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Reference Model for E-Government Monitoring, Evaluation and Benchmarking

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The e-government as a result of innovations, emerging technology and internet expansion is a reality today and became a necessity for any country wishing to enter the 21st century as a competitive nation in the world arena. The processes are constantly changing and continue to drive and provide opportunities and open new possibilities for e-government development. The evolution of society requires public administrations to tackle many new challenges and changes. All these evolutionary changes demand the further development of government solutions to meet the challenges and new adequate requirements. After the solution is developed, it must be assessed whether those requirements have been met. As the e-government is constantly evolving all around the world this evolution is regularly measured and tracked by public institutions, private agencies and researchers. There are a number of published research papers on models that aim to evaluate e-government but most of them are focused on some particular purposes and objectives, types of evaluation perspectives. However, there is no evaluation model that could be directly adapted to e-government development in each country or each organization or each service in the country.
In this paper, we aim to combine the analyzed models into a conceptual model that could provide a common framework for future research in the area of e-government assessment and a common point of reference in this area. For this purpose, a reference model for e-government monitoring, evaluation and benchmarking is proposed. The model is not associated with any particular e-government definition and/or model, evaluation purpose, dimension or criterion. It could be adapted to many specific cases in the process of design of specific models for monitoring, evaluation or benchmarking of e-government or e-government service.

Keywords: *e-government, e-government services, assessment, evaluation, monitoring, benchmarking, reference model.*

Introduction

The rapid transformation of our society and the digital revolution, along with budgetary pressures pose challenges for governments and the future of public services (European Commission, 2013a). This promotes not only to invest in e-government projects in the hope that these challenges will be met, but also to measure and assess the government's progress in the improvement and change. There are proposed various modeling techniques and approaches for e-government benchmarking, monitoring and evaluation. As a *benchmarking* in our context, we refer to a process of comparing one's e-government characteristics (such as services) to best practices from other countries or different e-government administrations in the same country, as a *monitoring* - a process of comparing one's e-government characteristics in different periods for measuring improvements after development of changes in e-government solution of the same administration, and as an *evaluation* - a process of assessment one's e-government characteristics according to some purpose or perspective (e.g. evaluating the maturity of e-government service). However, despite the importance of e-government evaluation, the literature analyzed in this paper suggests that this area is still fragmented and limited by different e-government evaluation models. As a result, it is not so easy to find and adapt the model in case of the particular country or the organization.

This paper aims to review different methods and approaches of evaluation and benchmarking and to present a generic model that could be applied for constructing the particular e-government assessment models.

E-government because of the processes of innovations, emerging technology and Internet expansion over the last years became a reality today. These processes are constantly and continue to drive e-government development. E-government is said to be an efficient and effective way of delivering government services to its customers. Web information accessibility and online transactional services increase transparency, openness of bureaucratic institutions and hence accountability and reduce cost of transactions (Kachwamba & Hussein, 2009). It made a great effect on transforming the way of interaction in society that opened new possibilities for the development of governments. Initially, e-government may seem like another option for communication with citizens. People connected to the Web using their desktop and mobile devices or dedicated kiosks are able to communicate, access information and services by means that several decades ago were not possible. But in the face of rising demands from demographic, economic, social, and global trends, e-government no longer appears to be a matter of choice, but a necessity for any country wishing to enter the 21st century as a competitive nation in the world arena (Kumar *et al.*, 2007). Citizens and businesses are therefore expecting better and more individualised public solutions and services, efficient and effective service delivery, burden reduction, transparency

and participation. As a result the e-government added new concepts in the science of public administration such as: transparency, accountability, citizen participation in the evaluation of government performance, and changed the political practices which transitioned to e-democracy and e-governance (Mohammad *et al*., 2009). It may be, however, these e-government benefits will depend on the stakeholder groups interests (Rowley, 2011); therefore this should be taken seriously during the realization of e-government services and solutions.

