 8.2: Domain experts questionnaire feedback Question 4

<table>
<thead>
<tr>
<th>Sno</th>
<th>Question</th>
<th>Easy</th>
<th>Moderate</th>
<th>Difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.</td>
<td>How you can describe the method?</td>
<td>2</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Total selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was not difficult because the tools that design the LART method support requirement elicitation process</td>
<td>6</td>
</tr>
<tr>
<td>I was little bit nervous, because my boss was in the workshop</td>
<td>1</td>
</tr>
<tr>
<td>I was completely confident to express my view in front of the others</td>
<td>6</td>
</tr>
<tr>
<td>I was completely unable to express my view because of my boss</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 8.3: Domain experts questionnaire feedback Question 5

talk during the discussion. However, one participant was nervous, and one of the participant felt afraid to talk because of the presence of his boss. The summary of the results is found in Table 8.3.

Question number 6 was an open question. This question has various answers but, the answers were summarized in a single relevant sentence. Some participants mentioned the need for training; others talked about education, and others explained the importance of practical training on improving the LART. The summarized answer to this question is shown in Table 8.4.

The four experts (system analysts) from the two workshops filled out the questionnaire. The results are summarised in Table 8.5. Question number one shows that two participants found that LART creates an excellent link between system analyst and domain expert, two judged it to be acceptable, and no one reported a need for improvement. Question number two aimed to check how well the domain experts can validate the developed ORM scheme. This question was answered excellent by two experts. The other two experts found it moderate, but no one indicated the need for an improvement. Question number three wants to discover how the ICT Roundtable was improved by using a thinkLet. This question was responded with excellent by two experts, the other two found it moderate and none of them filled the need for improvement. Question number four investigates the relevance of the LART method and the cultural issues involved in the sustainability of the resulting system. This question got one excellent, three moderate

<table>
<thead>
<tr>
<th>Question</th>
<th>Total selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a need for training</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 8.4: Domain experts questionnaire feedback Question 6
### Table 8.5: System analysts (Experts) questionnaire feedback

<table>
<thead>
<tr>
<th>Sno</th>
<th>Question</th>
<th>Excellent</th>
<th>Acceptable</th>
<th>Needs Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How the LART method creates a link between system analyst and domain expert?</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Do the Domain Experts can validate the Object Role Modeling scheme?</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>Does the Roundtable approach improved with thinkLet?</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>How relevant for the LART method and cultural behavior in sustainability of the system?</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>Do you think LART method will help to handle cultural issues for sustainable system development?</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

and 0 needs improvement. Question number five wants to understand if the LART method can handle cultural issues for sustainable system development. This question answered excellent from two experts, other two experts said moderate and none felt a need for improvement.

Question number 6 from the system analyst questionnaire was an open question, asking for additional comments and observations on the LART method. This question aims to extract details that participants may want to express to improve the technique. The results are divided into three categories; the requirement identification, selection of domain experts and cultural issues. The results are summarised as follows:

1. It was noted that participants of the higher administrative level could help in requirement identification.

2. Moreover, identifying relevant domain users is critical for better system requirement identification.

3. Finally, the culture of letting the boss speak on behalf of everyone cannot easily be eliminated.

### 8.7 Data analysis

The LART method executes ORM modeling using the ICT Roundtable approach. We found that the linguistic component in ORM plays a vital role in building mutual understanding in modeling exercises. The LART method brings both technical and non-technical stakeholders to the same communication link in system development. Some domain experts managed to formulate formal sentences, and
could spot some mistakes on the ORM scheme. This showed up in results from questionnaires filled out by domain experts seen in question number 1 up to 4; such that out of ten participants, seven participants have gained good understanding of LART (see Table 8.1 and Table 8.2). They can spot mistakes and formulate formal sentences. This impression is a result of the LART method enhancing non-technical stakeholders to engage themselves in design and development activities. The same results appeared on the experts' questionnaire, from questions 1 and 2 (see Table 8.5). The questionnaire results exhibit active participation and valuable contributions from participants. These are issues that stimulate the modeling process to obtain a complete and correct documentation.

As expected, domain experts were very knowledgeable within their domain, while system analysts knew very little about it. The linguistic technique managed to create a strong link of understanding and to promote clear communication for non-technical participants to understand the linguistic domain formulation obtained by ORM modeling. This situation brought confidence, thereby contributing to the construction of the domain requirements (see Table 8.3). However, the graphical representation of the ORM modeling was experienced to be too technical, domain experts had some difficulty understanding the graphical representation of the domain.

The ICT Roundtable approach was measured in two dimensions: first, the single-level and multi-level. The single-level approach collects same level participants and was used in the first workshop. The multi-level approach was used in the second workshop, and involved three administrative levels.

The single-level workshop showed a high level of interaction, and an equal degree of participation. This setting combines participants of the same administrative power. This characteristic exhibits collectivism behavior. Hence, some thinkLet patterns were rarely adhered: strawPoll and leafhopper.

In the multi-level workshop some participants dominated the discussion and others were less active due to varying administrative power (see 8.3). This behavior was controlled using thinkLet approach in leafhopper. Five thinkLet patterns supported the ICT Roundtable discussion: brainstorming, summary, leafhopper, strawpoll, and discussion. These thinkLet patterns were introduced to control the discussion and to reach an end result in collaboration. During the multi-level workshop all thinkLet patterns were depicted. However, due to the time factor, we entailed the form filling questionnaires as a tool to emulate the leafhopper characteristics.

Questions number 4 and 5 in Table 8.5 and Table 8.3 exhibit cultural behavior, such that participants, instead of talking, used the questionnaires to express their thoughts as shown in Table 8.3. The use of questionnaires was a decent way to exhibit privacy and anonymity of individuals. This tool was anonymously filled out, as a leafhopper is. With this result, the thinkLet patterns have shown a great use to enhance the ICT Roundtable approach. Therefore, both ICT Roundtable and thinkLet patterns are participatory stimuli for effective collaborative engineering.

The ICT Roundtable setting stimulates active participation to interact and share individual experiences, where face to face communication was an important stimulus for learning in a collaborative environment. In a multi-level combination,
the higher and lower level division was clearly exhibited. This led to some difficulties with handling cultural behavior in a collaborative setup. This claim was also commented from experts’ questionnaires. Top-level management officers led the discussion; they showed more knowledge on system functionality along with managerial insight. Indeed, they were benevolent figures in the system requirements phase. Generally, participants have shown their willingness to understand modeling techniques. However, training is required to enhance usability of the LART method. Therefore, the LART method is more efficient with the ICT Roundtable setting for teams with not too much level combination, while consideration for higher levels fulfills the recommended function.

8.8 Discussion

The previous section (8.7) describes the results of the workshops that were used to quantify the usefulness of the LART method. Initially, the designation of the LART method considered both practical and operational strategies to maximize the effectiveness of modeling projects. The actual usefulness of the LART method was displayed in the linguistic approach, while its operational implementation was exhibited in the ICT Roundtable setting.

The ICT Roundtable setting invites respected stakeholders to contribute some portion of the development. The involvement approach is a perfect thing in the development of public systems, but, this approach encompasses some challenges in its implementation. This includes understanding, inspiration, anonymity and security. For that reason, we have added some plugins to strengthen the ICT Roundtable approach. The thinkLet patterns together with hierarchical implementation strengthens the LART method.

The hierarchical decomposition was incorporated mainly to handle social and cultural behaviors. Whereas, the unheard can be heard using very new modeling techniques. Since the LART method can execute at hierarchical levels, from lower levels to the top organizational levels, therefore, everyone’s voice can be included in the proposed design. Things that improve acceptance behavior of the proposed design.

