

Investigating E-government Knowledge Base Ontology Supporting Development Projects Monitoring in Sub Saharan Africa

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Abstract

In recent years, a number of developed countries have employed ontology in e-government projects. On the other hand, Sub Saharan African (SSA) countries have followed the trends towards e-government and adoption of new technologies during the past eight years, resulting in many applications developed in various government departments. However, little work has been done in building knowledge base ontologies that facilitate communication amongst stakeholders and that specify processes and data description of these applications; thereby, guaranteeing their maintainability, interoperability and sustainability. This paper presents a case study of constructing ontology in support of e-government initiatives in the domain of development projects monitoring in a Sub Saharan African country. Case studies of development projects conducted in different SSA countries as well as related published works in various fields including project management, project monitoring and evaluation, and capacity building are reviewed and the features of the ontology are extracted. The main purposes of the ontology encompass; providing developers of potential e-government applications for development projects monitoring in Sub Saharan Africa and the developing world at large, with key concepts and activities of the domain, facilitating communication amongst all the role players involved in development projects implementation by providing a common and shared representation of concepts and activities of the domain, and serving as a knowledge base system to the monitoring and evaluation activities of development projects - thereby, strengthening efficiency, effective and sustainable implementation of development projects in Sub Saharan Africa. Further, the study aims at sensitizing and serving as a practical case study of building ontology in support of e-government adoption processes in Sub Saharan Africa.

Categories and Subject Descriptors: J.1 [**Computer Applications**]: General; D.2.10 [**Software Engineering**]: Design - *Methodologies; Representation*

Additional Key Words: E-government, Ontology, Knowledge Base System, Development Project, Protégé

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I. INTRODUCTION

The continuous improvement of Information and Communication Technologies (ICT) has drastically changed the way governments the world over, deliver services to citizens, businesses and organizations. The use of ICT for public services delivery is called electronic government (e-government). The ICT facilities and the Internet technologies are used to deploy web-based applications that support government processes. This support consists of: (1) providing a large range of government information and services (health care, education, social services, community development, taxes return, etc.) online, (2) facilitating online citizens' participation to government processes and decision making, and (3) streamlining and reorganizing government processes. Sub Saharan African (SSA) countries have followed the trends towards e-government and adoption of new technologies during the past eight years [Bwalya 2009; Kaaya 2004; Ngulube 2007]. Consequently, many applications have been and are currently being developed in various government's departments [Bwalya 2009; Kaaya 2004; Kitaw 2006; Shuppan 2009], aimed at providing better delivery of services to citizens, businesses and organizations. However, little work has been done in building knowledge base ontologies that facilitate communication amongst stakeholders and that specify processes and data description of these applications.

Jakachira et al. [2008] present a web-based e-government application that allows citizens from the Dwesa rural area in South Africa to access government services online; through the application, citizens from the Dwesa rural area can download, fill and send forms and reports electronically to the department of Home Affairs and the municipality respectively. The Zambia Health Management Information System (ZHMIS) and Immigration Management System (ZIMS) are presented by Bwalya [2009]; both systems are e-government applications that provide online services delivery in the health and immigration sectors. Shuppan [2009] presents three case studies of e-government applications implemented in Ghana, Tanzania and Kenya. In Ghana, the e-government application called GCNet allows all customs transactions related to the import and export of goods to be done electronically. The Tanzanian e-government application is an integrated tax management system (ITAX). Implemented with the support of the German Agency for Technical Cooperation (GTZ), the ITAX allows electronic collection of tax revenues all over Tanzania. In Kenya, the Business Keeper Monitoring System (BKMS) is an e-government application that allows anonymous online reporting of incidents of corruption. To facilitate anonymous reporting, the BKMS uses a secure website; this makes it possible for a whistleblower to communicate with the corruption investigators of private businesses or with the police without revealing his or her identity [Shuppan 2009]. Kaaya [2004] presents an analysis of the status of e-government services in three East Africa countries including Kenya, Tanzania and Uganda. The study has conducted the visibility and usability tests of government websites in the three countries and has concluded that all of the East Africa websites are at the first and second stages of e-government development. Three case studies of e-government initiatives carried out in Rwanda, Ethiopia and Mauritius are presented by Kitaw [2006]; the case studies were selected to illustrate the three e-government delivery models (government to citizens (G2C), government to government (G2G) and government to business (G2B)) in Sub Saharan Africa. The Rwanda case study illustrates the G2C model; it focuses on e-government applications which deliver secure web-based email service, online electronic forms for national identity document or passport and visa, as well as Public Internet Access Centers [Kitaw 2006]. The Ethiopian WeredaNET project have been selected to illustrate the G2G model; its aim was to build terrestrial and satellite-based network connecting lowest levels of government (federal, regional and local) and deliver the following services: video conferencing, Web services, Voice over IP, and electronic messaging [Kitaw 2006]. In Mauritius, the Contributions Network Project (CNP) illustrates a G2B e-government model; the CNP has developed an e-government application that allows electronic submission of returns, payment of taxes and contributions [Kitaw 2006].