The evolution of society requires public administrations to tackle many new challenges including those around demographic change, employment, mobility, security, environment and many other areas (European Commission, 2013a). Moreover, e-government development can be seen as a complex strategy intended to change the beliefs, attitudes, values, and structure of governments so that they can better adapt to information technologies, markets, and challenges (Zarei *et al*., 2008). All these evolutionary changes demand the further development of government solutions to meet the challenges. In order to respond to these changes new requirements for the government should be introduced. To develop a successful government solutions careful requirements elicitation and analysis has to be performed (Krenner, 2002). However, merely listing requirements is not enough and repeated consultation with potential users is necessary if user requirements are to be successfully implemented (van Velsen *et al*., 2008). The requirements will direct the decision-makers and developers to develop the government solutions on the desired way. When developing government solutions, one focus should be on public services as they are the central elements of the system from the point of view of the public administration as well as from the point of view of the citizens and businesses (Krenner, 2002). The requirements may reflect different aspects of the government to be developed and may be classified according to different views or dimensions. There may be different categories of requirements - not only for the public services but for the whole government system. For example, they can be defined as process specific, technical, user, security related, law based, organizational, social and political as well as data and information specific requirements.

After the solution is developed, it must be assessed whether those requirements have been met. Probably, in view of the constantly changing environment and the emergence of new challenges, the assessment should show how the requirements themselves should be changed - added, modified or even abandoned. As the e-government is constantly evolving all around the world this evolution is regularly measured and tracked by public institutions, private agencies and researchers (Assar *et al*., 2010). These measurements mean the evaluation of e-government – the existing or developing e-government solutions in line with new features and challenges to be met. Development of an e-government model is seen as a unique system of systems represented in a generic model (Zarei *et al.*, 2008). It is usually called the e-government development or evaluation model.

Evaluation is vital to discovering the current state of e-government development, working out the extent to which objectives within various strategies and action plans have been reached, ascertaining strengths and weaknesses, shaping new guidelines, looking for examples of best practice and finally comparing different e-government organisations at the national and international levels (Kunstelj & Vintar, 2004).

E-government provides a number of benefits that can be seen from different points of view of different stakeholders perspective (Gomez-Reynoso & Sandoval-Almazan, 2013). That leads to different purposes or perspectives of e-government assessment, monitoring and benchmarking. For example, policymakers and researchers use e-government benchmarking studies to help monitor implementation of e-government services, using the information to shape their e-government investments (Rorissa *et al*., 2011). For European countries, benchmarking is used to stimulate mutual learning, to perform multilateral surveillance, and to contribute to further convergence of their policies (Capgemini *et al*., 2014). E-government assessment for benchmarking might measure inputs, process, outputs, gain (outputs relative to inputs), demand, usage, effectiveness, impact, value for money (Bannister, 2007). They also are used to assess the progress made by an individual country over a period of time, and to compare its growth against other nations (Rorissa *et al.*, 2011) and/or e-readiness in different areas such as IT infrastructure, human resources, policies and regulations, economic environment, e-government transformation (Azab, 2009). On the other hand there is an urgent need to study how to efficiently and effectively develop e-government systems and how to measure progress so as to establish a road map to achieve the desired service level (Siau & Long, 2005) or the maturity of the service (Valdes *et al.*, 2011). Taking into consideration the amount of information and communications technology (ICT) investments made by the governments as well as their inherent potential for transforming public services e-government evaluation is imperative (Tsohou *et al.*, 2013). In other cases the assessment may be focused on tangible and intangible benefits received from the government (Gupta & Jana, 2003), project value (Esteves & Joseph, 2008), user acceptance (Verdegem & Verleye, 2009), public value (Friendland & Gross, 2010; Karunasena & Deng, 2012), e-government policies (Stanimirovic *et al.*, 2010; Stanimirovic & Vintar, 2013), stages of growth, Internet service delivery, cost and benefits (Griffin & Halpin, 2005), functionality, user-centricity, democracy (Mukabeta Maumbe *et al*., 2008), integration (Lam, 2005), interoperability (European Commission, 2013b), open data (Kalampokis *et al.*, 2011) and others.

Methods and Models for E-government Assessment

A number of methods and models for e-government assessment and evaluation have been proposed in the literature. Their classification depends on different aspects of the models, such as the purpose and objectives of e-government assessment, types of evaluation perspectives - dimensions, criteria, measurement rules and others. A well known representative of the evaluation of models is "e-government readiness" or "e-readiness". E-government readiness primarily assesses the extent to which governments

or economies are equipped to deliver various governmental services online and exploit ICT for internal functioning of the government (Omari & Omari, 2006). However, "readiness" maybe interchanged with "development": the term "e-government development" describes how far governments have actually advanced in this field instead of how ready or able they might be to do so, which was how "e-government readiness" described national capacity (United Nations, 2010).

