Knowledge Exploitation via Ontology Development in e-Government Project Management

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Abstract

When public organisations engage in government transformation projects, communication, knowledge exploitation and management issues are inevitable and complex problems. Problems relating to communication, knowledge sharing and project management issues generally occur in more than one phase of e-Government projects and involve various different stakeholders. The elaboration of ontology contributes for the standardization and classification of concepts and terminologies and it has been happening in some sectors, as, for example, in the software engineering, the e-Government services implementation and the project management. In the area of e-Government, the development of e-Government Transformation Project Management ontology aims at adopting and customizing the existing project management approaches according to the specific challenges encountered in e-Government environment. In this context this research presents an ontological representation of the concepts of e-Government project management. It intends to collaborate in the excellence and productivity of the management of e-Government project process and enable the interoperability and knowledge reuse between all factors and stakeholders related with the implementation of such types of projects.

1. Introduction

There is a unanimous view among politicians, decision makers, public administration officials, e-Government researchers and information technology practitioners that knowledge is an important driving force in government transformation [1]. Communication and knowledge exchange between project teams comprising members from within information systems vendors, external consultants and different public organizations is often hampered by, among other things, confusion in terms and vocabulary [2]. Extended collaboration, such as joint private and public sector ventures, will raise the difficulty and complexity of communication between the cooperating stakeholders. One of the main technical issues is the knowledge management problem when processing shared implicit and explicit knowledge with different systems. Collaboration in e-Government projects faces knowledge confliction during knowledge sharing and project development. Poor knowledge management for involved parties can mislead the project processes and cause serious wastage of resources, lack of best practices exploitation and even the failure of the project.

For e-Government project management to be properly understood and successfully applied, it needs to be more comprehensively conceptualized. Such a conceptualization needs to address a variety of concerns beyond the existing hard rational IT project management approaches. E-government is a detailed and complex development that is difficult to conceptualize. What is known and understood is mostly of a descriptive and anecdotal nature. The end result is that e-government implementations have yet to realize the upper stages of maturity and that the understanding and knowledge of the area is still in the process of formation.

The development of ontology expands the practitioner's ability to generate information by using search methods beyond simple keywords. If only keywords are used in e-Government project management process, then information that is retrieved will often lack the precision necessary for generating quality information. Therefore, in order to retrieve quality information more quickly and accurately, a broader and more extensive ontology development is required.

So the assumption is building an e-Government project Ontology for common understanding within the group of all project stakeholders during the project management will improve the definitions of goals and finally the rate of successful projects. In this paper, we propose electronic Government Transformation Project Management (eGTPM) ontology which is specifically targeting the challenges that we encounter in e-Government project cases.

The remaining of this paper first introduces related work in Section 2. Section 3 presents the proposed e-Government project management ontology. Section 4 illustrates the implementation of the ontology and section 5 describes the validation procedure of the ontology. Finally, Section 6 concludes the paper.

2. Related Work

In this section, the knowledge management and ontology methodology literature related to e-Government project management will be reviewed. A specific emphasis will be focused on methodological considerations that shed light on how one might construct an ontology process that could be used in the e-Government environment.

Knowledge is defined as reliable information which is accumulated by knowledge workers. For a public organization to be successful, it must have a structure to manage these invisible assets [3], [4]. From a decision science perspective, knowledge management may be viewed as the transformation of data to information and then information into knowledge [4], [5], [6], [7], [8]. There are several processes and objectives that comprise the knowledge management function in all types of organizations. Figure 1 shows the subsystems that comprise knowledge management. Knowledge management involves the internal management of data and information flows into, through, and out of the organization. These activities include the following: generating information, disseminating information, selecting knowledge, deploying knowledge, creating unique value, and organizing information.

Figure 1. Knowledge Management Subsystems

Ontologies constitute abstract conceptual models of particular domains, which identify the kinds of entities existing in a particular domain and the kinds of relations among them, being acceptable from a group of people dealing with this domain [9]. A domain ontology establishes a common vocabulary for the group of people dealing with this domain, in order to create, exchange, combine, retrieve and reuse knowledge. According to Uschold and Grunninger [10], ontologies are of critical importance for knowledge acquisition and exchange. Before developing our ontology, we studied the literature on relevant knowledge-based approaches to software management, project management and e-Government areas.