Most of the above e-government applications currently run in SSA countries provides only one way interaction with citizens. They present government information in form of simple web pages and offer few online services to citizens and stakeholders. Government services delivered online mainly consist of downloading, filling and submitting forms to government departments; in many cases, the online submission is still unavailable and citizens have to visit government offices in order to submit their forms [Kaaya 2004; Ngulube 2007]. Largely, there is no structured database of government valuable information accessible interactively through these applications nor evidence of proper knowledge base systems that specify processes and data description of these applications; thereby, guaranteeing their maintainability, integration, interoperability and sustainability.

In this paper, we present a case study of constructing ontology in support of e-government initiatives in the domain of development projects monitoring in a Sub Saharan African country. The ontology presented here is not intended to provide a definitive and comprehensive account of the many aspects of development projects implementation, but it aims at serving as a foundation for further specification efforts. Case studies of development projects conducted in different SSA countries as well as related published works in various fields including project management, project monitoring and evaluation, and capacity building are reviewed and the features of the ontology are extracted. The main purposes of the ontology encompass: (1) providing developers of potential e-government applications for development projects monitoring in Sub Saharan Africa and the developing world at large, with key concepts and activities of the domain, (2) facilitating communication amongst all the role players involved in development projects implementation by providing a common and shared representation of concepts and activities of the domain, and (3) serving as a knowledge base system to the monitoring and evaluation activities of development projects; thereby, strengthening efficiency, effective and sustainable implementation of development projects in Sub Saharan Africa. Further, the study aims at sensitizing and serving as a practical case study of building ontology in support of e-government adoption processes in Sub Saharan Africa.

The rest of the paper is organized as follows. Section 2 defines ontology and describes its use in software engineering and e-government. The methodology we followed to gather information and to build the ontology is presented in section 3. Section 4 presents and discusses the results. A conclusion is drawn in the last section.

2. ONTOLOGY MODELING

2.1. Definition and Role of Ontology

There are several definitions of ontology in the literature [Gomez-Perez and Benjamins 1999]; the most common definition is taken from Gruber [1993]. Ontology is an explicit specification of a conceptualization. A conceptualization is an abstract and simplified view of a domain of knowledge we wish to represent for certain purposes; the domain could be explicitly and formally represented using existing objects, concepts, entities and the relationship that exists between them [Gruber 1993]. Ontology is widely used in disciplines such as software engineering, databases, artificial intelligence, and many more [Welty 2003]. In these fields, developers use ontology to represent knowledge in a way that can be automatically processed by a machine. In particular, the interest of ontology in software engineering is acknowledged by many authors. In [Ceccaroni and Kendall 2003; Usero and Orenes 2005] the authors argued that ontology represents the concepts of a domain of knowledge and the relationships between them, which provide a shared and common understanding of the structure of information among people and software agents, thereby facilitating software development and improving processes in the corresponding domain. Aside the semantic representation of concepts of a domain of knowledge, ontology also provides data type description which specifies the data component of applications [Bettahar et al. 2005]. Ontologies are application independent; which allow domain knowledge reuse and easy software maintenance, and contributes to the semantic interoperability of applications [Gruber 1993]. The complexity of government processes along with the increasing number of applications that are implemented in various government departments, need ontologies to streamline and re-organize government services and facilitate their integration, maintenance and interoperability [Bettahar et al. 2005; Mondorf and Herborn 2008]. The above works demonstrate the usefulness of ontology in e-government processes and particularly for e-services integration. Some practices of ontology in e-government are described in the next section.