Usually, lower level officers have a fleeting stay at one position. That means they alternate between related subsystems or are newly appointed to that position. Therefore, the execution of the LART method in different organization a hierarchy is needed to integrate information flow as a system in general. For requirements elicitation process, the upper-level execution is preferred to run at the middle-level management position, such as directors. These officers usually stay longer at one position, thus they have general knowledge of a system as a single entity in functionality and relationship. However, they lack panoramic details as a subsystem. Hence, the hierarchical execution of the LART method would mainly be for correctness and completeness of the requirements document. For the requirements elicitation exercise, two levels are ideal for requirements elicitation exercise. Though, additional levels might be needed for work such as policy and strategy development.
Anonymity and security were minimized in hierarchical decomposition, but, cultural characteristics such as power distance need to be well managed. Even though the first workshop involved same level participation, it showed essential mindfulness of a power distance. They were very much concerned for the ICT Roundtable execution at the higher level. Such that, one member said “Kuna vitu ukivingiza bosi atajua tuu ni nani aliesema”, or, translated in English: “for some details, if introduced, the boss will exactly spot them down to the person who introduced that concept”. This aspect has some indication of fear from lower officers to the higher officers. Therefore, even the hierarchical decomposition would support freedom to express individual voices. Then, the issue of personal fear cannot be removed. But, without any doubt this approach can handle anonymity with thinkLet patterns. Furthermore, the validation exercise did not catch any misunderstanding during the workshop, but based on literature the thinklet patterns are a useful tool for disagreement.

Zanzibaris are characterized as having a clan culture (see Section 4.1.2). They live as a group and as an extended family. By promoting group work for this type of population, collectivism is stimulated in a working environment which supports a sphere of collaborative problem solving. Because, the involvement approach is pretty much internalized within daily life of the Zanzibaris, the LART method minimizes the authoritative decision but stimulates collectivism.

The ORM approach is described as an easy method for its implementation. This is due to it’s linguistic way of conceptualizing domain knowledge. Indeed, the nature of the requirements elicitation exercise requires domain experts to convey their domain knowledge in a full state. But, the graphical representation of the ORM modeling is somewhat technical, such as unique constraints and mandatory constraints. But, they are more descriptive and a very short representation of textual data. Again, the link between textual representation and graphical representation is completely obvious, if domain experts have prior knowledge on both textual and graphical representations of the ORM modeling. The domain experts may describe the complete domain in a distinct way that may stimulate the validation process. Therefore, understanding of both textual and graphical representation activates the involvement of the domain expert in the modeling exercise.

Summarizing, the validation exercise in Zanzibar has shown the usefulness of the LART method. There is a need to run the LART method as a prototype to prove its value. One of the participants from the expert team commented on the LART as follows:

".....I think LART is good, though we will need better understanding and more empirical evidence of its reliability in organization. We shall definitely consider it for use in the future, I mean more research to ensure its generalisation is need. How successful is it in organizations it has been used. This will build confidence on its usefulness."

At the moment of writing, the organization is considering to do further experiments to better evaluate LART better and to consider how it could be introduced as a development process in their daily operations.
8.8.1 Suggestions for organizational and tool support

This section proposes a better way to implement the LART method for any organizational setting. The LART method is a useful method to collect information hierarchically. This study has tested the LART method in both mixed-level collaboration and a single-level collaboration. The results have shown that, the single-level collaboration corresponds well with cultural and social behavior such as power distance.

LART execution follows the bottom-up approach, and starts from the lower level to move up the top. Each level executes exclusively from the other level. The lowest level is where the officers have direct contact with target users, also known as an operational level. Officers who work at the operational level are known as operational officers. The operational officers have more information concerning the specific details of the system process. However, being specific loses generality of the system as a whole. Therefore, the upper-level is required to fill in the remaining part.

Usually, operational officers have a fleeting stay at one position. That means they alternate between related subsystems or are newly appointed to that position. Therefore, the next level execution of the LART method is needed to integrate the information flow as a system in general. For the requirements elicitation process, the second level execution is preferred to run at the middle-level management position; such as directors. Officers at the middle-level usually stay longer at one position and they are distinct in their managerial skills. Because of that, they have general knowledge of a system as a single entity. However, they lack constructive details at the operational level from a subsystem perspective, but, they can describe system relationship functionality. Hence, the LART execution at this level is mainly for correctness and completeness of the requirements document extracted from the lower level. For the requirements elicitation exercise, two levels are ideal (see Figure 8.3) Though, other top-levels have to be included for policy and strategy development.

8.8.2 Challenges faced during the validation experiment

The main challenge in the validation exercise was the availability of the governmental employee. It is well known that the success of any organization is directly affected by the performance of their employees, whether they directly deal with customers or not. For the selected domains, the target officers were mostly located at the end user service providers. They are very busy generating government revenue. This was also acknowledged during the initial process to arrange appropriate times for the validation workshops.

The time factor showed up in two ways. One was the complexity for a big data set analysis. The other one was availability of the stakeholders. The data set factor was considered in the aspect of data collection time and analysis of that data. A large data set needs more time while a small data set that is sufficient for our task takes less time for analysis compared to the more comprehensive data set. Indeed, stakeholder availability also influenced completion time. Top management officers are usually busy with scheduled administrative tasks. That
is why scheduling around their availability was difficult. Hence, for same level ICT Roundtable setting this study was executed only with lower management officers.

The evaluation task was conducted at the government offices who have already started using e-government applications. Then, the requirements elicitation process was performed as a dummy approach to show a practical picture of the LART method. This limitation did not affect our key attributes, but initially affected the participant response.

The other challenge was trust. It was somewhat challenging to gain acceptance to conduct the validation work. The main reason was that the validation would detect some problems with their current systems, while they believed their system were well functioning and that they did not need any modifications.

8.9 Conclusion

The LART method is characterized by its unique feature of linguistic techniques applied in an ICT Roundtable setting at various hierarchical levels. The hierarchical implementation means decomposing the managerial positions for the same levels. With that reflection, the exercise has gotten a chance to explore a better way to implement the LART method for any organization setting. The LART method is a useful method to collect information hierarchically. This study has tested the LART method in both a mixed-level collaboration and a single-level collaboration. The results have shown that, the single-level collaboration corresponds well with cultural and social behavior, such as power distance. The LART execution follows the bottom-up approach; it executes exclusively from the lower

Figure 8.3: LART for requirements elicitation in organization
level to the top-level. The low-level is where the officers have direct contact with target users and have more information concerning specific details of the subsystem process. However, being specific loses generality of the system as a whole. Therefore, the upper-level is required to fill in the remaining part.

The linguistic approach stimulates mutual understanding between people of the same level. These people share daily working experiences and probably have common business interests. Bringing them into an ICT Roundtable setting for the requirements elicitation exercise helps to obtain complete and correct documentation to be used for the development process. Indeed, the working environment of the same level has shown high resilience considering the problems they had. They felt safe to raise their voices and to express their feelings in front of people of the same level openly without any fear of aggression. This was completely different in the multi-level execution. Therefore, the LART method is a practical approach for Zanzibars’ cultural setting. The cultural behavior is a somewhat broad term when it comes to its generality, but, we characterize this fact in the aspect of the selected domain. Zanzibari’s are known to exhibit a high power distance and high collectivist behavior. Such that, a boss is the decision maker and staff at lower levels only execute the boss’ decision. Hence, having a single-level for discussion stimulates collectivist behavior, while minimizing power distance behavior at the same time. Thus, for sensitive discussion, participants at the same level may have enough time to conceptualize their issues independently.
Chapter 9

Conclusion

In this research, we have studied better approaches to sustainable system development. We have highlighted cultural behavior, shared understanding, and hierarchical decompositions are important variables towards successful system development. This chapter summarises the thesis contribution and provides directions for future research.

9.1 Contribution

This study has two major contributions: (1) The LART method. This method was introduced to enhance the requirements engineering process for system development. The LART method was designed to support collaboration that imparts system sustainability, see Chapter 7. (2) System dynamic theory. This study extends System Dynamics theory with Extended Causal Diagram (ECD). This diagram has dependent and independent variables used to analyze the performance of causal effects. Hence it can be used by policymakers in decision making, see Chapter 6.