Ramal et al [11], work contains an identification of various knowledge domains connected with software maintenance. The domains identified are computer science, application and general common sense knowledge. Research regarding ontologies in the area of software maintenance process has been conducted from Derrider [12], Dias [13] and Kitchenham et al. [14]. Works have also been published in relation to their use in the maintenance process, included in the taxonomy, along with development, in the engineering processes category. Ruiz et al [15], work is concentrated in defining an ontology to assist in the management of software maintenance projects. This ontology includes some elements such as product, activity, process, agent, measure and some dynamic aspects such as workflow. In the case of software management processes, Nour et al. [16] developed ontology based techniques and tools that allow recovery of the acquired experience in previous software projects to be applied to new projects.

Capability Maturity Model Integration (CMMI) is used to guide mapping, description, standardization and change of software processes in an organization. Therefore, several authors took CMMI as an inspiration for an ontology that should help an information system to support process planning, process definition, process control and management and process change in an organization [17]. Liao et al. [18] for example, define an ontology which models the CMMI in processes and practices. Both, processes and practices can be atomic or composite. Processes can be further classified to user defined categories. Various process areas from CMMI, such as the requirements management or configuration management, are then modelled as subclasses of the composite or fundamental processes depending on whether they can be further decomposed. They propose that the CMMI-based ontology can be used in a tool which supports software process definition and evaluation.

By examining these ontologies we remarked that they are characterized by a purely software engineering and technology perspective, since they have been created mainly for supporting the development of software artefacts and information systems, in order to be used by persons with software engineering skills and education; however, they lack project management perspective (problems/solutions-oriented), so they do not support the search for and exchange of knowledge concerning the specific needs and challenges of e-Government project management.

Apart from ontologies, in order to include the project management fundamental principles, we examined the most often used methods and techniques applied in e-Government project management. Prince2 is a project management methodology covering the organization, management

and control of projects, developed and maintained by the UK National Computing Centre [19]. PMBOK [20] is a framework describing the sum of knowledge within the profession of Project Management in an attempt to document and to standardize generally accepted project management information and practices. HERMES is an open method for the uniform and structured management of projects in Information and Communication Technologies (ICT) implemented from Swiss government. Common characteristic of the above approaches is that they are generic ones, not covering the specific features and demands of e-Government projects.

Even though that several stimulating approaches, with exploitable results, exist regarding ontologies existence in adjacent areas (software management, e-Government service provision, project management), a gap is detected regarding the area of e-Government project management which is characterized by specific needs and challenges such as goal orientation, high complexity and multiple dimensions, politics driven, many stakeholders with different concerns and also different views and perceptions of the problem.

3. e-Government Project Management Ontology

To define a suitable classification scheme an analysis of e-Government implementation projects from a macro perspective took place in order to identify the essential determining characteristics. The issues of an e-Government project are manifold and raise varied problems. To clarify the phenomenon of e-Government project implementation, it is useful to understand which issues describe the e-Government project itself. The analysis of literature brings to light at least three specific aspects, reflecting in turn the e-Government project nature and management perspectives.

The knowledge is organized around three different aspects: knowledge about the e-Government project types domain; knowledge about the e-Government management procedure; and knowledge about the e-Government stakeholders; each of these aspects is described in a sub-ontology. For each one of the sub-ontologies we defined competency questions, captured the necessary concepts to answer these questions, established relationships among the concepts, described the concepts in a glossary and validated them with experts.

Building such ontology is a significant work. We spent three months to define it, the main investigator working part-time, and the two others participating in weekly validation meetings. Our first difficulty was to define clearly what was to be the focus of the ontology. This was solved defining scenarios for the use of the knowledge. A second difficulty was to review the relevant literature in search of definitions and validation of the concepts. In this phase, we deemed important to base each and every concept on independent sources from the literature.

3.1. The e-Government domain sub-ontology

Knowledge about the e-Government project types is intuitively fundamental to e-Government project management. The sub-ontology is pictured in the upper part in Figure 2. The competency questions for the e-Government domain sub-ontology are: What are the fundamental types of e-Government projects? How do they relate to e-Government dimensions? Answering these questions led to a decomposition of the e-Government project type in five different concepts. These are: Beneficiary, Administration level, Domain sector, Function and Nature. Each of these concepts will be described in further details in the following subsections with direct references made to how each is essentially manifested in the experience of e-Government project implementation.

3.2 Beneficiary

Based on the e-government literature, beneficiaries can be classified in four major groups. They are government (G2G), business (G2B), citizen (G2C), international government (G2I) [21]. This approach to the cataloguing of beneficiaries insures that the organisations will be fully cognizant of who is to be gained. It should be noticed that a large number of e-Government projects perform poorly because of the irrelevance to beneficiaries and stakeholders.