2.2. Practices of Ontology in E-government

A number of countries employ ontology in e-government projects [Ralf 2003; Bettahar et al. 2005]. The OntoGov project which aims at developing an ontology platform that facilitates the consistent configuration and re-configuration of e-government services is presented by Apostolou et al. [2005]. Bettahar et al. [2005] describe a methodology for building ontology in the social care domain within the context of e-government. Gomez-Perez et al. [2006a] present an ontology-based model for efficient and fast retrieval of government documentation; they further introduce a set of legal ontologies for the transaction domain in e-government [Gomez-Perez et al. 2006b]. Ortiz-Rodriguez [2006] uses a set of government ontologies to represent Mexican local government processes. An ontology-based fraud detection system for e-government is presented by Alexopoulos et al. [2008]. Herborn and Wimmer [2004] present an ontology

driven semantic for business registers; which aims at facilitating business transactions amongst companies across European Union countries. Salhofer et al. [2009] present an approach of using ontology for services integration in e-government; the approach consists of building ontology at the start of an e-government project and uses the resulting ontology as a domain model for generation of application services. A so called goals/desires approach was employed to illustrate how e-services could be derived from goals predefined in form of simple sentences or phrases. A method of automatic ontology mapping is presented by Chen et al. [2008]; a Semantic Service Agency (SSA) is designed for each government department; each SSA is a domain ontology which has a department portal and supply to the citizen the whole set of available services or a part of the services; a Semantic Integrating Model is employed to integrate all the SSA; ontology mapping is achieved using semantic similarity techniques. The next section presents the ontology modeling approaches.

2.3. Ontology Modeling Approaches

Several methodology approaches for building ontology have been proposed in the literature [Fernandez-Lopez 1999; Beck and Pinto 2003; Calero et al. 2006]. These approaches recommend different steps and tasks that must be performed when building ontology. However, there is still no standard method for building ontology. The approach described in this research was adopted from the Uschold and King [Fernandez-Lopez 1999, Calero et al. 2006] ontology modeling approach. Further, a new ontology could be constructed from existing ontologies or from scratch [Calero et al. 2006]; we have adopted the later as our domain of interest. It was not aligned to any existing ontology domains. The methodology we used to gather information and construct the ontology is presented in the next section.

3. METHODOLOGY

3.1. Data Collection

We gathered concepts and activities of the domain by: reviewing case studies of development projects implemented in Sub Saharan Africa, interviewing municipalities' and non-governmental organizations' employees, and academic members, and reviewing related published and working papers in various fields including project management, project monitoring and evaluation, and capacity building.