Another important class of evaluation models is composed of the e-government maturity models as an essential part of stage models that means the evolution of e-government is often modeled by sequential steps, in the stages of growth models (Klievink & Janssen, 2009; Concha *et* al., 2012). Differences between these two classes are that "e-readiness" comprises of all prerequisite necessary to implement e-government while "e-government maturity" refers to the actual level of e-government progress an e-government has attained based on the assessment (Al-Khatib, 2009). These models were analyzed and discussed by different authors (Irani *et al.*, 2006; Coursey & Norris 2008; Lee, 2010; Ifinedo & Singh, 2011; Fath-Allah *et al.*, 2014; Tripathi & Gupta, 2014) and some of them were adapted to the new models (Moon, 2002; Siau & Long, 2005; Affisco & Soliman, 2006). Summing up these analysis it can be concluded that most of the stage models are focused on different purposes and/or evaluation dimensions what is conditional on appropriate definitions of various stages but the architecture of the evaluation model for all these models is the same.

However, most of these methods of e-government assessment have been too narrowly defined for them to properly promote the development of solutions, i.e. integrated services or life-events, that could fully utilise IT potential and offer real benefits to citizens and businesses as well as the administration itself. Mostly they are just the reflection of too narrow focus on e-government development (Kunstelj & Vintar, 2004). So some authors proposed an expanded way to assess e-government development based on reasonable holistic principles rather than a stage model only (Sandoval-Almazan *et al.*, 2013).

Design of holistic models are based on well known Wimmer's Holistic Framework which supports integrated modeling of e-government services and synchronization with the technical developments (Wimmer & Tambouris, 2002). Though this approach was initialy used to ensure that the e-government services delivered by a project will meet all relevant requirements it can be successfully applied to other evaluation purposes. This is shown by the efforts of following works which apply a holistic approach to create multidimensional evaluation models and use them in practice. As an example of such an activity has been created e-Government Maturity Model (eGov-MM), integrating the assessment of technological, organizational, operational, and human capital capabilities, under a multi-dimensional, holistic, and evolutionary approach (Iribarren *et al.*, 2008; Valdes *et al.*, 2011)**.** A similar model named e-Government Procurement Observatory Maturity Model (eGPO-MM) is focuses on both legal and institutional arrangements, and portals' technical aspects (Concha *et al.*, 2012). Other authors propose a multidimensional model based on a conceptual model that is a necessary initial effort to build more integrated and comprehensive methodologies for measuring and evaluating electronic government (Luna-Reyes *et al.*, 2012)**.** Another work provide a holistic evaluation model from a specific stakeholders' perspective that is based on the most successful measurement factors that impact the satisfaction of users with an e-government service (Osman *et al.*, 2011)**.**

However, these models can not be directly adapted to e-government development in each country (Yildiz, 2007) or each organization or each service in the country, as there may be different local policies and requirements. On the other hand the necessary pre-conditions for e-government depend upon the most important needs of a society. For example, the level of technical infrastructure, legal framework and professional skills needed for egovernment, vary with the objectives being pursued (Omari & Omari, 2006). Different infrastructures (including technical, cultural, social, political and economic) of different countries create different requirements that should be adequate to their governments and their citizens (Zarei *et al.*, 2008). So there is a need for more customized models that could be adapted to different and changing requirements in order to monitor, evaluate and benchmark readiness of public administrations to comply with the new challenges (Valdes *et al.*, 2011). According to the above analysis there was not found a model that could be universally applied for e-government assessment of any country or any service. The presence of a number of these models poses another problem – the lack of a common framework of reference for the assessment (Siau & Long, 2005). In addition, analysis of the literature and practice suggest that a universal assessment model has not been created yet for the cases where there are different goals and different evaluation criteria, or if they are changing.

There were made some attempts to develop e-government assessment frameworks or models, but most of these models were focused only on a certain perspective. For example, stage models that are focused on evaluation of maturity, sophistication and some other indicators (Mukabeta Maumbe *et al.*, 2008; Kachwamba & Hussein, 2009; Lee, 2010; El-Qawasmeh, 2011; Ifinedo & Singh, 2011), a marketing model - on marketing indicators (Steyaert, 2004), a comprehensive framework - for the assessment the value of project post-implementation (Esteves & Joseph, 2008), a conceptual model - for measuring user satisfaction (Verdegem & Verleye, 2009), conceptual framework - for evaluation of public value (Karunasena & Deng, 2012), an integrated indicator model - for evaluation of e-government policies (Stanimirovic & Vintar, 2013). Although efforts are being made to create different e-government evaluation models at present there is no methodology that allows for flexible and comparative measurement of the phenomenon of e-government in a comprehensive and integral way (Luna-Reyes *et al.*, 2012).