3.3. Administration Level

e-Government structures reflect overall government structures. In most countries (e.g. USA, Australia, Germany etc.) there are three distinct levels of government [22], there is the Federal Government on the national level, each state or prefecture is an independent unit of government and there are a number of local governments. An e-Government project can cover the whole country (national level), a part of it (regional level) or a municipality (local level) in such a way determining its administration coverage. On top of those, there are collaborative initiatives among countries (international level) in order to provide interoperable services to citizens and businesses. Realising that ICTs are not limited by borders, e-Government strategies are formulated and implemented at national, regional and local levels. The policy and implementation procedure depends of each country's political system and administrative structure and

regional and local e-Government projects are undertaken in such a way that they link and are compatible to national policy and simultaneously address regional communications policy, financing and regulatory issues in a way that promotes harmonization.

3.4. Domain Sector

Domains [21] (Interior, Finance, Social Security, Agriculture, Education etc.) refers to large well-defined areas of the public sector where the tasks to be performed in relation to citizens and businesses are delivered by several different authorities cutting across tiers of authority. The domains can consist of parts of or one or more ministries and municipal and regional spheres of responsibility. In the individual domain sectors action plans are drawn up, ensuring coordinated, efficient and targeted digital development. The link between the individual domain and the national level is achieved by articulating action plans for the respective domains and implementing them within the framework of the overall strategy for digitalizing the public sector.

3.5. Function

An e-Government project could provide a system that is extroversive offering services through a public interface (front office systems) or introvert interoperating with other systems in the background (back office systems). Introvert systems are defined as the systems and procedures that mainly computerize the public administration operations, particularly in the back office. In the e-Government context, the "front office" would be the user interface, such as a web site.

3.6. Nature

Project nature is defined for providing more precise specifications on projects which present similar problems and for which similar results can be expected. Based on their scope e-Government projects are divided in policy and technical oriented nature. Those two fields are the first level classification of nature concept. They can be further analyzed in a more detailed structure decomposing in more levels the nature of the e-Government project.

3.7. The e-Government management sub-ontology

E-Government management sub-ontology attempts to develop e-Government project management field beyond its current conceptual base connecting it more closely to the specific challenges of e-Government projects. E-Government management sub-ontology provides a sound basis for project management in e-Government area, being a result-oriented approach to project management and offering a radical departure from the more traditional project management methodologies (PMI, Prince2 etc.) , focusing on what must be achieved, the goals [23], rather than on trying to predict timescales and resources for activities. E-Government management sub-ontology provides a knowledge rich environment for planning, organizing and monitoring e-Government projects, satisfying the specific e-Government project challenges.

The management sub-ontology includes several elements with relationships with each other:

e-Government Project: An e-Government project is a finite endeavour consisting of a set of processes undertaken to create a unique product or service that meets all the requirements established by the stakeholders at the beginning of the development and brings beneficial change or added value to the public. An e-Government project is divided in a number of result paths that covers all the dimensions established at project initiation.

Result Path: An e-Government project usually addresses several needs or purposes in an organization; it usually has a composite goal and the plan is therefore multi-dimensional. Each result path defines a specific dimension that the e-Government project should cover.

Goal: A Goal is defined as a practical and tangible step within the project described as a state, which must be reached to meet the final objective. A goal consists of a set of coordinated activities, performed in sequence or in parallel.

Activity: Activity is a specific task that must be done or a decision that must be made, stated in a verb. It describes how to reach the defined goal.

Artefact: An artefact is any kind of material element that can be created, used, or updated during the project implementation. There are two types of artefacts: deliverables, and systems. It is a piece of work that has to be done as part of the project. The granularity of the result depends on the nature and scale of the project and may range for example from producing a particular software module (system), installing a specific type of equipment (system) or producing a paper deliverable (deliverable).

System: An information system project result (software, hardware etc.).

Deliverable: A paper type of deliverable (study, report etc.).

Template: The template intends to function as a guide during the deliverable implementation and sometimes it could be adapted to each project specific situation.

