

# Conceptual Diagram Development for Sustainable e-Government Implementation

Maryam M. Khamis and Theo P. van der Weide

Radboud University, Netherlands

[m.khamis@cs.ru.nl](mailto:m.khamis@cs.ru.nl)

[tvdw@cs.ru.nl](mailto:tvdw@cs.ru.nl)

**Abstract:** E-government implementation has received extra attention as a new way to increase the development of a country. International organizations such as the ITU and the United Nations provide strategic guidance to overcome the challenges of ICT use. Yet, the development of ICT use in developing countries is still very low. Researchers are contributing to support successful implementation with models and theories that conceptualize the complex situation.

This paper extends the DPSIR-based e-government conceptual framework into the direction of implementation strategies. The main focus is on improving stakeholder involvement during requirements engineering. Object Role Modeling (ORM) was used (1) to develop a semi-natural language (controlled language) that is understandable both for domain stakeholders and system analysts and (2) to make a common description of the application domain in this language. The proposed model can be used to construct quantitative simulation tools to be used by policy makers.

**Keywords:** *Conceptual data modeling, Object Role Modeling, Manual service, Digital Service, DPSIR, Zanzibar*

---

## 1. Introduction

Over the last decade, a lot of effort has been made to improve the use of Information and Communication Technology (ICT) in developing countries. International organizations such as the International Telecommunication Union (ITU) and the United Nations provide 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 (ITU, 2016). Yet, the development of ICT use in developing countries is still very low. Many projects have been established but few have been successful (Heeks, 2006). As a result, the development of ICT deployment does not meet the expected goals, especially in developing countries. Currently there is huge difference of ICT setting compared to the world average. Data shows that internet penetration in developing countries (7% of the households) compares low to the world average 46% (ITU, 2015). Studies show that failures are caused in particular by insufficient customer requirements and project specification (Tohidi, 2011 ; Montequin et al., 2014). Also, requirement engineering is largely ignored in the development of e-government solution (Alexandrova, Rapanotti and Meehan, 2011). Both findings are strongly related to insufficient stakeholder involvement during the initial phase of project implementation (Elkadi, 2013 ; Montequin et al., 2014). As a result, the projects do not conform to requirements and lead to slow down e-government development efforts (Yonazi, 2010).

Stakeholder involvement has a great influence on the success of any government project (Elkadi, 2013 ; Montequin et al., 2014). Citizen, government, ICT infrastructure, deployment and services are correlated components that have an important contribution to e-government implementation (Khamis and van der Weide, 2016). Indeed, designing, deploying and evaluation of correlated components are very important in understanding the context especially in e-government initiatives (Yonazi, 2010). Khamis and van der Weide (2016) have described causal relations between these components using the DPSR (Driver, Pressure, State, Impact and Response) framework.

In this paper we focus at the improvement of stakeholder involvement in requirements engineering. We extend the e-government based conceptual DPSIR framework (EEA, 2007) into the direction of implementation strategies by defining a conceptual framework and a related conceptual language. We apply Object Role Modeling (ORM) (Hofstede, Proper and van der Weide, 1993; Halpin, 1998) for this purpose, since the main goal 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. This common language is described by the so-called information grammar; the resulting description is called the requirements document. However, many modeling

approaches have been deployed to support e-government development. Yet the need to find 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 policy makers.

When focusing on some particular point of view defined by some policy maker, we can introduce a conceptual base for the resulting conceptual subspace (van der Weide, Tulinayo and van Bommel, 2016). Then we extend the causal relations coming from the overarching DPSIR model with more concrete causal relations. These causal relations describe the quantitative 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 paper is as follows. A literature review provided in Section 2. In Section 3 we describe the theoretical basis deployed in this study; we go into more detail about modeling since this is the main research method to be used in this paper. Section 3 presents the informal domain description as the requirement document for e-government. The e-Government conceptual model follows in Section 4. We conclude this paper in Section 5.