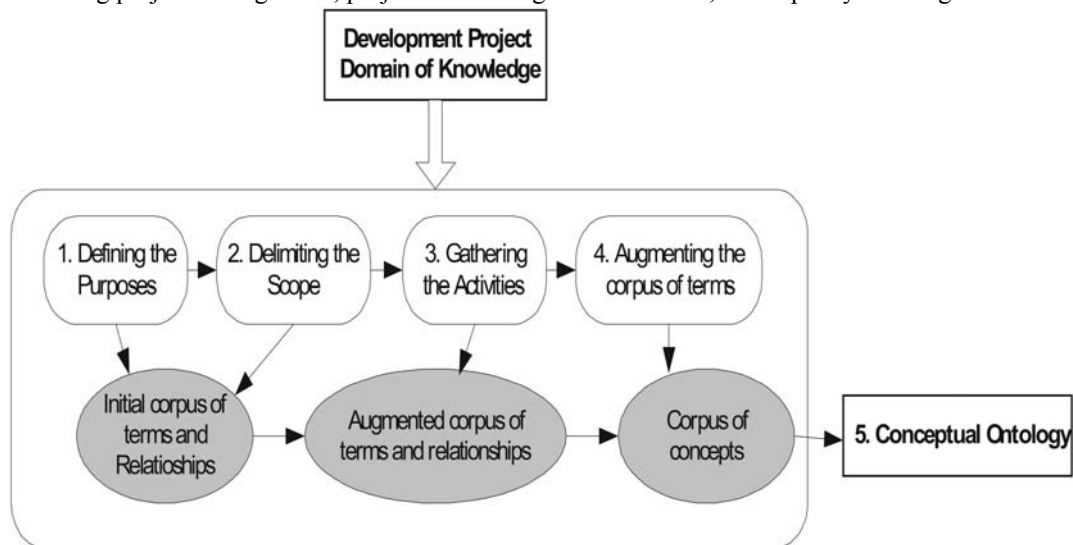


Figure 1: Framework of the Ontology Building Process

3.2. Framework for Building the Ontology

We followed five steps in building the ontology. Figure 1 shows the framework of the ontology building process.

3.2.1. Purposes of the Ontology

The purposes of the ontology were deduced from the analysis of the role and the current state of impact of development projects in Sub Saharan Africa. Clearly speaking, Sub Saharan African governments use

development projects as tools for providing solutions to problems facing their people. However, the number of actors involved including government, donors, non-governmental organization (NGO), private companies, civil society, academic institutions and communities, makes development projects implementation a complex task; furthermore, other human factors such as corruption, incompetence, weak monitoring and evaluation have led to poor performance of development projects in Sub Saharan Africa since many decades of multiple aids from national and international aids agencies, government and non-governmental organizations [Copson 2006; Okereke 2007]. Then, in this era of e-government adoption in Sub Saharan Africa [Kaaya 2004; Ngulube 2007], we believe that it is important to look at building consistent knowledge base systems as ontologies to support potential e-government initiatives towards effective monitoring and evaluation mechanisms of projects, for efficient, effective, transparent and sustainable implementation of development projects in Sub Saharan Africa.

3.2. 2. Scope of the Ontology

The scope of the ontology was delimited by analyzing the life cycle of a development project and the activities that are carried out during various phases. According to the works in [Quartey 1996; Ahsan and Gunawan 2009] the life cycle of a development project can be broadly broken into three main phases including planning, implementation and evaluation. In our research, we assume that development projects have been designed and planned conveniently and that all the role players are known. Our work focuses on the implementation phase of projects i.e. the phase of the real delivery to people. The resulting ontology will then serve as a knowledge base system to the monitoring and evaluation activities of projects; thereby strengthening efficiency and effective delivery to communities.

3.2. 3. Activities of the Domain

The two previous steps of the framework provided the first corpus of terms of the domain including potential role players involved in the implementation phase of development projects (government, donors, NGO, private companies, civil society, academic institutions, and communities). Further, we gathered the activities of the domain by reviewing case studies of development projects implemented in Sub Saharan Africa and interviewing six municipalities' and NGO's employees and three academic members. The interviews with municipalities' and NGO's employees were scheduled at specific periods of time and took about twenty five to thirty minutes each, whereas interviews with academic members were done in form of regular discussions about the subject, for almost an hour each. The case studies reviewed were selected based on their level of details in describing the activities of development projects implementation. Table 1 presents selected development projects that we have reviewed.