In this research, we aim to combine the analyzed models into a conceptual model that could provide a common framework for future research in the area of e-government assessment and a common point of reference in this area. The aim of this paper is to summarize the efforts and offer a reference model for e-government monitoring, evaluation and benchmarking, which is not associated with a particular e-government definition, and/or

model, evaluation purposes, dimensions or criteria, but which could be used universally and be flexible enough to adapt to each particular case. In other words, the proposed model is not depended on the specific objectives and evaluation perspectives.

The research method is based on inductive approach that consist of the empirical study of the literature on individual e-government evaluation methods and models, observation and practical experience.

Reference Model

The proposed reference model for e-government evaluation is built using entity-relationship modeling technique and is presented in Figure 1.

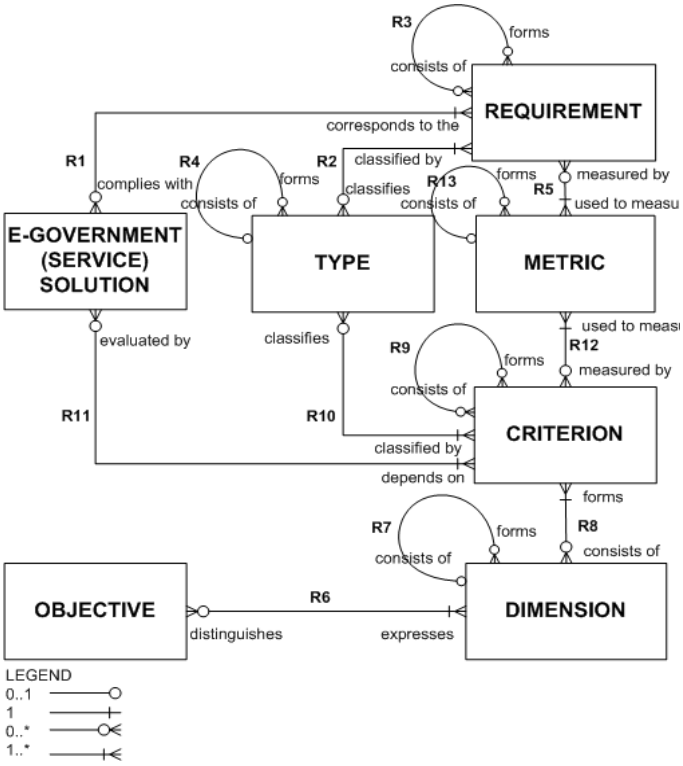

Figure 1. Reference model for e-government assessment.

The model is constructed around the key elements - entities:

- *E-government (service) solution*: solution (technical, organizational, *etc.*), which implements e-government or e-government services.
- *Requirement*: any requirement to be met by the e-government (service) solution.
- *Objective*: any objective to which the evaluation is directed.
- *Dimension*: any intrinsic aspect that is used for e-government evaluation.
- *Criterion*: any criterion (indicator, variable) which is used to form the dimension.
- *Metric*: a real-valued function that is used to measure the evaluation.
- *Type*: any type of related entity – *Requirement* or *Criterion.*