## **2. Literature review**

Various dimensions may be considered to achieve a successful e-government deployment. On the basis of these dimensions, various 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 (Mbale and Staden, 2010 ; Rawas, 2010 ; Vuksic, Pozgaj and Milanovic, 2010) and (2) (prospective) models developed to give guidance to the implementation process (Altameem, Zairi and Alshawi, 2006 ; Napitupulu and Sensuse, 2014 ; Choi et al., 2016). Both approaches have a significant impact in 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 requirement analysis. Similarly, the quality of conceptual design is influenced by the quality of the conceptual modeling method (Moody, 2005). Both requirements and modeling approach 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 common understanding by the domain expert and the system analyst in providing a correct and complete requirement document of the application domain (Halpin, 2015). 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 (Sondheimer et al., 2003). 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. But, it has been used in many complex applications. For example, it has been used to build urban metrological model for estimation of possible wind acceleration along canyons (Samsonov, Konstantinov and Varentsov, 2015). Tulinayo, van Bommel and Proper (2011) combine ORM modeling with System Dynamics methods to evaluate the hospital management process of pregnant women during the dilation stage from admission to discharge. Similarly, Ssebuggwawo, Hoppenbrouwers and Proper (2010) combine two meta models (Rules, Interactions and Models (RIM) Framework and Multi-criteria decision analysis (MCDA) method and link these models as a blue print to analyze and evaluate the deep structure of collaborative modeling using ORM design.

Besides, other models were developed to add strength to e-government implementation. Altameem, Zairi and Alshawi (2006) developed a model for successful e-government implementation. 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 by Aagesen and John (2011). This model focuses on technology affordance, political direction, provided services, administrative interpretation and regulations. Then, this model conceptualizes the need of government particularly for the legislation process and its underlying politics.

Moreover, maturity model has been used to understand e-government development. Napitupulu and Senses (2014) have used success factors to evaluate the maturity of e-government implementation. They use analysis approach to explore e-government in different dimension. Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were 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, cannot correct implementation failures developed using incorrect requirements. Furthermore, Choi et al. (2016) use design-reality gap analysis to assess e-government implementation in developing countries. 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 key success factors in e-government implementation. Accordingly, it is equally important to understand success factors for the sake of e-government implementation success.

In like manner, Mbale and Staden (2010) developed the model HAE bottom up for health, agriculture and education (HAE) and used it to assess factors relevant for the initial phase of e-government implementation. This model was used to assess developing countries based on a typing of government sectors, in order 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 important strategy during e-government implementation. This model describes the theoretical aspects to understand e-government implementation issues. Rawas (2010) 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. Vuksic, Pozgaj and Milanovic (2010) use a theoretical framework to examine multiple factors influencing e-government implementation in Croatia. The model helps to understand the relationship between goal, objective and the context of the project. Hence, can be quite good to analyze project implementation risks

### 3. Theoretical basis

In this section we first discuss 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.

#### 3.1 Modeling

An application domain is some part of the real world that has our special attention. An application domain comprises a particular point of view on some part of the real world. Sometimes the application domain also is referred to as the universe of discourse (UoD) (Halpin, 2015). We may be an observer of this UoD, or be part of this UoD, but our goal will be to be able to understand the application domain and make motivated statements about this domain. Understanding the application domain has two aspects. Following Frederiks and van der Weide (2006), we assume two roles during the modeling process: the domain experts and the system analyst. 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 will be referred to as the informal semantics of the common language. The system analyst will answer 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 to 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 relevant 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 intention is to find an equivalent description of that domain, but written in the formal language associated with the modeling technique used (Sugumaran and Storey, 2006 ; Halpin, 2015). In the ORM approach, a format for controlled natural language is prescribed such that the controlled language 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 being the model at the same time. We will refer to this document as the requirements document. According to (Parnas and Madey 1995), a requirement is anything that is necessary to fulfill certain concerns. Requirements may be described in terms of the domain language. The requirements document is seen by (Parnas and Madey 1995) 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 system's users.

After this first step, the system analyst and domain expert will 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 further explore some aspect of the description so far. This 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 document.

The requirements document can be seen as a bridge between the informal application domain and a formal model. As such, it has to satisfy some properties. Firstly, it should be complete. This means 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 (Sugumaran and Storey, 2006). 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 with respect to modeling technique used.

### **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 the purpose of understanding and communication. (La-Ongsri and Roddick, 2015 ; Storey, Trujillo and Stephen, 2015 ; Wang, 2015). ORM modeling is done by analyzing sample sentences that are generated by domain experts to describe their application domain (Frederiks and van der Weide, 2006). These sample sentences are processed by the 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, this requirements analysis method is more stable than other modeling approaches such as ER modeling (Halpin and Wagner, 2003).