Table 1: Selected Case Studies of Development Projects in SSA

Project	Country of Implementation	Financier	Development Sectors
Participatory Design of a Community-Based Child Health Information System in South Africa (http://www.egov4dev.org/health/case/childhealthis.shtml)	South Africa	- South Africa Government - UK Department for International Development	Health Care
Ghana Agricultural Information Network System (GAINS) (http://www.ciard.net/index.php?id=580)	Ghana	- Government - World Bank - International Institute of communication and Development (IICD)	Agriculture and Rural development
Integrated Urban Housing Project (IUHP) (http://practicalaction.org/?id=iuhd_working_papers)	Kenya	- United Kingdom Department for International Development (DFID)	Housing
The Women's Information Resource Electronic Service (WIRES) (http://www.bridges.org/case_studies/135)	Uganda	- International Development Research Centre (IDRC) (http://www.idrc.ca/) - World Bank - Hivos	Information and Communication Technology (ICT)
Integrated Development project with the "Wa Nyè U Saalu Zie" Union (http://www.fao.org/sd/erp/Celim.pdf)	Burkina Faso	- Celim Bergamo (Non-Governmental Organization)	Social, Health and Agriculture

The case studies and project reports we reviewed do not provide information on activities related to the finance and the monitoring indicators of development projects implementation. Then, we conducted interviews and investigated related published and working papers in various fields including project

management, project monitoring and evaluation, and capacity building [Ahsan and Gunawan 2009; Bergeron et al. 2006; Crawford and Bryce 2003; Goldman et al. 2006; Mosse and Sontheimer 1996; Quartey 1996; World Bank 1996]. The subject content of the papers reviewed, with regard to development projects monitoring activities, has motivated their choice in this research. This step produced an augmented corpus of terms and the relationships between them.

3.2. 4. Improving the Corpus of Terms of the Ontology

The corpus of terms obtained from the previous steps may not be complete enough to satisfy the purposes of the ontology. Then, the actual corpus has to be improved [Bettahar et al. 2005]. Our approach consisted of building a set of questions which needed to be answered by the ontology in order to fulfil its purposes; this process has added a set of new terms in the corpus. The concepts of the ontology are terms that define the domain or activities carried out in the domain [Bettahar et al. 2005]. Finally, we represented the conceptual version of the ontology as in Figure 2.