These contributions were achieved using a design science research methodology, blended with other approaches such as conceptual design, SWOT analysis and literature review. This section presents a summary of the findings of this study through research questions listed in Chapter 1

Main Research Question: "How to develop a sustainable public system that is aware of cultural issues in general and for Zanzibar in particular?"

The main research question was refined into a number of sub-questions. This chapter summarizes the results obtained in sequential order.

Research question RQ1 is: What are core variables for public system implementation, and how do they influence project deployment?.

We have used the conceptual design approach to answer this question. The following paragraph summarizes the detailed information as appeared in Chapter 3.
We have used DPSIR (Driver-Pressure-State-Impact-Response) to identify core variables that influence success for government projects. The DPSIR model is a result obtained from the analysis of various studies and models such as Technology Acceptance Model (TAM), Diffusion of Information model (DOI), SERVQUAL model, and Theory of Planned Behavior (TPB). These models are frequently used frameworks for extracting opportunities and barriers of e-government service deployments. Hence, by using DPSIR framework, we describe causal relationships that influence success of government project implementation. As an example of the government system, the DPSIR was used to identify success factors for e-government implementation. The DPSIR mapping identifies five critical success factors, i.e infrastructure, service, deployment, citizen and government. This framework implies that: the infrastructure is a driving force, service represent a pressure, deployment reflect a state, citizen is an impact and government is a response. Therefore; government, infrastructure, deployment, service and citizen are core components that influence e-government implementation. Their causal relation has a direct impact on e-government exploitation.

Research question RQ2 is: How to characterize the cultural identity of a country and of an organization in general and for Zanzibar in particular?

This question was answered in Chapter 4, Section 4.1. We have used the H0ofstede model to understand national and organizational cultural identity. National culture was described in six dimensions: (1) power distance, (2) collectivism versus individualism, (3) femininity versus masculinity, (4) uncertainty avoidance, (5) long term orientation versus short term orientation and (6) indulgence versus restraint.

The organizational culture measures the way the organizational members think and work for their organization. The following dimensions describe cultural behavior in organization: (1) means-oriented vs. goal-oriented (2) internally driven vs. externally driven (3) easy-going work discipline vs. strict work discipline (4) local vs. professional (5) open system vs. closed system (6) Employee-oriented vs work-oriented According to these dimensions, Zanzibar has got more scores on power distance and low score on individualism. Furthermore, Zanzibar is depicted as a means oriented (process based) and local (parochial) organizational culture, while on the other organizational dimensions Zanzibar has a middle score.

Research question RQ3 is What is the current condition for e-government implementation in Zanzibar?

This question was addressed in Chapter 4, Section 4.2. To answer this question, we assess the existing situation for our case of e-government implementation in Zanzibar. For strategic e-government implementation, the SWOT method (Strength, opportunity, Threats and Weaknesses) was used to analyze the status of e-government in the country. The analysis showed that Zanzibar has sufficient reasons to change service delivery to the electronic base. There are some weaknesses and threats but are not barriers to success. They are manageable to reduce implementation difficulties and enhance sustainability for development. Moreover,
opportunities and strengths are stepping stone to achieve implementation expectations. However, technological evolution may convey some challenges, but experience from other countries can help to reduce implementation snags. Currently, Zanzibar is exploiting e-government opportunities. This can be seen for many government offices have introduced G2C services. Yet, its adaptations are still challenged because the infrastructure is among significant threat for e-government deployment.

This study conducted at Zanzibar as our case domain. For e-government implementation, Zanzibar has completed preliminary steps. Zanzibar infrastructure is ready for e-government as the fiber cable connection is currently in use. Zanzibar has a dedicated center to carry e-government services. This achievement is deployed for many government organizations running services; G2G and G2C applications. However, some challenges that exist are that many applications are developed and funded by external agencies that lead to dubious sustainability of the system.

Research question **RQ4** is: *How can we model the conceptual structure of a complex domain by using natural language approximations?*

Research question (RQ4) extends research question (RQ1). It answered in Chapter 5. The focus of this question was on citizen and government as stakeholders for government projects. Hence, we consider modeling approach as a technical solution for government systems and stakeholder involvement as an approach for system development. Hence, we propose Linguistic approach to control the quality in development process, specifically during requirements elicitation phase. We apply the Object Role Modeling (ORM) to develop a semi-natural language that is understandable for both stakeholders and the system analyst. Using ORM in requirements elicitation phase stimulates successful design accepted by stakeholders. Modeling in ORM technique enhances validation of the data models. This approach helps users to get what they want to satisfy their needs. Usually, software developers focus on user acceptance criteria. Then, using the ORM approach in modeling improves software system development field. Therefore, the sustainability of system development can finally be achieved.

The research question **RQ5** is: *How can the modeling approach model the dynamics of complex systems?*

This question was answered in Chapter 6. We use modeling technique to understand system characteristics. Complex systems comprise several components that are interrelated and influence each other in various ways. We use a modeling approach to explore the influences and interconnections between system components. Linguistic approach was used to extend requirements elicitation process as a basis for system understanding. Then, we use other modeling techniques such as causal diagrams, extended causal diagrams and system dynamics to evaluate system characteristics and variable influences. The details of this evaluation were done by the Sysdea online tool to simulate the domain on real time data. The introduction of Extended Causal Diagrams was to consolidate the system dynamics theory, where
by a policymaker can use this tool to analyze the underlying application domain in a semi-quantitative manner.

The research question RQ6 is: What is the effect of cultural differences on design and development of ICT projects and how can modeling successfully be applied in a collaborative environment?

This question was answered in Chapter 7. The design process has been considered as a collaborative work between a developer and users. Thus, involvement is a crucial aspect in system development. With this intension, the ICT Roundtable approach was proposed to cover this aspect. The ICT Roundtable approach was used to stimulate the user’s participation and involvement in the design process. However, collaborative development is susceptible to tension, even conflicts. Then, we propose thinkLet for collaborative engineering to handle those challenges. The thinkLet technique was deliberately employed to intensify collaborative working environment, and making the group development process more effective. Indeed, the thinkLet patterns alone may find it hard to attain active participation. With this concern, we introduced hierarchical decomposition method to organize the ICT Roundtable method. The hierarchical decomposition defines the ICT Roundtable participants at the appropriate working environment and administrative position. Indeed, the ICT Roundtable meeting can be repeated more than one level based on bottom-up approach.

9.1.1 Summary of findings

Various factors that influence e-government implementation. This study uses the Driving force, Pressure, State, Impacts and Response (DPSIR) framework to identify the causal relationship of the e-government components. Components such as: infrastructure, services, deployment, citizen and government are core components for e-government implementation and sustainability. Using DPSIR, our study revealed that the causal relation between these components is in one direction except between government and citizen, their causal relation is symmetric, and they both affect each other. Therefore, these components show a direct relationship that influences e-government success and sustainability.

The general concept for e-government is mostly about government services for the citizen. Based on DPSIR framework, the citizen is a target component in e-government implementation. The efficient method to develop e-government projects is to extract details from the real word to the abstraction level. With this intension, this study has proposed Object Role Modeling approach to construct a useful application from the user experience. Then, we proposed causal diagrams, extended causal diagrams, stock and flow diagrams and simulation to extract user thinking to a real implementation.

The study was extended to understand citizen influence for e-government deployment. Therefore, we considered citizen as a key attribute in a design process as the one to influence acceptance or rejection of the product. On this aspect, we propose a LART (Linguistic approach in a Roundtable setting) approach to coordinate implementation of e-government projects. The LART is a method that
defines the proper implementation of e-government projects. This method has considered both success and challenges of a collaborative design; includes cultural behavior as well as collaborative engineering challenges. Collaborative challenges were answered with thinkLet patterns to support development projects from requirement engineering perspectives. Also, we organize the cultural behavior for requirement engineering exercise using hierarchical decomposition technique.