### **3.3 Object Role Modeling (ORM)**

Object role modeling (ORM) is a fact oriented approach to modeling and querying information at a conceptual level (Hofstede, Proper and van der Weide, 1993 ; Halpin, 1998). It is an attribute free approach which structures the conceptual model directly from natural language sentences. This characteristic makes the design to more stable compared to other Object Oriented (OO) or Entity Relational (ER) modeling (Halpin and Wagner, 2003). For example, Unified Modeling Language (UML) modeling has weak support for constraints, it can be ignored or duplicated in more than one objects. OO approach can be used in implementation but not in analysis. (Oriol, Teniente and Tort, 2015).

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 will also describe 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 (Huth and Ryan, 2004), together with a set of axioms, derived from the population rules. We will refer to such a logic theory as Object Role Calculus (ORC) (Hofstede, Proper and van der Weide, 1993). The associated logic theory is a basis for

formal reasoning about the domain that is described by the information grammar. Proof assistants such as the Coq Proof Assistant (Gilles et al., 2006), may help policy makers.

### 3.4 Domain Specific Languages

Domain Specific Languages (DSL) have been introduced to narrow the gap between the application domain and its implementation (Fowler, 2011). Therefore such languages must satisfy the following conditions (Ostermann, 2016):

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 describe 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 (Eysholdt and Behrens, 2010), that is the basis for a Java framework via Eclipse. In Kameni, van der Weide and de Groot (2016) the transformation of ORM into Xtext is described.

### 3.5 The Requirement Document for e-Government: the Zanzibar case.

Zanzibar (Unguja and Pemba Islands) launched an e-government project in 2013 (Telecompaper, 2013). The project was designed to encourage government offices to increase efficiency in the use of information and communication technology. This project centered on advance communication 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 aim of this project is 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 realizes the high contribution of ICT use to achieve the designed country goals. It was clearly stated that, having ICT legal and institutional framework, using ICT in all government sectors and increasing access to market information using affordable ICTs, influences social and economic development. Accordingly, the introduction of the e-government project in Zanzibar is the result of the implementation plan ZSGRP II.

The e-government project involves laying of fiber optic cables all over the country then making connections and finally, construction of an e-government data center (Telecompaper, 2013). Laying of fiber cable has been completed, and the connections between government offices are currently in progress. RGoZ is the owner of the fiber network infrastructure and its accompanying equipment. However, they agreed with Zantel Telecommunication Company to support technical operation. The operation of the fiber cable network has been accomplished by RGoZ and a joint agreement with Zantel telecommunication network to provide fiber network service. Equipment such as Point of Presence (POP) and Network Operation Center (NOC) are installed, monitored, configured, upgraded, and repaired. Failure to operate equipment in a proper manner results in equipment response failure towards electronic requests. Each equipment record 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 to the ZSGRP II plan. The use of electronic services in government offices has been 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 healthcare in Zanzibar (Lungo & Igira, 2008). 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. The existing information system helps to manage back office records, yet there is a gap for a citizen system 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. However, a citizen can also use ICT tools to send and receive a service electronically without any staff interaction. Name this service an

electronic service. Using electronic services helps to reduce administrative work and increase service efficiency. Conversely, human-based requests increase processing and handling time. Changes in processing time affects the number of administrative staff required for a particular service. As a result, the budget of administrative services fluctuates. In conclusion, time is an important factor to measure employee performance. Government can use this factor to measure 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 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 implementation of the plan. Failure to maintain the existing investment of fiber cable may result in a huge loss to the government and community in general. The described threat has been realized by the State University of Zanzibar (SUZA) at Tunguu campus. SUZA was among one of the government organizations who explored the benefits of fiber cable network. Unfortunately, the road maintenance at Fuoni road lead to the age of 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 believed to be 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 a great opportunity to share operating costs for e-government sustainability.