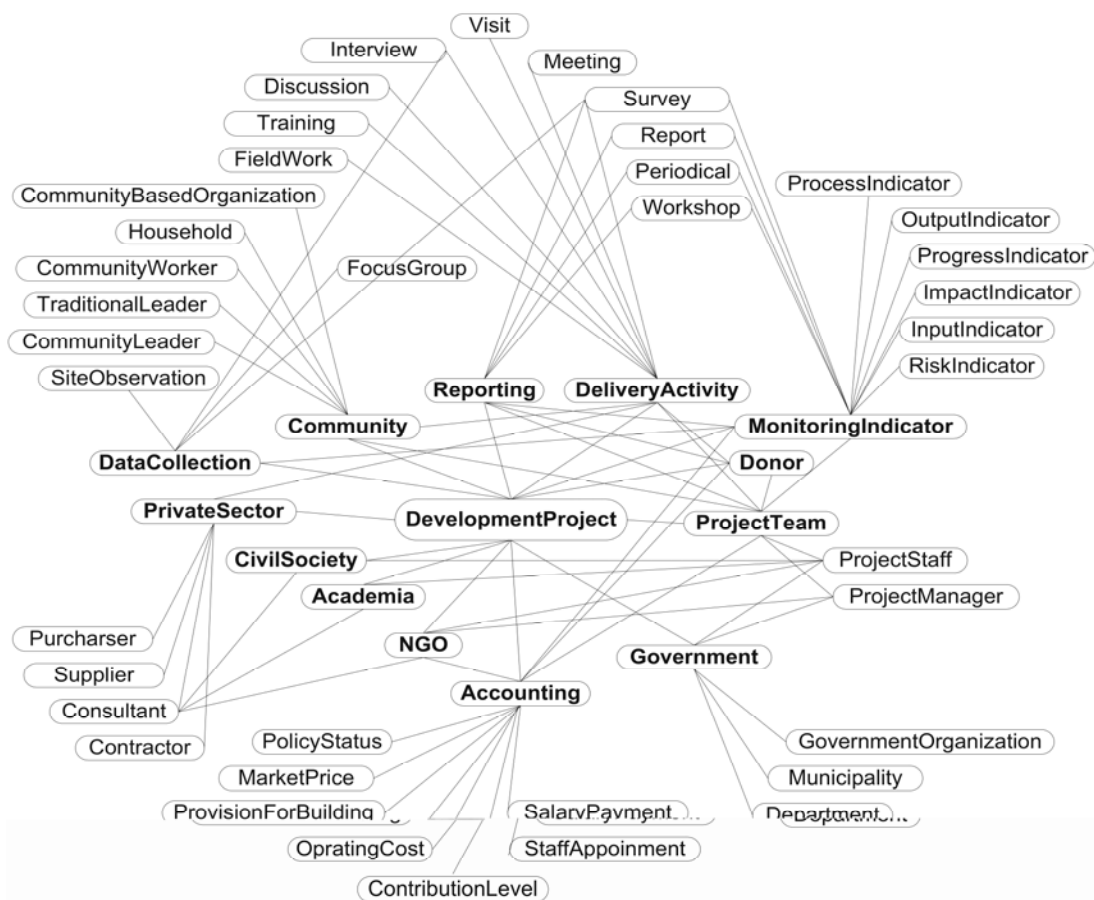


Figure 2: Conceptual Representation of the Ontology

4. RESULTS AND DISCUSSIONS

We have represented in Figure 2 the domain ontology of concepts and activities of development projects monitoring in a SSA country. Further, we used the ontology knowledge base editor Protégé to create the ontology. A screenshot of the Protégé version of the ontology is presented in Figure 3.