9.1.2 How may government, policy makers and citizens benefit from this work

The government can use the proposed tools to evaluate government decisions; such as analyzing risk factors on controversial matters and policy formulation to be used for more extended period. From citizen perspective, this work involves local users to the development irrespective their knowledge. Local stakeholders are treated as domain experts. The knowledge of their domain is beneficial for system design and development. Hence, the proposed approach activates a citizen’s position to involvement condition as a paradigm in the development process. Indeed, designing users system without listening their voices is also not effective to the end product. Eventually, this approach has used linguistic approach as a bridge to link both technical and non-technical stakeholders in the development of users system. Therefore, the success and sustainability of a system design is a success for every citizen and government at large.

9.1.3 Implication for future research

This research proposes a new method to implement ICT systems in a government organization. The study proposes the LART method to extract user needs described in Chapter 7, then more techniques were added to analyze system components depicted in Chapter 6. The LART method aims to improve the development process, where stakeholder involvement is a core factor. Also, the modeling techniques were purposely used to evaluate influences between system components.

Eventually, the proposed tool was validated in real case analysis selecting two government offices at Zanzibar. Then, the future work is to run a prototype of the LART method in other cultural settings, and to improve on the specific tools being used during the group discussions.
Appendices
1. APPENDIX A

.1 Appendix A

Evaluation form for LART method

1) How well does the LART method create a link between System Analyst and Domain Expert?
   ☐ Excellent ☐ Acceptable ☐ Needs Improvement
   Comment: ______________________________________________________

2) Do the Domain Experts can validate the Object Role Modeling scheme?
   ☐ Excellent ☐ Acceptable ☐ Needs Improvement
   Comment: ______________________________________________________

3) Do you think the Roundtable approach is improved with thinklet?
   ☐ Excellent ☐ Acceptable ☐ Needs Improvement
   Comment: ______________________________________________________

4) How relevant for the LART method in cultural behavior for multilevel cooperation?
   ☐ Excellent ☐ Acceptable ☐ Needs Improvement
   Comment: ______________________________________________________

5) Do you think the LART method will help to handle cultural issues for sustainable system development?
   ☐ Excellent ☐ Acceptable ☐ Needs Improvement
   Comment: ______________________________________________________

6) Anything that observed.

Figure 1: Questionnaire filled by computing experts
Appendix B

Evaluation form for LART method

1. Did you understand the LART method?
   □ Yes □ No

2. How you can describe the method?
   □ Easy □ Moderate □ Difficult
   Comment: ________________________________________________

3. Can you formulate formal sentences from your case domain?
   □ Yes □ No
   If yes, give one example: ____________________________________

4. Can you spot any mistake from a given example?
   □ Yes □ No
   Give example: ____________________________________________

5. Was it difficult to express your views? Please select all that apply.
   □ It was not difficult because the tools that design the LART method support requirement elicitation process.
   □ I was little bit nervous, because my boss was in the workshop
   □ I was completely confident to express my view in front of the others
   □ I was completely unable to express my view because of my boss

6. How we can improve the LART method?
   Comment: ________________________________________________

Figure 2: Questionnaire filled by domain experts
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Summary

It has been reported that system design and development methods are biased towards western culture, and (therefore) are less successful in non-western context resulting in many failed projects. In this thesis, a case study of introducing e-government in Zanzibar is presented in order to study ICT projects implementation in different cultures.

The findings of the study formed a basis for the development of a new method for system design that is more appropriate for e-government projects in non-western settings. The thesis starts by explaining the phenomenon of ICT projects failure using Hofstede’s cultural dimension theory. Power distance was observed as important factor in successful implementation of e-government projects. The study took an explicit approach to cultural differences in system implementation using ongoing e-government projects involving Government to Citizen (G2C) services in Zanzibar.

The study used a semi-natural language based approach to design enterprise ontology. The organization decomposition mechanism was used to effectively separate and cover all aspects of system implementation. The various subgroups at each decomposition level, connected by linking pins, may have their typical dialect (for example, focusing more on the customer side or the technical side of the application); the translations between these dialects are formally described as a part of the assignment of each project subgroup. Round Table method, developed by Dr. Nick Moens to support effective group discussions using specific thinksLet patterns such as storytelling was used.

The dynamic system description is based on the developed enterprise ontology and obtained by a systematic translation mechanism. Extended Causal Diagrams are introduced that enhance Causal Diagrams with dynamic relations between their variables.

Future research may be directed in testing the method in other cultural settings, and to improve on the specific tools being used during the group discussions.
Mukhtasari

Mada ya tasnifu ya Maryam Khamis hii ni ‘Kufahamu Utekelezaji wa Mifumo Changamano kwa Kutumia Mkabala wa Modeli: Mfano wa Mfumo wa Serikali Mtandao wa Zanzibar’.

Imeripotiwa kuwa mbinu za kusanifu na kuunda mifumo ya TEHAMA zinaazingatia zaidi utamaduni wa Kimagharibi, na hivyo kusababisha mifumo ya aina hiyo kufeli katika mazingira ya Kimagharibi na hatimaye kugeuka kushindwa kwa miradi mingi. Katika tasnifu yake, Maryam anatumia uanzishwaji wa mfumo wa Serikali Mtandao wa Zanzibar kama mfano wake mkuu katika kutafiti miradi ya TEHAMA katika tamaduni tofauti. Mataokeo yake, ambayo yameleezwa katika Tasnifu hii, yamekuwa ni msingi wa kuundwa kwa mbinu mpya ya kusanifu mfumo unaoaafaa zaidi kutumia katika miradi ya Serikali ya TEHAMA kupitia miktadha innungumizea na hatimaye kusababisha mifumo ya aina hiyo kufeli katika mazingira ya Kimagharibi.

Kwanza, Maryam anaelezea dhana ya kushindwa kwa miradi ya TEHAMA katika muktadha wa Modeli za Tamaduni Maarufu za Dkt. Hofstede, na baadae kupendekeza na kuunda mbinu ambayo inazingatia tafutu za utamaduni katika kutekeleza miradi ya TEHAMA. Maryam ameitathmini mbinu yake hiyo kwa kupitia baadhi ya miradi ya “kutoka serikali kwenda kwa wananchi (Government to Citizen – G2C)” inayotakwaa na mifumo inayotakwaa na mazingira ya Kimagharibi.

Mbinu yake imezeka dhana ya kuunda mbinu na kusababisha mifumo unaoaafaa zaidi kutumia katika kuchumiza mafunzo ya kwire hii. Yeye ametumia utaratibu na kusababisha mifumo unaofaa zaidi kutumika katika mazinat corpse ya kubadilika ya sahihi ya mazingira ya Kimagharibi. Kwa hiyo, Maryam anaelezea dhana ya kushindwa kwa miradi ya TEHAMA katika muktadha wa Modeli za Tamaduni Maarufu za Dkt. Hofstede, na baadae kupendekeza na kuunda mbinu ambayo inazingatia tafutu za utamaduni katika kutekeleza miradi ya TEHAMA. Maryam ameitathmini mbinu yake hiyo kwa kupitia baadhi ya miradi ya “kutoka serikali kwenda kwa wananchi (Government to Citizen – G2C)” inayotakwaa na mifumo inayotakwaa na mazingira ya Kimagharibi.

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gira mengine yenye tamaduni tofauti ili kuboresha mfumo unaotumia vikundi vya majadili viopekezwa kwenye tasnifu hii kwa lengo la kusaidia kubuni na kutekeleza miradi ya TEHAMA ambayo ni endelezi.
Samenvatting

Het is al vaker gerapporteerd dat methoden voor systeemontwerp en -implementatie meer geschikt zijn in een westere cultuur, en minder (misschien wel daardoor) minder geschikt in een niet-westerse situatie. Dit is een belangrijke factor waardoor veel projecten in dergelijke situaties mislukt zijn. In dit proefschrift wordt de introductie van e-Government in Zanzibar gekozen als de basis om ICT-projecten in verschillende culturen te bestuderen. Het resultaat is een een methode voor systeemontwerp en -implementatie die meer geschikt is voor toepassing in een niet-westerse situatie. De thesis begint met

Allereerst wordt het fenomeen van falende ICT-projecten bekeken in de context van de culturele modellen van dr. Hofstede. De zogenaamde power distance, bijvoorbeeld, blijkt een belangrijke factor te zijn. De nieuw ontwikkelde methode neemt deze cultuuraspecten mee. De methode is geëvalueerd in een paar toepassingen die in ontwikkeling zijn in het Government to Citizen (G2C) project door de regering in Zanzibar.