Introducing new technology to the community requires citizen capacity to operate equipment. Citizen capacity refers to knowledge of using electronic services. Citizen awareness and readiness is an important phase to overcome technological challenge in e-government deployment. It is well known that the community is the primary stakeholder of e-government activities. Citizen acceptance of new technology increases the use of new 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 trainings and workshops have been conducted to equip citizen in various technological problems. For example, computer trainings and workshops have been conducted to empower health officers to manage District Health Information System (DHIS) (Braa, Heywood and Sahay, 2012).

Transparency, openness and accountability that featured e-government implementation may create government officials hampering e-government development efforts. Many developing countries follow 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 (Matavire, et al., 2010). Taking this into consideration as a threat may reduce risks of e-government project failures.

#### **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.

##### **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 properties that are relevant in our application domain for our purposes for citizen are described by the following elementary sentences:

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 latter properties provide knowledge about the skill level of the citizens, and the tools that they have access to.

In their interaction with the government, citizens require services that are offered by government. In our system we want to keep track of service requests, when they were issued, when they were handled, the kind of request and relevant details related to the request. A service request is identified by the requesting citizen, the kind 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.

## 4.2 Organizations

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

## 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.

1. an Office is identified by Office-Nr.
2. Office is sub-office of Office
3. Office organizes Service.

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

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 we record:

For our application domain it is important to distinguish between technical and administrative staff. We introduce the following specializations of Staff:

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 we record for both staff groups what they can handle:

12. TechnicalStaff manage Equipment.
13. AdministrativeStaff operate Equipment.

Finally, we make explicit the managers of offices:

14. OfficeManager IS Staff having FunctionType 'manager'.

## 4.4 Services

A service is an action or help of public needs that are provided by government to both citizens and organizations (Chelliah et al., 2016). A service may be anticipated by 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:

3. Customer GENERALIZES Citizen, Company.

We will distinguish between services that are delivered by humans (in the traditional way) and those that are being delivered via modern ICT. We will record whether a service is delivered automatically by ICT equipment, and use that relation to partition the services:

4. Service is delivered automatically.
5. DigitalService IS Service being delivered automatically.
6. ManualService IS Service BUT NOT DigitalService.
7. ManualService has ManualRequest
8. DigitalService has DigitalRequest

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

#### **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 (Sá, Rocha and Cota, 2016). We assume that the government strategy is to offer trainings to the citizens in order to obtain the required skills. Each training offered has assigned its own training identification. Each training also has associated training objectives. Typically, a country will have its own system to describe skill levels.

1. Training is identified by Training-ID.
2. Training trains for Skill.

Next it will be relevant to record who is (officially) offering the trainings, and who has successfully completed a training, and therefore is supposed to master the skills offered by that 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 relation is maintained (more efficiently) on a statistical basis. Of course, government will implement some form of quality assurance, for example by an accreditation system for training institutions and by requiring independent examinations. Quality issues will not be considered in this paper.

Using this information, it can be calculated to what extent skills that are required for a service actually are met by the citizens. Using the address information, it can be seen what areas are underrepresented in mastering specific skills, and therefore are not yet open for digital services.

#### **4.6 Infrastructure**

Finally we consider the infrastructure required for a successful implementation of e-Government. Basically we see two kinds of issues here. Firstly, we consider the equipment required to process a service, and 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 will have a list of approved hardware configurations, and will also record what services can be run on each configuration:

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



The ability to access the digital communication network will be 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 relation also may be maintained (more efficiently) by statistical methods. With respect to 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.

#### 4.7 Model summary

Figure 1 shows a graphical representation of the information grammar developed in the previous subsections. It represents the scenario taken from the Zanzibar study described in Section 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.