Role: A general name for a set of responsibilities (political leadership, project manager, service modeller, data modeller, security expert, key user etc.) in an e-Government project that can be executed by one or more participants. A role is assigned to one

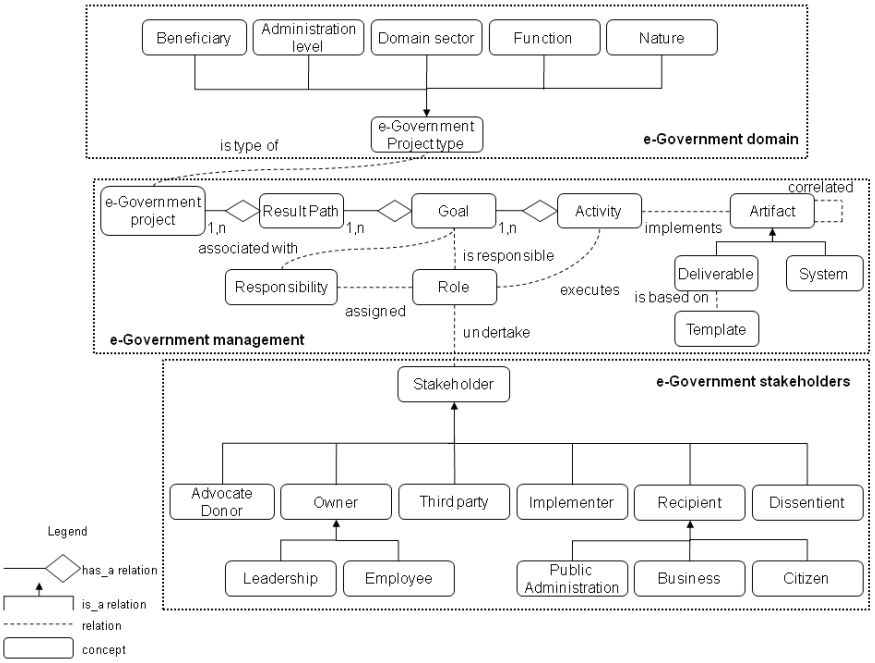

Figure 2. E-Government Transformation Project Management (eGTPM) Ontology

or more stakeholders that have a common set of capabilities and skills. Each role can perform an activity or be responsible for a goal.

Responsibility: The nature of the assignment in a specific goal or activity (executes the work, decides, manages progress, must be Informed, available to advise, provides training etc.).

3.8. The e-Government stakeholders sub-ontology

The complex nature of information system implementation in government has outlined areas in which a multitude of potential stakeholders can have a direct or indirect impact in the project result [24], [25]. Many of the challenges faced by public sector agencies are organizational issues associated with the introduction of new technologies and work processes [26], [27]. The development of citizen-centred services further requires cooperation and technical compatibilities that may be difficult to engineer given the prevalence of institutional conservatism and risk aversion that characterizes the public sector [28], [29]. The political context of the public sector highlights not only the multiple agencies that are involved in the implementation of e-government, but also the potential impact each can have to the successful development of e-government [30], [31]. To support the implementation of e-government therefore, the process of identifying and managing a broad range of constituent stakeholders must be considered to ensure that the implementation process encompasses all levels of stakeholders [30], [32]. The usefulness of stakeholder theory has been identified as appropriate for the public sector [33] and has been further developed to determine stakeholder requirements in eGovernment projects [30], [32], [34] to support the process of managing stakeholder relations, reduce the risk of stakeholder conflict and aid the process of eGovernment implementation [35].

All governmental programs and initiatives have multiple stakeholders, that is people or organizations that care about the idea and how it affects them or other things they care about. The users or customers of services are key stakeholders and most efforts to use information on their behalf take them into account. But stakeholder considerations go far beyond this group to include (1) those who are directly involved in the process of designing, delivering, and paying for the system or service and (2) those who are indirectly affected, either by the outcome of the initiative or by the competition for resources that could have gone to a different effort that they value. Stakeholder analysis needs to identify both positive and negative impacts on all these groups. While it is important to understand how certain stakeholders can benefit, it is equally important to know who must contribute and who can be hurt and how [36].

At the strategic level, stakeholder communication needs to be clear, consistent, focused on the essentials, and delivered in plain language. Strategy is not conveyed in a detailed work plan, but rather a

high level statement that tells stakeholders and observers what kind of project to expect. It answers key questions such as: What is the goal? Will the approach be incremental or more radical? How long will it take? Who will do the work? Who is the leader? What roles do users and other stakeholders play? Who pays for what? What kind of technology will be used? What are the major result paths or goals? The definitions of each concept of the specific sub-ontology are the following:

Stakeholder: The e-Government project stakeholders which are affected positively or negatively from the results are identified.

Advocate-Donor: Those who are pushing the project forward; often they will be from outside the implementing agency, and they may well be providing key funding for the project.

Owner: The organization or department that owns and uses the system, who is ultimately responsible for the project result.