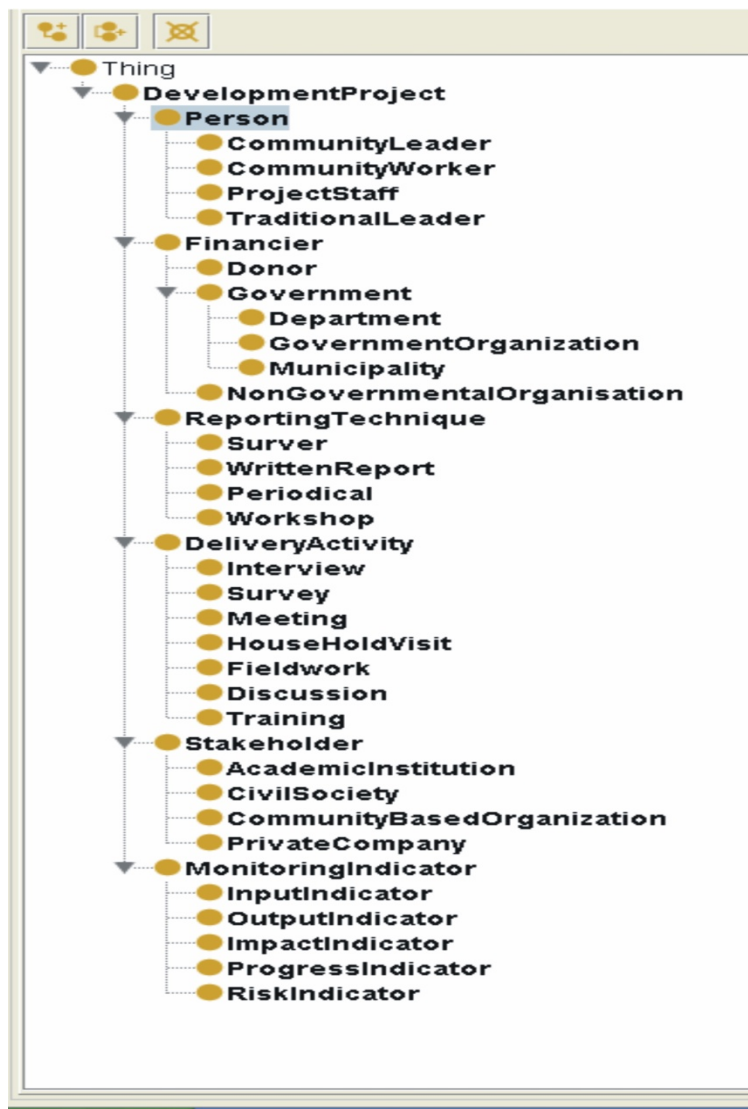


Figure 3: **Protégé Version of the Ontology**

From Figure 2, one can see that the ontology provides sufficient information about development projects implementation, to be able to facilitate communication between actors involved. For instance, the ontology shows that the level of impact of a project on a given community could be obtained by conducting a survey to get output indicators that represent the needed information.

The ontology aimed at serving as a knowledge base system to the monitoring and evaluation activities of development projects; to fulfil that goal it should be used as a data component of potential web-based e-government applications related to development projects implementation. These applications should provide the target users who are amongst others; government authorities, civil servants, donor organizations' and NGOs' employees, project staff, and communities, with appropriate and user-specific interfaces so that they can either update or query the knowledge base ontology. For instance, citizens could query the ontology to find out which are the development projects being run in their locality and who are the stakeholders involved. Similarly, a donor organization could query the ontology to get information on how far a particular development project has been implemented, in order to make decisions. A government authority could query the ontology to get the level of satisfaction of a community on the implementation of a particular project or get the level of contribution from the donors. Project staff could use appropriate interfaces to save statistical information as monitoring indicators in the knowledge base ontology.

5. CONCLUSION

This study demonstrates that ontology is useful in the e-government development processes as it provides a common and shared representation of concepts and activities of a domain of knowledge; thereby, allowing easy communication between stakeholders and facilitating integration, maintenance and interoperability of applications.

The literature discloses that many e-government projects in developed countries use ontology for data type description and web service features, and that the current e-government applications that are being run in SSA countries lack knowledge base components as ontologies that support their sustainability. We believe that this situation is in part due to the little academic debate on the subject in Sub Saharan Africa and the lack of proper protocols of collaboration between industries, governments and current research efforts towards promoting ICT and e-government in the continent.

The study examines case studies of development projects implemented in Sub Saharan African countries and reveals that many actors are involved in development projects implementation including government, NGOs, civil society, private sector, academia, donors and communities. The development project's activities are managed, monitored and coordinated by the project management team which must define specific indicators to monitor the activities. The project team deliver services to communities through community workers, community-based organizations, community leaders, traditional leaders, providers, suppliers, and households. The activities carried out during the delivery depend on the type of project (infrastructure development, water supply and sanitation, education, healthcare, etc.) and include: fieldwork, training, group reflection, discussions, interviews, surveys, meetings, and field visits. The data is collected during the delivery by means of site observation, focus groups, interviews and surveys. Finally, feedback is given to donors and stakeholders through regular reports or periodicals, and workshops. Given the importance of the development projects to SSA countries and the developing world at large, the above information would be certainly valuable to new researchers interested in the field in the future.

A case study of constructing ontology in support of e-government adoption processes in Sub Saharan Africa was carried out in the study. It uses a five step framework to methodically gather concepts and activities of the domain and to build the ontology. The complexity of the domain as well as the techniques employed to gather the ontology's features make it an added value to the ontology modelling body of knowledge. Overall, the study is aimed at raising the awareness of governments and e-government application developers from SSA countries and the developing world at large on the role of ontology in sustainable e-government development processes. In the near future, it would be valuable if European countries which are more experienced on the use of ontology in e-government projects enter into partnerships with African governments in order to strengthen the use of ontology in Sub Saharan African e-government projects.

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