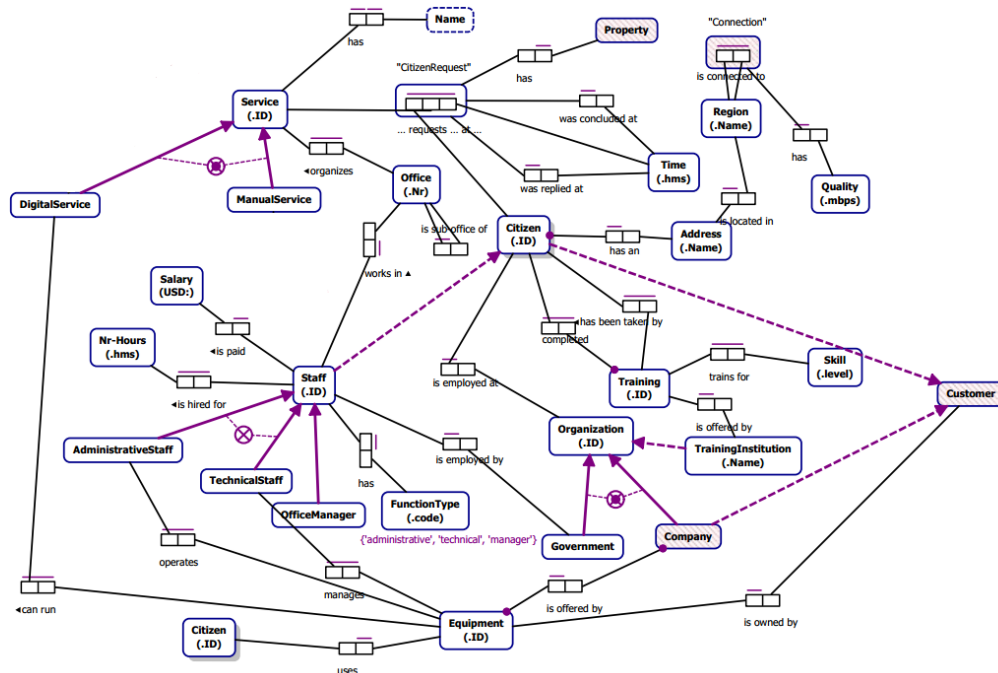


Figure 1: ORM conceptual model of e-government implementation

#### 5. Conclusion and further research

Through our modeling process, we have contributed to the understanding of e-government implementation. In our approach we especially focus on stakeholder involvement by describing the result of a communication protocol between domain expert and system analyst. Further research should go into more depth about the context of this communication protocol. For example, the Round Table Approach (Moens and Broerse, 2006) describes a very promising approach to create a situation to stimulate open communication between all stakeholders.

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 purpose 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. Special support is available to generate special tools, for example a parser for the domain specific language.

Our interest will be more in the conceptual language, ORC, for example. The conceptual language will allow us to (formally) reason about the application domain. Especially, we will be interested in application domain dynamics. Our next steps will be to introduce special conceptual bases (van der Weide, Tulinayo and van Bommel, 2016) for the conceptual model we introduced in this paper, and then focus on a first-order model to describe the changes of the conceptual base as 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 expected to be helpful for policymakers to validate intended decisions. Another step forward would be to involve proof assistants who can verify the correctness of intended decisions.