4. Ontology Implementation

In order to implement the ontology, we adopted Protégé version 4.0 due to it is extensible, and provides a plug-and-play environment that makes it a flexible base for rapid prototyping and application development. Protégé ontologies can be exported into different formats including RDF Schema (RDFS) and Web Ontology Language (OWL). Particularly, we have implemented the eGTPM Ontology in OWL. The first challenge during this task was how to transform the UML diagram from conceptualization phase into the OWL formalism. This task was hard and time consuming. Modeling in OWL implied to transform composition relations into bidirectional relations. In addition, some concepts modelled as classes in UML were properties in ontology. And not all relations in UML were modelled in ontology but only those relations that were necessary to answer competence questions.

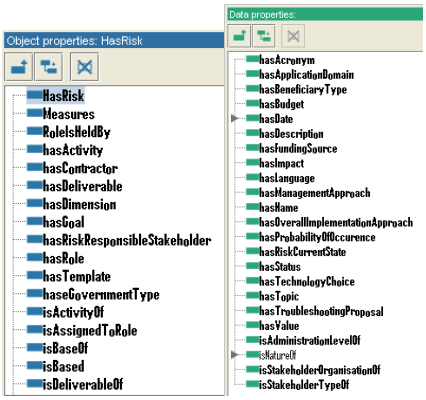

Figure 3. eGTPM Properties Definitions (Protégé)

To compare the ontology implementation with its conceptualization, graphics by using the OWLViz and Ontoviz plug-ins were generated and compared with UML diagrams. On the one hand, OWLViz enables the class hierarchies in OWL Ontology to be viewed, allowing comparison of the asserted class hierarchy and the inferred class hierarchy. With OWLViz primitive and defined classes can be distinguished, computed changes to the class hierarchy may be clearly seen, and inconsistent concepts are highlighted in red. OntoViz generates a graphics with all relations (Figure 3) defined in the ontology instances and attributes. It permits visualizing several disconnected graphs at once. These graphs are suitable for presentation purposes, as they tend to be of good clarity with none overlapping nodes. Besides, these graphics are very useful for analyzing when a concept must be modelled as a class and when must be modelled as an attribute.

Third party. Others who could have an important influence on the project or on whom the project will have an important effect.

Implementer. Those who analyze, design and implement the e-Government system including the builders/suppliers of the hardware, software and networks.

Recipient. Those to whom data or services are delivered by the specific e-Government project. Sometimes the recipients are divided into primary recipients, who get the data/services directly; and secondary recipients, who only get the data/services indirectly via the primary recipient.

Leadership. The people politician or high ranked public official who have the political responsibility regarding decision making of the project.

Employee: those from the owner organisation who carry out the activities that make the e-Government system work; not just clerical staff, but may also be managers and technical maintenance staff.

5. Ontology Validation

With the ontology defined, we validated it in two ways: validation of the quality of the ontology itself (how clear it is, how complete, concise, etc.), and validation of the usefulness of the concepts for e-Government project management. In this section we present how we validated the ontology in these different ways [37], [38].

5.1. Quality Assessment

To validate the quality of the ontology we considered the six following desirable criteria [37], [38]: (a) consistency, referring to the absence (or not) of contradictory information in the ontology; (b) completeness, referring to how well the ontology covers the real world (e-Government project management for us); (c) conciseness, referring to the absence (or not) of needless information or details;

(d) clarity, referring to how effectively the intended meaning is communicated; (e) generality, referring to the possibility of using the ontology for various purposes inside the domain fixed (e-Government project management); and (f) robustness, referring to the ability of the ontology to support changes.

To evaluate these criteria, we asked five experts to study the ontology and fill a quality assessment report composed of questions for each criterion. These people were chosen for their large experience in e-Government project management or for their academic background in the area. The evaluation results were satisfactory; on a scale of 0 to 5 no criterion has an average below 3.5. This evaluation was useful in pointing out specific problems. For example, we had not included a relation to specify that activities may interact between themselves, some definitions were not clear, or some restrictions were not expressed.

Besides the expert assessments experiment, we also checked the completeness and conciseness of the ontology by instantiating the concepts from the documentation of a real e-Government project. The project of the implementation of the Greek e-Government Interoperability Framework (e-GIF) was used to instantiate eGTPM ontology [39]. All the concepts from the ontology were instantiated.