E-government (service) solution in our context represents the e-government models of a very general form or represents only a separate part that concentrates on some determinants such as e-government service issues only. Though there are many concepts mentioned in different definitions of e-government the service is a key concept which can be found in most cases. That's why most of evaluation methods of e-government are limited to the assessment of e-government services only. Before the construction of e-government solution, we have to define what does e-government mean and the key characteristics that will be realized in this solution. As e-government is a largely amorphous concept with different meanings for different people (Azab, 2009) there are multiple definitions of e-government among authors (Jansen, 2005; Yildiz, 2007; Mukabeta Maumbe *et al.*, 2008). Therefore, it could be a reason that a common model that could fit for every e-government case does not exist though there were some attempts to fill in this gap by creating holistic reference framework for integrated modeling of e-government services (Wimmer, 2002), or a generic model based on paradigm that the public administration is composed of an unstructured network of entities that exchange electronic requests in order to deliver services (Dias & Rafael, 2007). An important number of authors describe e-government service models of the revolutionary approach to the dynamic phenomenon, which describes the stages of e-government in terms of their degree of technological and organizational sophistication, from developing a web page to integrating government systems behind the web interface (Hassan *et al.*, 2011). While there is increasing adoption of e-governments the objectives and specific requirements of implementations differs. Therefore, the solutions should be designed individually for every e-government case. Like in the cases of the definitions of e-government the solution models may vary from the very generic that focus just to the use of ICT by the government, to the more specific like enhancing online access and delivery of information and services through the Internet (Rorissa *et al.*, 2011) by using different electronic media or other digital means. And though most implementations activities focus on service delivery concerns with little emphasis on real transformation of the services themselves or the processes associated with their delivery these other issues of transformation initiative like effective constituent relationship management (West, 2004), improvement of related internal processes (Mukabeta Maumbe *et al.*, 2008), its administration, rules, regulations and frameworks set out to carry out service delivery and to co-ordinate, communicate and integrate processes within itself (Almarabeh & AbuAli, 2010), as well as transparency, accountability (Frissen *et al.*, 2007), openness and collaboration (European Commission, 2013a) and other issues could also be incorporated into the e-government models.

Each *e-government (service) solution* will meet the relevant *requirement*s (see relation R1 in figure 1). Most often they are expressed by the contract-style requirement lists (Wimmer, 2001), but also may be and other, more complex forms of requirements. Various e-government service requirements studies have come up with similar requirements that are able to form a generic set of requirements but for each e-government service domain they should be expanded with the particular specific

requirements (van Velsen *et al.*, 2008). Therefore the *requirements* may be classified by one or more *type*s (see R2 in figure 1) that will separate the general requirements from the specific. An example of requirement separation by *type* is presented next. There are four major areas of e-government development: government-to-customer (G2C), government-to-business (G2B), government-to-government (G2G), and government-to-employee (G2E) (Siau & Long, 2009). G2C and G2E involve interaction and cooperation between government and individuals, while G2B and G2G deal with the relationship between government and organizations. Moreover, G2C and G2B involve external interaction and collaboration between government and outside institutes, such as individual citizens and businesses; while G2E and G2G involve the internal interaction and cooperation between governments and their employees, as well as between governments at different levels and distributed locations. As these areas have different objectives and activities, therefore different requirements are specific to each of them.

One of the drawbacks of the evaluation is that they do not differentiate between different levels of e-government services. The implementation of e-government services can take various forms ranging from a single website that provide static information (e.g. contact information: address, telephone and fax numbers, email address, etc.) to an interactive, consolidated gateway to integrated services at all levels of government, from local to federal/national (Rorissa *et al.*, 2011) that are full-service portals (e.g. highly interactive). For this purpose several classification for e-government development have been proposed, for example, according to e-service types: informational, interactive/transactional and personalized (Osman *et al.*, 2011; Rorissa *et al.*, 2011; Tsohou *et al.*, 2013). Here we have another example, when *type* categorizes e-government services and requirements according to the phases of e-government development: publishing, interacting, and transacting (Kumar *et al.*, 2007).

On the other hand, the *requirements* themselves may create different levels of hierarchical structures (see R3 in figure 1). For instance, they may be grouped into "Functional Requirements" and "Technical Requirements" or other form of more complicated structure (Lenk, 2002). There may have any number of levels of the hierarchy, or may include any number of hierarchies. *Types* themselves may be also grouped together to form any number of levels in the hierarchy (see R4 in figure 1) (e.g. "Type of the service" could be a super-type for the "Service interaction mode" type).

It is important to know if the *requirements* are met in a particular solution, therefore they should be valued or measured. *Requirements* may be measured by one or more *metrics* (see R5 in figure 1). For instance, *metrics* could be responses to questions that would be included in some questionnaire (Luna-Reyes *et al.*, 2012). A set of *metrics* combining a questionnaire may be used as a tool to gather information for the evaluation if the *requirement* is met for the particular case. For this purpose organization must provide the appropriate responses to the questionnaire. The answers to the questions may be boolean (*Yes*-1 or *No*-0) (e.g. "Is this service provided on-line? (Y/N)"), incremental measurement scale (e.g. a score may range from 1 to 10) (Valdes *et al.*, 2011), or any other actual (numerical) information (e.g. "How many service transactions were provided on-line?").