## References

- Aagesen, G. and John, K. 2011. 'Service delivery in transformational government: model and scenarios', *Electronic Government, an International Journal*, vol. 8, no. 2/3, pp. 242 - 258.
- Alexandrova, A., Rapanotti, L. and Meehan, A. 2011. Requirements practices in e-government solution development. In: *2011 International Conference on e-Learning, e-Business, Enterprise Information Systems, and e-Government*, July 18-21 2011, Las Vegas, USA.
- Altameem, T., Zairi, M. and Alshawi, S. 2006. 'Critical success factors of e-Government: A proposed model for e-Government implementation', *2006 Innovations in Information Technology*, Dubai, 1-5.
- Braa, J., Heywood, A. and Sahay, S., 2012. Improving quality and use of data through data-use workshops: Zanzibar experience, *Bull World Health Organ*, vol. 90, pp. 379-384.
- Chelliah, P.P.M., Thurasamy, R., Alzahrani, A.I., Alfarraj, O. and Alalwan, N. 2016. 'E-Government service delivery by a local government agency: The case of E-Licensing', *Telematics and Informatics*, vol. 33, no. 4, pp. 925 - 935.
- Choi, H., Park, M.J., Rho, J.J. and Zo, H. 2016. 'Rethinking the assessment of e-government implementation in developing countries from the perspective of the design-reality gap: Applications in the Indonesian e-procurement system', *Telecommunications Policy*, vol. 40, no. 7, pp. 644 - 660.
- EEA, 2007. European Environment Agency, the dpsir framework used by the EEA. [online] Available at: <[http://ia2dec.pbe.eea.europa.eu/knowledge\\_base/](http://ia2dec.pbe.eea.europa.eu/knowledge_base/)> [Accessed 2015].
- Elkadi, H. 2013. 'Success and failure factors for e-government projects: A case from Egypt', *Egyptian Informatics Journal*, vol. 14, no. 2, pp. 165 - 173.
- Eysholdt, M. and Behrens, H. 2010. 'Xtext: implement your language faster than the quick and dirty way', *Proceedings of the ACM international conference companion on Object oriented programming systems languages and applications companion*, 307-309.
- Fowler, M. 2011. *Domain Specific Languages*. Addison-Wesley.
- Frederiks, P.J.M. and van der Weide, T.P. 2006. 'Information modeling: The process and the required competencies of its participants', *Data and Knowledge Engineering*, vol. 58, no. 1, pp. 4-20.
- Gilles, B., Forest, J., Pichardie, D. and Rusu, V. 2006. 'Defining and reasoning about recursive functions: a practical tool for the Coq proof assistant', *International Symposium on Functional and Logic Programming*, 114-129.
- Halpin, T.A. 1998. *Object-Role Modeling (ORM/NIAM)*, *Handbook on Architectures of Information Systems*, Heidelberg: Springer Berlin.
- Halpin, T. 2015. *Object-Role Modeling Fundamentals: A practical guide to data modeling with ORM*, USA: Technics Publications, LLC.
- Halpin, T. and Wagner, G. 2003. 'Modeling reactive behavior in ORM', *International Conference on Conceptual Modeling*, pp. 567--569.
- Heeks, R. 2006. 'Health information systems: Failure, success and improvisation', *International Journal of Medical Informatics*, vol. 75, no. 2, pp. 125--137.
- Hofstede, A.H.M., Proper, H.A. and van der Weide, T.P. 1993. 'Formal definition of a conceptual language for the description and manipulation of information models', *Information Systems*, vol. 18, no. 7, pp. 489-523.
- Huth, M. and Ryan, M. (2004) *Logic in Computer Science: Modelling and reasoning about systems*. Cambridge University Press.
- ITU (2015) *ICT facts and figures 2015*, Switzerland: International Telecommunication Union. [online] Available at: <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf>.
- ITU (2016) *ICT facts and figures 2016*, Switzerland: International Telecommunication Union. [online] Available at: <http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2015.pdf>.
- Kameni, E., van der Weide, T.P. and de Groot, W. 2016. *A Domain Specific Language for Multi-Levels Agent-Based Model*, Nijmegen: Radboud University.
- Khamis, M.M. and van der Weide, T.P. 2016. 'Conceptual framework for sustainable e-government implementation in low infrastructure situation'. Slovenia.