5.2. Usefulness Assessment

One of the main objectives of the ontology was to represent the knowledge useful to e-Government project management. In this section we present a validation of the usefulness of the concepts represented for e-Government project management. To do so, we presented the instantiated knowledge to the e-Government project managers and asked them what concepts they used. For the first experiment we used an approach called think-aloud where the managers were asked to say everything they did and why they did it. The sessions were recorded and later transferred on paper to be analyzed. During the analysis, we tried to identify the kind of knowledge that the e-Government project managers were using at each moment based on the defined ontology. The ontology was presented and explained to the project managers and they were asked to fill in a questionnaire on the concepts they used. This form consisted of all the concepts we had instantiated previously and the list of their instances (as we identified them). The e-Government project managers were simply asked to tick the instances they had used during the managing procedure. They could not add new instances. The experiment was done with three project managers. They filled 6 forms corresponding to 6 different e-Government projects. The results of the assessment are given in Table 1. It shows the number of concepts that were instantiated for the eGTPM ontology during the two different assessment procedures (interview, questionnaire).

One may observe that there are a lot fewer concepts used in the first one than in the second. One reason for this is that there were fewer sessions in the first experiment and interviewees had less time to respond and the responses were more spontaneous. All uses of concepts detected in the first experiment were also found in the second one, it did not bring in any new instances.

6. Conclusions and Further Research

This study provides a reference ontology framework for public sector decision makers and e-Government practitioners during knowledge sharing and development in a government transformation project. This work adopts an ontological approach to analyze knowledge management processing in e-Government projects.

This defined ontology would be useful as a framework to guide future research trying to improve e-Government project management using knowledge engineering techniques. It could be the base of studies to answer questions as: What knowledge should be taken into account when considering e-Government initiatives? Which are the essential parts of the designed e-Government projects? How should we deal with each stakeholder? What is the relation between specific types of projects and particular stakeholders? What will be the expected results of the project? What kind of knowledge is most important? etc. Our ontology was based both on expert experience and a study of the relevant literature.

eGTPM ontology is created in order to support stakeholders in keeping in contact, sharing resources, approaches, solutions and problems occurring in the implementation of e-Government projects. The benefit for public organizations is to have a chance to re-use experiences, to be guided in the implementation, to join a community of people involved in e-Government projects, to discuss and share problems and solutions. Specific aims of eGTPM are:

- Improvement of the management performance of the public organization in terms of efficiency, transparency and quality as a result of the transparent and configurable flow of information
- Enhancement of the public reputation of the organization through well organized and technically functional internal management processes

Table 1. Number of concepts used in assessment

	Ontology	Interview		Questionnaire	
	Concepts number	Con. number	Percentage	Con. number	Percentage
e-Government domain sub-ontology	10	7	70 %	9	90 %
e-Government management sub-ontology	6	4	66,6 %	5	83,3 %
e-Government stakeholders sub-ontology	12	9	75 %	10	83,3 %
Total	**28**	**20**	**71,4 %**	**24**	**85,7 %**

- Provision of a knowledge repository with re-usable components
- Standardization of the participating roles in e-Government projects
- Provision of visibility to e-Government resources in terms of results and templates
- Provision of visibility to the variety of projects and approaches on e-Government implemented in different areas and in different organizations

Knowledge management and its activities are in this context not considered as a separate task, but as an integral part of the organizational procedures of e-Government project design and implementation, and hence an integral part of e-Government project management.

This research is intended to be the base of a long-term project aiming at building a knowledge-based environment to help successful implementation of e-Government projects. Future work includes:

- Better evaluation of the usefulness of the concepts contained in the ontology (we are conducting further validation experiment).
- Investigating the possibility of designing manual procedures (process) to populate the ontology.
- Population of the ontology real data.
- Investigating the possibility of creating (semi-)automated tools to assist in populating the ontology from existing e-Government projects.

eGTPM offered some substantial benefits when compared to traditional project planning and management techniques. The use of eGTPM helped to ensure that eGIF project was in line with the public organization's business plan, that the project team was committed to a realistic plan in which they had some ownership, and that the roles and responsibilities of project team members were clearly defined and linked to activities and goals. Organization's final aim for the project was reflected on 15 specific intermediate goals.

eGTPM is currently being used in e-Government projects aimed at measuring the performance of development projects. We intend to demonstrate how to convert an e-Government project into the eGTPM ontology and we will demonstrate the benefits that can be reached with it. Furthermore, we will compare different metrics in order to measure the practical applicability of eGTPM.

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Then, an eGTPM method would also require some tools support, so that the knowledge base can be extended and populated; not to mention support for the actual use of the toolset in real projects.

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