As it was mentioned above the e-government evaluation may be focused to different *objectives*. Depending on the evaluation *objective* it may be distinguished one or more *dimensions* (*areas, determinants*) of evaluation and each *dimension* may express one or more evaluation *objective* (see R6 in figure 1). For instance, for e-government assessment Jansen (2005) identified three major dimensions: "E-democracy", "E-service" and "E-administration"; (Layne & Lee, 2001) used two dimensions: "Integration" and "Technology & Organiztional Complexity"; (Luna-Reyes *et al.*, 2012) introduced three dimensions that are based on general areas of measurement framework of e-government: "Characteristics", "Determinants" and "Results"; (Pina *et al.*, 2009) assessed the level of e-government developments using four dimensions: "Transparency", "Interactivity", "Usability" and "Web site maturity". *Dimensions* themselves may create different levels of hierarchical structures (see R7 in figure 1). For instance, the structure of assessment model consists of two hierarchical levels of the dimension: "Leverage Domains" and "Key Domain Areas" (Valdes *et al.*, 2011).

Each *dimension* is evaluated by using one or more *criterion* (*critical variable, indicator*) (e.g. "Existence of Information", "Quality of Information" (Luna-Reyes *et al.*, 2012)) and each *criterion* may be used to evaluate one or more different *dimensions* (see R8 in figure 1). For instance, *dimension* "IT Architecture" consists of 5 *criteria*: "Security", "Application", "Data", "Technology" and "Network" (Valdes *et al.*, 2011). *Criteria* themselves may be grouped and form any number of levels of hierarchical structures (see R9 in figure. 1). For instance, *criteria* may be classified into three groups: the technical issue group, the economic issue group, and the social issue group (Alshawi & Alalwany, 2009). Or it may be any other form of more complicated structure (Lenk, 2002). Furthermore, like in case of *requirements*, the *criteria* may be classified by one or more *type*s (see R10 in figure. 1) and their selection may depend on the *e-government (service) solution* to be evaluated (see R11 in figure 1).

E-government (service) solution assessment is essentially carried out by the evaluation of each *criterion* by one or more *metrics* (see R12 in figure 1). Like in case of *requirements*, most cases each *criterion* conform to one *metric* only but it is possible to measure the *criteria* using more than one *metric*; or the same *metric* may be used to measure different *criteria*. For instance, Osman *et al.* (2011) used 49 questions as *metrics* to assess 4 *criteria* where were used the same questions for the measurement of different *criteria.* Furthermore, *metrics* themselves may form any number of levels of hierarchical structures (see R13 in figure 1). For instance, Gupta & Jana (2003) used 6 level *metrics* hierarchy for measuring performance of e-government. *Criteria* in this case must be examined according to the level of measure that is applicable in a specific context.

Metrics associated with each *criterion* as well as *criteria* and *dimensions* may be selected on the basis of the literature review or any other resource like evaluation reports or experts opinions on this area, for example

(Steyaert, 2004; Jansen, 2005; Osman *et al.*, 2011; Luna-Reyes *et al.*, 2012; Concha *et al.*, 2012; Stanimirovic & Vintar, 2013; Osman *et al.*, 2013; Tsohou *et al.*, 2013). Each *criterion* or *dimension* may be calculated according to some *rules* by using *metrics* and other variables. There may be different forms of rules expressed by simple formulas or structures that are more complicated.

Next formulas samples illustrate the widespread cases for calculation of *criteria* and *dimensions*. They bear a sufficiently broad class of evaluation models, starting with the simplest already mentioned above e-government stage models and ending with the multidimensional hierarchical evaluation models (for instance, Valdes *et al.*, 2011; Concha *et al.*, 2012; Luna-Reyes *et al.*, 2012). However, for such the models it does often occur when the evaluation formulas are not presented at all (for instance, Iribarren *et al.*, 2008; Stanimirovic & Vintar, 2013; Osman *et al.*, 2013).

For computing of *criterion* c_i (i=1, … M, M – number of evaluation criteria) a weighted average evaluation formula (1) is often used:

$$c_i = \sum_{j=1}^{m_i} \gamma_{ij} (v_j / v_j^{max}) \quad (1)$$

where

m_i – the number of *metrics* that are used for the evaluation of *criterion* c_i;

γ_{ij} – weight for the *metric* j of *criterion* i on condition - $\sum_{j=1}^{m_i} \gamma_{ij} = 1$, for every i;

v_j – evaluated value for the *metric* j;

v_j^{max} – the maximum potential value for the *metric* j according to the chosen measurement scale.