De methode gebruikt een semi-natuurlijke taal benadering om de zogenaamde enterprise ontology op te stellen. Door een speciaal decompositie-mechanisme worden de aspecten van systeemontwikkeling effectief van elkaar gescheiden. De diverse delergroepen op ieder decompositieniveau, verbonden door zogenaamde linking pins, mogen een eigen dialect (bijvoorbeeld gericht op het beschrijven van klantaspecten of technische details) gebruiken; de vertalingen tussen deze dialecten is een deel van de opdracht van elke subgroep.

De dynamische systeembeschrijving is gebaseerd op de eerder ontwikkelde enterprise ontology, en wordt verkregen door een systematische transformatiemethode. Extended Causal Diagrams worden ingevoerd om de gebruikelijke causal Diagrams te verbeteren door de toevoeging van dynamische relaties tussen de variabelen.

Binnen de subgroepen wordt gebruik gemaakt van de door dr. Moens ontwikkelde Round Table method, om te komen tot effectieve groepsdiscussies gebruik maken van specifieke zogenaamde thinkLets zoals bijvoorbeeld story telling.

Vervolgonderzoek zou gericht kunnen zijn op het testen van de methode in andere culturele settings, en het verbeteren van de specifiek binnen de subgroepen.
Curriculum Vitae

Maryam Masoud Khamis was born on 17\textsuperscript{th} October, 1979 in Zanzibar Tanzania. She graduated with a Bachelor of Science in Computer Science with honors in 2005 from University of Dar es Salaam. Thereafter, she employed at the State University of Zanzibar as tutorial assistant. Also, she worked with Ministry of Health as assistant researcher from June 2006 to December 2008. In 2010, she obtained a Master of Computer Science with commendation from Bedfordshire University in England. In June, 2014 she started pursuing her PhD.
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<td>2003-03</td>
<td>Computer Interaction and Presence in Virtual Reality Exposure Therapy</td>
<td>Martijn Schuemie (TUD)</td>
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<td>2003-04</td>
<td>Content-Based Video Retrieval Supported by Database Technology</td>
<td>Milan Petkovic (UT)</td>
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<td>2003-05</td>
<td>Causation in Artificial Intelligence and Law - A modelling approach</td>
<td>Jos Lehmann (UVA)</td>
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<td>2003-06</td>
<td>Development and specification of virtual environments</td>
<td>Boris van Schooten (UT)</td>
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<td>2003-07</td>
<td>Formal Explorations of Knowledge Intensive Tasks</td>
<td>Machiel Jansen (UvA)</td>
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<td>2003-08</td>
<td>Repair Based Scheduling</td>
<td>Yongping Ran (UM)</td>
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<td>2003-09</td>
<td>The resolution of visually guided behaviour</td>
<td>Rens Kortmann (UM)</td>
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<td>2003-10</td>
<td>Electronic Business Negotiation: Some experimental studies on the interaction between medium, innovation context and culture</td>
<td>Andreas Lincke (UvT)</td>
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<td>2003-11</td>
<td>Reasoning under Uncertainty in Natural Language Dialogue using Bayesian Networks</td>
<td>Simon Keizer (UT)</td>
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<td>Dutch speech recognition in multimedia information retrieval</td>
<td>Roeland Ordelman (UT)</td>
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<td>2003-13</td>
<td>Searching with Opponent Models</td>
<td>Jeroen Donkers (UM)</td>
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<td>2003-14</td>
<td>Freezing Language: Conceptualisation Processes across ICT-Supported Organisations</td>
<td>Stijn Hoppenbrouwers (KUN)</td>
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<td>2003-15</td>
<td>Plan Merging in Multi-Agent Systems</td>
<td>Mathijs de Weerdt (TUD)</td>
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<td>2003-16</td>
<td>Feature Grammar Systems - Incremental Maintenance of Indexes to Digital Media Warehouses</td>
<td>Menzo Windhouwer (CWI)</td>
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<td>2003-17</td>
<td>Extensions of Statecharts with Probability, Time, and Stochastic Timing</td>
<td>David Jansen (UT)</td>
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<td>2003-18</td>
<td>Learning Search Decisions</td>
<td>Levente Kocsis (UM)</td>
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<td>2004-01</td>
<td>A Model for Organizational Interaction: Based on Agents, Founded in Logic</td>
<td>Virginia Dignum (UU)</td>
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<td>2004-02</td>
<td>Monitoring Multi-party Contracts for E-business</td>
<td>Lai Xu (UvT)</td>
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<td>2004-03</td>
<td>A Theoretical and Empirical Analysis of Approximation in Symbolic Problem Solving</td>
<td>Perry Groot (VU)</td>
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<td>2004-04</td>
<td>Organizational Principles for Multi-Agent Architectures</td>
<td>Chris van Aart (UVA)</td>
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<td>2004-05</td>
<td>Knowledge discovery and monotonicity</td>
<td>Viara Popova (EUR)</td>
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<td>2004-06</td>
<td>The Evaluation of Business Process Modeling Techniques</td>
<td>Bart-Jan Hommes (TUD)</td>
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<td>2004-07</td>
<td>Voorbeeldig onderwijs; voorbeeldgestuurd onderwijs, een oostap naar abstract denken, vooral voor meisjes</td>
<td>Elise Boltjes (UM)</td>
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<td>2004-08</td>
<td>Politie en de Nieuwe Internationale Informatiemarkt, Grensregionale politiën gehevensuitwisseling en digitale expertise</td>
<td>Joop Verbeek (UM)</td>
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<td>2004-09</td>
<td>For the Sake of the Argument; explorations into argument-based reasoning</td>
<td>Martin Caminada (VU)</td>
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<td>2004-10</td>
<td>Knowledge-rich indexing of learning-objects</td>
<td>Suzanne Kabel (UVA)</td>
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<td>2004-11</td>
<td>Change Management for Distributed Ontologies</td>
<td>Michel Klein (VU)</td>
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<td>2004-12</td>
<td>Creating emotions and facial expressions for embodied agents</td>
<td>The Duy Bui (UT)</td>
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<td>2004-13</td>
<td>Using Multiple Models of Reality: On Agents who Know how to Play</td>
<td>Wojciech Jamroga (UT)</td>
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<td>2004-14</td>
<td>Logic in Conflict. Logical Explorations in Strategic Equilibrium</td>
<td>Paul Harrenstein (UU)</td>
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<td>2004-15</td>
<td>Multi-Relational Data Mining</td>
<td>Arno Knobbe (UU)</td>
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<td>2004-16</td>
<td>Hybrid Genetic Relational Search for Inductive Learning</td>
<td>Federico Divina (VU)</td>
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<td>2004-17</td>
<td>Building of Qualitative Knowledge Models</td>
<td>Mark Winands (UM)</td>
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<td>2004-18</td>
<td>Supporting the Construction of</td>
<td>Vania Bessa Machado (UvA)</td>
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<td>2004-19</td>
<td>Learning Search in Complex Games</td>
<td>Thijs Westerveld (UT)</td>
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<td>2004-20</td>
<td>Learning from Design: facilitating multidisciplinary design teams</td>
<td>Madelon Evers (Nyenrode)</td>
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<td>2005-01</td>
<td>Methodological Aspects of Designing Induction-Based Applications</td>
<td>Floor Verdenius (UVA)</td>
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<td>2005-02</td>
<td>AI techniques for the game of Go</td>
<td>Erik van der Werf (UM)</td>
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<td>2005-03</td>
<td>A Pragmatic Approach to the Conceptualisation of Language</td>
<td>Franc Grootjen (RUN)</td>
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<td>2005-04</td>
<td>Towards Database Support for Moving Object data</td>
<td>Nirvana Meratnia (UT)</td>
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<td>2005-05</td>
<td>Two-Level Probabilistic Grammars for Natural Language Parsing</td>
<td>Gabriel Infante-Lopez (UVA)</td>
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<td>2005-06</td>
<td>Adaptive Game AI</td>
<td>Pieter Spronck (UM)</td>
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<td>2005-07</td>
<td>Hypermedia Presentation Generation for Semantic Web Information Systems</td>
<td>Flavius Frasincar (TUE)</td>
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<td>2005-08</td>
<td>A Model-driven Approach for Building Distributed Ontology-based Web Applications</td>
<td>Richard Vdovjak (TUE)</td>
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<td>2005-09</td>
<td>Storage, Querying and Inferencing for Semantic Web Languages</td>
<td>Jeen Broekstra (VU)</td>
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</table>
2005-10 Anders Bouwer (UVA) Explaining Behaviour: Using Qualitative Simulation in Interactive Learning Environments