- La-Ongsri, S. and Roddick, J.F. 2015. 'Incorporating ontology-based semantics into conceptual modelling', *Information Systems*, vol. 52, pp. 1 - 20.
- Lungo, J.H. and Igira, F., 2008. Development of health information system in Zanzibar: practical implications. *Journal of Health Informatics in Developing Countries*, Vol. 2, no.1.
- Matavire, R., Chigona, W., Roode, D., Sewchurran, E., Davids, Z., Mukudu, A. and Boamah-Abu, C., 2010. Challenges of eGovernment Project Implementation in a South African Context, *The Electronic Journal Information Systems*, vol. 13, no. 2, pp. 153-164.
- Mbale, J. and Staden, S.V. 2010. 'The HAE Bottom-Up Model (HAE-BUM): Envisages the enhancement of development and strengthen the e-Governance or e-Government implementation systems', *IST-Africa*, 2010, Durban, 1-9.
- Moens, N. and Broerse, J. 2006. 'Innovation in sectoral governance & development with ICT: conceptualising the ICT Round Table process', *Journal of Sytemics, Cybernetics and Informatics*, vol. 4, no. 6, pp. 33-40.
- Montequin, V.R., Cousillas, S., Ortega, F. and Villanueva, J. 2014. 'Analysis of the success factors and failure causes in information and communication technology (ICT) projects in Spain', *Procedia Technology*, vol. 16, pp. 992 - 999.
- Moody, D.L., 2005. Theoretical and practical issues in evaluating the quality of conceptual models: current state and future directions. *Data & Knowledge Engineering*, Vol. 55, no. 3, pp.243-276.
- Napitupulu, D. and Sensuse, D.I. 2014. 'Toward maturity model of e-Government implementation based on success factors', *International Conference on Advanced Computer Science and Information Systems (ICACSIS)*, 2014 , Jakarta, 108-112.
- Oriol, X., Teniente, E. and Tort, A. 2015. 'Computing repairs for constraint violations in UML/OCL conceptual schemas', *Data and Knowledge Engineering*, vol. 99, pp. 39 - 58.
- Ostermann, K. 2016. *Domain Specific Languages*, [online], Available at: [http://www.informatik.uni-marburg.de/~seba/teaching/sedesign12/05\\_DSLs.pdf](http://www.informatik.uni-marburg.de/~seba/teaching/sedesign12/05_DSLs.pdf) [Accessed 01 September 2016].
- Parnas, D P., and Madey J., 1995. Functional documents for computer systems, *Science of Computer Programming*, Vol. 25, no. 1, 1995, Pages 41-61, Available at: <http://www.sciencedirect.com/science/article/pii/016764239596871J>.
- Rawas, M. 2010. 'Towards a better understanding of e-Government implementation', *Second International Conference on Engineering Systems Management and Its Applications (ICESMA)*, 2010 , Sharjah, 1-6.
- Samsonov, T.E., Konstantinov, P.I. and Varentsov, M.I. 2015. 'Object-oriented approach to urban canyon analysis and its applications in meteorological modeling', *Urban Climate*, vol. 13, pp. 122 - 139.
- Sá, F., Rocha, Á. and Cota, M.P. 2016. 'Potential dimensions for a local e-Government services quality model', *Telematics and Informatics*, vol. 33, no. 2, pp. 270 - 276.
- Sondheimer, N.K., Osterweil, L.P., Billmers, M.P., Sieh, J.T. and Southard, B.B., 2003. E-Government through process modeling: A requirements field study. *In IADIS International Conference e-Society* (pp. 129-136).
- Ssebuggwawo, D.D., Hoppenbrouwers, S.S. and Proper, H.E. 2010. 'Collaborative Modeling: Towards a Meta-model for Analysis and Evaluation', *Enterprise Information Systems*, p. 56.
- Storey, C.V., Trujillo, C.J. and Stephen, W.L. 2015. 'Research on conceptual modeling: Themes, topics, and introduction to the special issue', *Data and Knowledge Engineering*, no. 98, pp. 1 - 7.
- Sugumaran, V. and Storey, V.C. 2006. 'The role of domain ontologies in database design: An ontology management and conceptual modeling environment', *ACM Transactions on Database Systems*, vol. 31, no. 3, pp. 1064--1094.
- Telecompaper 2013. *Zanzibar launches e-government programme*, [online] Available at: <http://www.telecompaper.com/news/zanzibar-launches-e-government-programme--917224>.
- Tohidi, H. 2011. 'E-government and its different dimensions: Iran', *Procedia Computer Science*, vol. 3, pp. 1101 - 1105.
- Tulinayo, F.P., van Bommel, P. and Proper, H.A. 2011. 'Grounded system dynamics: A procedure for underpinning system dynamics with a domain modeling method', *IFIP Working Conference on The Practice of Enterprise Modeling*, 112--125. Norway
- van der Weide, T.P., Tulinayo, F. and van Bommel, P. 2016. 'Static and Dynamic Aspects of Application Domains: An Inductively Defined Modeling Technique That Allows Decomposition', *Complex Systems Informatics and Modeling Quarterly*, vol. 7, pp. 25-50.
- Vuksic, V.B., Pozgaj, Z. and Milanovic, L. 2010. 'E-government policy and implementation in Croatia', *32nd International Conference on Information Technology Interfaces (ITI)*, 2010, Croatia, 423-428.
- Wang, Q. 2015. 'A conceptual modeling framework for network analytics', *Data and Knowledge Engineering*, vol. 99, pp. 59 - 71.
- Yonazi, J., Sol, H. and Boonstra, A., 2010. Exploring issues underlying citizen adoption of e-government initiatives in developing countries: The case of Tanzania. In *Proceedings of the 10th European Conference on E-Government: National Center for Taxation Studies University of Limerick. Ireland* (p. 425).