Each *metric* value v_j is assessed by the chosen measurement scale, which depends on the question structure in the evaluation questionnaire and the answer value or experts‘ opinion:

- At issue in need of logical answer "Yes" or "No" v_j can obtain the appropriate value of "1" or "0". In this case, the maximum possible value of the *metric* $v_j^{max}=1$.
- In case of evaluation of incremental measurement scale the answers can acquire numerical values from the chosen measurement scale according to pre-defined assessment condition for each scale. For instance, for the assessment of service maturity may be subject to a 4-stage model, in which v_j can gain value from the set $v_j \in \{1, 2, 3, 4\}$ ($v_j^{max}=4$), depending what conditions of the maturity level description meet the valued features of the service: "1" - "Informative", "2" - "Simple Transactions", "3" - "Complex Transactions", "4" - "Integrate“ (Concha *et al.*, 2012).
- In case of actual quantitive evaluation the measure answers may obtain any of the numerical values from the interval [0, v_j^{max}], where v_j^{max} – the maximum possible value of the *metrics*.

In the simplest case of formula (1) the weights are equal for all *metrics* - $\gamma_{ij} = 1/m_i$, j=1,…, m_i, but can be used different weighting values that can be determined, for example, in accordance with international practice, or expert opinion (Valdes *et al.*, 2011).

However, in some cases for the evaluation of one criterion it can be applied more complex formulas, for instance, such as the simultaneous combination of different properties - maturity and usage of the service operations (Ostasius, 2012).

For evaluation of any level of the hierarchy of *dimensions* may be used aggregation formula (2):

$$D_k^l = \sum_{i=1}^{n_k^l} \alpha_{ik}^l D_i^{l-1} \quad (2)$$

where

l – hierarchy level of *dimensions*: l = 1,2, ...;

D_k^l – the aggregate evaluation of the *dimension* k for the hierarchy level l;

D_i^{l-1} – evaluation of the *dimension* i for the hierarchy level l -1;

$D_i^0 = c_i$, for each i, i = 1, ..., M, M - number of evaluation *criteria*;

n_k^l – number of *dimensions* that are used in the calculation of the aggregated *dimension* D_k^l;

α_{ik}^l – evaluation weight of *dimension* i of level l on condition $\sum_{i=1}^{n_k^l} \alpha_{ik}^l = 1$, for every k and l.

Weights α_{ik}^l can be chosen in the same way as in the case of the *criteria*.

Formula (2) can also be used in the calculation of aggregated estimates of *criteria* and/or *metrics*.

Conclusions

This study contributes to the area related with e-government assessment. Despite the increased interest in e-government evaluation, it appears that literature does not offer much studies of reusable multidimensional integrated models for e-government evaluation. Furthermore, they are mostly focused on some particular evaluation purposes or are limited to some specific area of the assessment because it depends on the specifics of each country, their differences in economic, cultural, educational issues, or the specific of policies and requirements concerning e-government and services in the organization itself.

In the paper we have examined and summarized the efforts and models proposed in the literature and offered a reference model as a reusable conceptual model for e-government assessment. This model is not associated with any particular e-government definition and/or model, evaluation purposes, dimensions or criteria. We identified and presented the main elements of the model entities (e-government solution, objective, dimension, criterion, metric, requirement and type), and established relationships between them. Moreover, to the best of our knowledge, this is the first application of entity relation modeling technique in the e-government field, although it has been widely applied in other fields such as system or data modeling. We also presented the main generalized formulas of most commonly occuring calculations of the evaluation criteria and dimensions.

The practical implications that derive from the proposed reference model are that there is no need to create a new evaluation model for every specific case from

scratch. We believe that the proposed model will cover a wide range of evaluation models, so it can be used in designing specific models for e-goverment monitoring, evaluation or benchmarking. An evaluation reference model corresponds to an existing off-the-shelf-solution, therefore, what you need is, according to the evaluation object and the objectives, to select the parameters – dimensions, criteria and metrics for your specific evaluation model. Additionally, this model can be used for evaluation of any service or solution that is not necessarily concerned with e-government.

Future work will be focused on the validation of the reference model by constructing in practise the specific monitoring, evaluation and benchmarking models for various e-government cases and services.

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