2005-11 Elth Ogston (VU) Agent Based Match-making and Clustering - A Decentralized Approach to Search

2005-12 Csaba Boer (EUR) Distributed Simulation in Industry

2005-13 Fred Hamburg (UL) Een Computermodel voor het Ondersteunen van Euthanasiebeslissingen

2005-14 Borys Omelayenko (VU) Web-Service configuration on the Semantic Web; Exploring how semantics meets pragmatics

2005-15 Tibor Bosse (VU) Analysis of the Dynamics of Cognitive Processes

2005-16 Joris Graaumans (UU) Usability of XML Query Languages

2005-17 Boris Shishkov (TUD) Software Specification Based on Re-usable Business Components

2005-18 Danielle Sent (UU) Test-selection strategies for probabilistic networks

2005-19 Michel van Dartel (UM) Situated Representation

2005-20 Cristina Coteanu (UL) Cyber Consumer Law, State of the Art and Perspectives

2005-21 Wijnand Derks (UT) Improving Concurrency and Recovery in Database Systems by Exploiting Application Semantics

2006

2006-01 Samuil Angelov (TUE) Foundations of B2B Electronic Contracting

2006-02 Cristina Chisalita (VU) Contextual issues in the design and use of information technology in organizations

2006-03 Noor Christoph (UVA) The role of metacognitive skills in learning to solve problems

2006-04 Marta Sabou (VU) Building Web Service Ontologies

2006-05 Cees Pierik (UU) Validation Techniques for Object-Oriented Proof Outlines


2006-07 Marko Smiljanic (UT) XML schema matching – balancing efficiency and effectiveness by means of clustering

2006-08 Eelco Herder (UT) Forward, Back and Home Again - Analyzing User Behavior on the

2006-09 Mohamed Wahdan (UM) Automatic Formulation of the Auditor’s Opinion

2006-10 Ronny Siebes (VU) Semantic Routing in Peer-to-Peer Systems

2006-11 Joeri van Ruth (UT) Flattening Queries over Nested Data Types

2006-12 Bert Bongers (VU) Interactivation - Towards an e-ology of people, our technological environment, and the arts

2006-13 Henk-Jan Lebbink (UU) Dialogue and Decision Games for Information Exchanging Agents

2006-14 Johan Hoorn (VU) Software Requirements: Update, Upgrade, Redesign - towards a Theory of Requirements Change

2006-15 Rainer Malik (UU) CONAN: Text Mining in the Biomedical Domain

2006-16 Carsten Riggelsen (UU) Approximation Methods for Efficient Learning of Bayesian Networks

2006-17 Stacey Nagata (UU) User Assistance for Multitasking with Interruptions on a Mobile Device

2006-18 Valentin Zhizhkun (UVA) Graph transformation for Natural Language Processing


2006-20 Marina Velikova (UvT) Monotone models for prediction in data mining

2006-21 Bas van Gils (RUN) Aptness on the Web

2006-22 Paul de Vrieze (RUN) Fundaments of Adaptive Personalisation

2006-23 Ion Juvina (UU) Development of Cognitive Model for Navigating on the Web

2006-24 Laura Hollink (VU) Semantic Annotation for Retrieval of Visual Resources

2006-25 Madalina Drugan (UU) Conditional log-likelihood MDL and Evolutionary MCMC

2006-26 Vojkan Mihajlovic (UT) Score Region Algebra: A Flexible Framework for Structured Information Retrieval

2006-27 Stefano Bocconi (CWI) Vox Populi: generating video documentaries from semantically annotated media repositories
2006-28 Borkur Sigurbjörnsson (UVA) Focused Information Access using XML Element Retrieval

2007

2007-01 Kees Leune (UvT) Access Control and Service-Oriented Architectures

2007-02 Wouter Teepe (RUG) Reconciling Information Exchange and Confidentiality: A Formal Approach

2007-03 Peter Mika (VU) Social Networks and the Semantic Web


2007-06 Gilad Mishne (UVA) Applied Text Analytics for Blogs

2007-07 Natasa Jovanovic’ (UT) To Whom It May Concern – Addressee Identification in Face-to-Face Meetings

2007-08 Mark Hoogendoorn (VU) Modeling of Change in Multi-Agent Organizations

2007-09 David Mobach (VU) Agent-Based Mediated Service Negotiation


2007-11 Natalia Stash (TUE) Incorporating Cognitive/Learning Styles in a General-Purpose Adaptive Hypermedia System

2007-12 Marcel van Gerven (RUN) Bayesian Networks for Clinical Decision Support: A Rational Approach to Dynamic Decision-Making under Uncertainty

2007-13 Rutger Rienks (UT) Meetings in Smart Environments; Implications of Progressing Technology

2007-14 Niek Bergboer (UM) Context-Based Image Analysis

2007-15 Joyca Lacroix (UM) NIM: a Situated Computational Memory Model

2007-16 Davide Grossi (UU) Designing Invisible Handcuffs. Formal investigations in Institutions and Organizations for Multi-agent Systems

2007-17 Theodore Charitos (UU) Reasoning with Dynamic Networks in Practice

2007-18 Bart Orriens (UVT) On the development an management of adaptive business collaborations

2007-19 David Levy (UM) Intimate relationships with artificial partners

2007-20 Slinger Jansen (UU) Customer Configuration Updating in a Software Supply Network

2007-21 Karianne Vermaas (UU) Fast diffusion and broadening use: A research on residential adoption and usage of broadband internet in the Netherlands between 2001 and 2005

2007-22 Zlatko Zlatev (UT) Goal-oriented design of value and process models from patterns

2007-23 Peter Barna (TUE) Specification of Application Logic in Web Information Systems

2007-24 Georgina Ramírez Camps (CWI) Structural Features in XML Retrieval


2008

2008-01 Katalin Boer-Sorbán (EUR) Agent-Based Simulation of Financial Markets: A modular, continuous-time approach


2008-03 Vera Hollink (UVA) Optimizing hierarchical menus: a usage-based approach

2008-04 Ander de Keijzer (UT) Management of Uncertain Data - towards unattended integration

2008-05 Bela Mutschler (UT) Modeling and simulating causal dependencies on process-aware information systems from a cost perspective

2008-06 Arjen Hommersom (RUN) On the Application of Formal Methods to Clinical Guidelines, an Artificial Intelligence Perspective

2008-07 Peter van Rosmalen (OU) Supporting the tutor in the design and support of adaptive e-learning

2008-08 Janneke Bolt (UU) Bayesian Networks: Aspects of Approximate Inference

2008-09 Christof van Nimwegen (UU) The paradox of the guided user: assistance can be counter-effective

2008-10 Wouter Bosma (UT) Discourse oriented summarization
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<th>Year</th>
<th>Student</th>
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<td>2008-11</td>
<td>Vera Kartseva</td>
<td>VU</td>
<td>Designing Controls for Network Organizations: A Value-Based Approach</td>
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<td>2008-12</td>
<td>Jozsef Farkas</td>
<td>RUN</td>
<td>A Semiotically Oriented Cognitive Model of Knowledge Representation</td>
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<td>2008-13</td>
<td>Caterina Carraciolo</td>
<td>UVA</td>
<td>Topic Driven Access to Scientific Handbooks</td>
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<td>2008-14</td>
<td>Arthur van Bunningen</td>
<td>UT</td>
<td>Context-Aware Querying: Better Answers with Less Effort</td>
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<td>2008-16</td>
<td>Henriette van Vugt</td>
<td>VU</td>
<td>Embodied agents from a user’s perspective</td>
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<td>2008-17</td>
<td>Martin Op’t Land</td>
<td>TUD</td>
<td>Applying Architecture and Ontology to the Splitting and Allying of Enterprises</td>
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<td>2008-18</td>
<td>Guido de Croon</td>
<td>UM</td>
<td>Adaptive Active Vision</td>
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<td>Henning Rode</td>
<td>UT</td>
<td>From Document to Entity Retrieval: Improving Precision and Performance of Focused Text Search</td>
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<td>2008-20</td>
<td>Rex Arendsen</td>
<td>UVA</td>
<td>Geen bericht, goed bericht. Een onderzoek naar de effecten van de introductie van elektronisch berichtenverkeer met de overheid op de administratieve lasten van bedrijven</td>
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<td>2008-21</td>
<td>Krisztian Balog</td>
<td>UVA</td>
<td>People Search in the Enterprise</td>
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<td>Jan Wielemaker</td>
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<td>Logic programming for knowledge-intensive interactive applications</td>
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<td>Loes Braun</td>
<td>UM</td>
<td>Pro-Active Medical Information Retrieval</td>
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<td>Jeroen de Knijf</td>
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<td>Studies in Frequent Tree Mining</td>
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<td>2008-25</td>
<td>Sietse Overbeek</td>
<td>RUN</td>
<td>Bridging Supply and Demand for Knowledge Intensive Tasks - Based on Knowledge, Cognition, and Quality</td>
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<td>2008-26</td>
<td>Muhamad Subianto</td>
<td>UU</td>
<td>Understanding Classification</td>
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<td>Volker Nannen</td>
<td>VU</td>
<td>Evolutionary Agent-Based Policy Analysis in Dynamic Environments</td>
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<td>2008-28</td>
<td>Alexander Boer</td>
<td>UVA</td>
<td>Legal Theory, Sources of Law &amp; the Semantic Web</td>
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2009-12 Peter Massuthe (TUE, Humboldt-Universitaet zu Berlin) Operating Guidelines for Services

2009-13 Steven de Jong (UM) Fairness in Multi-Agent Systems

2009-14 Maksym Korotkiy (VU) From ontology-enabled services to service-enabled ontologies (making ontologies work in e-science with ONTO-SOA)

2009-15 Rinke Hoekstra (UVA) Ontology Representation - Design Patterns and Ontologies that Make Sense

2009-16 Fritz Reul (UvT) New Architectures in Computer Chess

2009-17 Laurens van der Maaten (UvT) Feature Extraction from Visual Data

2009-18 Fabian Groffen (CWl) Armada, An Evolving Database System

2009-19 Valentin Robu (CWl) Modeling Preferences, Strategic Reasoning and Collaboration in Agent-Mediated Electronic Markets

2009-20 Bob van der Vecht (UU) Adjustable Autonomy: Controlling Influences on Decision Making

2009-21 Stijn Vanderlooy (UM) Ranking and Reliable Classification

2009-22 Pavel Serdyukov (UT) Search For Expertise: Going beyond direct evidence

2009-23 Peter Hofgesang (VU) Modelling Web Usage in a Changing Environment

2009-24 Annerieke Heuvelink (VU) Cognitive Models for Training Simulations

2009-25 Alex van Ballegooij (CWl) RAM: Array Database Management through Relational Mapping

2009-26 Fernando Koch (UU) An Agent-Based Model for the Development of Intelligent Mobile Services

2009-27 Christian Glahn (OU) Contextual Support of social Engagement and Reflection on the Web

2009-28 Sander Evers (UT) Sensor Data Management with Probabilistic Models

2009-29 Stanislav Pokraev (UT) Model-Driven Semantic Integration of Service-Oriented Applications

2009-30 Marcin Zukowski (CWl) Balancing vectorized query execution with bandwidth-optimized storage

2009-31 Sofiya Katrenko (UVA) A Closer Look at Learning Relations from Text

2009-32 Rik Farenhorst (VU) and Remco de Boer (VU) Architectural Knowledge Management: Supporting Architects and Auditors

2009-33 Khiets Tuong (UT) How Does Real Affect Affect Affect Recognition In Speech

2009-34 Inge van de Weerd (UU) Advancing in Software Product Management: An Incremental Method Engineering Approach

2009-35 Wouter Koelewijn (UL) Privacy en Politiegegevens; Over geautomatiseerde normatieve informatie-uitwisseling

2009-36 Marco Kalz (OU) Placement Support for Learners in Learning Networks

2009-37 Hendrik Drachslcr (OU) Navigation Support for Learners in Informal Learning Networks

2009-38 Riina Vuorikari (OU) Tags and self-organisation: a metadata ecology for learning resources in a multilingual context


2009-40 Stephan Raaijmakers (UvT) Multinomial Language Learning: Investigations into the Geometry of Language

2009-41 Igor Berezhnyy (UvT) Digital Analysis of Paintings

2009-42 Toine Bogers (UvT) Recommender Systems for Social Bookmarking

2009-43 Virginia Nunes Leal Franqueira (UT) Finding Multi-step Attacks in Computer Networks using Heuristic Search and Mobile Ambients

2009-44 Roberto Santana Tapia (UT) Assessing Business-IT Alignment in Networked Organizations

2009-45 Jilles Vreeken (UU) Making Pattern Mining Useful

2009-46 Loredana Afanasiev (UvA) Querying XML: Benchmarks and Recursion

2010

2010-01 Matthijs van Leeuwen (UU) Patterns that Matter

2010-02 Ingo Wassink (UT) Work flows in Life Science

2010-04 Olga Kulyk (UT) Do You Know What I Know? Situational Awareness of Co-located Teams in Multidisplay Environments

2010-05 Claudia Hauff (UT) Predicting the Effectiveness of Queries and Retrieval Systems

2010-06 Sander Bakkes (UvT) Rapid Adaptation of Video Game AI

2010-07 Wim Fikkert (UT) Gesture interaction at a Distance

2010-08 Krysztof Siewicz (UL) Towards an Improved Regulatory Framework of Free Software. Protecting user freedoms in a world of software communities and eGovernments

2010-09 Hugo Kielman (UL) Politieke gegevensverwerking en Privacy, Naar een effectieve waarborging

2010-10 Adriaan Ter Mors (TUD) The world according to MARP: Multi-Agent Route Planning

2010-11 Susan van den Braak (UU) Senesmaking software for crime analysis

2010-12 Gianluigi Folino (RUN) High Performance Data Mining using Bio-inspired techniques

2010-14 Sander van Splunter (VU) Automated Web Service Reconfiguration

2010-15 Lianne Bodenstaff (UT) Managing Dependency Relations in Inter-Organizational Models

2010-16 Sicco Verwer (TUD) Efficient Identification of Timed Automata, theory and practice

2010-17 Spyros Kotoulas (VU) Scalable Discovery of Networked Resources: Algorithms, Infrastructure, Applications

2010-18 Charlotte Gerritsen (VU) Caught in the Act: Investigating Crime by Agent-Based Simulation

2010-19 Henriette Cramer (UvA) People’s Responses to Autonomous and Adaptive Systems

2010-20 Ivo Swartjes (UT) Whose Story Is It Anyway? How Improv Informs Agency and Authorship of Emergent Narrative

2010-21 Harold van Heerde (UT) Privacy-aware data management by means of data degradation

2010-22 Michiel Hildebrand (CWI) End-user Support for Access to Heterogeneous Linked Data

2010-23 Bas Steunenbrink (UU) The Logical Structure of Emotions

2010-24 Dmytro Tykhonov (TUD) Designing Generic and Efficient Negotiation Strategies

2010-25 Zulfiqar Ali Memon (VU) Modelling Human-Awareness for Ambient Agents: A Human Mindreading Perspective

2010-26 Ying Zhang (CWI) XRPC: Efficient Distributed Query Processing on Heterogeneous XQuery Engines

2010-27 Marten Voulon (UL) Automatisch contracteren

2010-28 Arne Koopman (UU) Characteristic Relational Patterns

2010-29 Stratos Idræos (CWI) Database Cracking: Towards Auto-tuning Database Kernels

2010-30 Marieke van Erp (UvT) Accessing Natural History - Discoveries in data cleaning, structuring, and retrieval

2010-31 Victor de Boer (UVA) Ontology Enrichment from Heterogeneous Sources on the Web

2010-32 Marcel Hiel (UvT) An Adaptive Service Oriented Architecture: Automatically solving Interoperability Problems

2010-33 Robin Aly (UT) Modeling Representation Uncertainty in Concept-Based Multimedia Retrieval

2010-34 Teduh Dirgahayu (UT) Interaction Design in Service Compositions

2010-35 Dolf Trieschnigg (UT) Proof of Concept: Concept-based Biomedical Information Retrieval

2010-36 Jose Janssen (OU) Paving the Way for Lifelong Learning; Facilitating competence development through a learning path specification

2010-37 Niels Lohmann (TUE) Correctness of services and their composition

2010-38 Dirk Fahland (TUE) From Scenarios to components

2010-39 Ghazanfar Farooq Siddiqui (VU) Integrative modeling of emotions in virtual agents

2010-40 Mark van Assem (VU) Converting and Integrating Vocabularies for the Semantic Web
2010-41 Guillaume Chaslot (UM) Monte-Carlo Tree Search
2010-42 Sybren de Kinderen (VU) Needs-driven service bundling in a multi-supplier setting - the computational e3-service approach
2010-43 Peter van Kranenburg (UU) A Computational Approach to Content-Based Retrieval of Folk Song Melodies
2010-44 Pieter Bellekens (TUE) An Approach towards Context-sensitive and User-adapted Access to Heterogeneous Data Sources, Illustrated in the Television Domain
2010-45 Vasilios Andrikopoulos (UvT) A theory and model for the evolution of software services
2010-46 Vincent Pijpers (VU) e3alignment: Exploring Inter-Organizational Business-ICT Alignment
2010-47 Chen Li (UT) Mining Process Model Variants: Challenges, Techniques, Examples
2010-48 Withdrawn
2010-49 Jahn-Takeshi Saito (UM) Solving difficult game positions
2010-50 Bouke Huurnink (UVA) Search in Audiovisual Broadcast Archives
2010-51 Alia Khairia Amin (CWI) Understanding and supporting information seeking tasks in multiple sources
2010-52 Peter-Paul van Maanen (VU) Adaptive Support for Human-Computer Teams: Exploring the Use of Cognitive Models of Trust and Attention
2010-53 Edgar Meij (UVA) Combining Concepts and Language Models for Information Access

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2011-01 Botond Cseke (RUN) Variational Algorithms for Bayesian Inference in Latent Gaussian Models
2011-02 Nick Tinnemeier(UU) Organizing Agent Organizations, Syntax and Operational Semantics of an Organization-Oriented Programming Language
2011-03 Jan Martijn van der Werf (TUE) Compositional Design and Verification of Component-Based Information Systems
2011-04 Hado Philip van Hasselt (UU) Insights in Reinforcement Learning; Formal analysis and empirical evaluation of temporal-difference learning algorithms
2011-05 Bas van de Raadt (VU) Enterprise Architecture Coming of Age – Increasing the Performance of an Emerging Discipline
2011-06 Yiwen Wang(TUE) Semantically-Enhanced Recommendations in Cultural Heritage
2011-07 Yujiu Cao (UT) Multimodal Information Presentation for High Load Human Computer Interaction
2011-08 Nieske Vergunst (UU) BDI-based Generation of Robust Task-Oriented Dialogues
2011-09 Tim de Jong (OU) Contextualised Mobile Media for Learning
2011-10 Bart Bogaert (UvT) Cloud Content Contention
2011-11 Dhaval Vyas (UT) Designing for Awareness: An Experience-focused HCI Perspective
2011-12 Carmen Bratosin (TUE) Grid Architecture for Distributed Process Mining
2011-13 Xiaoyu Mao (UvT) Airport under Control; Multiagent Scheduling for Airport Ground Handling
2011-14 Milan Lovric(EUR) Behavioral Finance and Agent-Based Artificial Markets
2011-16 Maarten Schadd (UM) Selective Search in Games of Different Complexity
2011-17 Jiyin He (UVA) Exploring Topic Structure: Coherence, Diversity and Relatedness
2011-18 Mark Ponsen (UM) Strategic Decision-Making in complex games
2011-19 Ellen Rusman (OU) The Mind’s Eye on Personal Profiles
2011-20 Qing Gu (VU) Guiding service-oriented software engineering – A view-based approach
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2011-22 Junte Zhang (UVA) System Evaluation of Archival Description and Access
2011-23 Wouter Weerkamp (UVA) Finding People and their Utterances in Social Media
2011-24 Herwin van Welbergen (UT) Behavior Generation for Interpersonal Coordination with Virtual Humans On Specifying, Scheduling and Realizing Multimodal Virtual Human Behavior
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<td>Analysis and Validation of Models for Trust Dynamics</td>
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<td>Virtual Agents for Human Communication – Emotion Regulation and Involvement-Distance Trade-Offs in Embodied Conversational Agents and Robots</td>
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<td>Dynamic website optimization through autonomous management of design patterns</td>
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<td>Effective Focused Retrieval by Exploiting Query Context and Document Structure</td>
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<td>Discrimination-aware Classification</td>
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<td>Affective Signal Processing (ASP): Unraveling the mystery of emotions</td>
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<td>Strategic Reasoning in Interdependence: Logical and Game-theoretical Investigations</td>
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<td>Machine Learning for Pairwise Data, Applications for Preference Learning and Supervised Network Inference</td>
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2015-22 Zhemin Zhu (UT) Co-occurrence Rate Networks - Towards separate training for undirected graphical models

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<td>2016-42 Spyros Martzoukos (UVA) Combinatorial and compositional aspects of bilingual aligned corpora</td>
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<td>2016-26 Dilhan J. Thilakarathne (VU) In or Out of Control: Exploring Computational Models to Study the Role of Human Awareness and Control in Behavioural Choices, with Applications in Aviation and Energy Management Domains</td>
<td>2016-43 Saskia Koldijk (RUN) Context-Aware Support for Stress Self-Management: From Theory to Practice</td>
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<td>2016-27 Wen Li (TUD) Understanding Geo-spatial Information on Social Media</td>
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<td>2016-30 Ruud Mattheij (UVT) The Eyes Have IT</td>
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<td>2016-35 Zhaochun Ren (UVA) Monitoring Social Media: Summarization, Classification and Recommendation</td>
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2020-08 Ali Mirsoleimani (UL) Structured Parallel Programming for Monte Carlo Tree Search

2020-09 Myriam Traub (UU) Measuring Tool Bias & Improving Data Quality for Digital Humanities Research

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2020-11 Sepideh Mesbah (TUD) Semantic-Enhanced Training Data Augmentation Methods for Long-Tail Entity Recognition Models

2020-12 Ward van Breda (VU) Predictive Modeling in E-Mental Health: Exploring Applicability in Personalised Depression Treatment

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