Evaluative framewok for the measurement of e-government information systems agility

Aggoune Soumia, Imache Rabah, Mezghiche Mouhamed
LIMOSE laboratory, Computer Science Department
Faculty of Science, University of Boumerdès (UMBB)
Boumerdès, Algeria
Sou.agg@hotmail.fr, rimache@gmail.com,
mohamed.mezghiche@yahoo.fr

Khadraoui Abdelaziz
MATIS Geneva team, Information Systems Department
University of Geneva (CUI)
Geneva, Switzerland
abdelaziz.khadraoui@gmail.com

Abstract— **Agility is difficult to measure due to the vagueness of the concept. The overall problem of measurement is limited to three fundamental questions: what to measure? How to measure it? How to evaluate the results? Measurement of enterprise agility has been a major topic of research since the inception of agility in the early 90s. Some measurement methods have been developed; they mainly remain tied to manufacturing industry. Thereafter, the concept of agility was extended to supply chains, business networks and software development. In this paper, we try to extend more the concept of agility to the e-government field through an evaluative framework for the measurement of e-government information systems (E-GIS) agility. The key idea of this framework is to combine the fundamental parts of an E-GIS with their operational parameters to evaluate the overall agility of the system. One of the advantages of this practical framework is that agility parameters are measured thanks to quantitative metrics, which allow decision-makers to examine and compare different systems at different agility levels.**

Keywords- E-government, information system, evaluation, agility, methods engineering.

I. INTRODUCTION

The management of public administrations was subject to significant transformations in its work practices. During two decades, administrative reform and development have experienced Total Quality Management (TQM) in 1980s, and Reengineering and Reinventing Government (RRG) in 1990s. TQM -expressed in the works of Edwards Deming [23] and others ([9], [12], etc) - was not work well in government agencies because, the stress was on products rather than services. RRG has often been presented as a revolution in government management. In truth, it was less a revolutionary than an evolutionary movement. Some scholars have attacked reinventing government's pursuit of businesslike practices in government. They have called it an aggressive attack on the tradition of democratic accountability. New challenge in 2000s is to create an e-government (electronic government) which reflects the ultimate visions for governments to modernize and change the way their administrations work - that in general, is organized in a rather rigid and bureaucratic manner- in order to move forward in the 21st century with higher quality, cost-effective, government services and a better relationship between citizens and government.

Multiple projects and research tasks, which were interested in e-government problems, showed that the success of these projects is strongly depended on the quality of their information systems [1]. Besides, many literature reviews deal especially with the failure of e-government projects, and studies have shown that, it is not just e-government applications, but information systems in general that fail [7]. The quality of E-Government Information Systems (EGIS) is thus, qualified as a critical success factor of e-government projects. However, the instability of the internal and external environments of these EGIS makes agility an essential and necessary quality that conducts to dynamically accommodate environment changes and evolutions, and that enhances their sustainability. In the literature, many definitions and explanations of agility have been proposed ([15], [19], [6], [13], [22], [14], [7], etc.). Nevertheless, no consensus yet to what agility exactly is. In this–paper, the definition given by [19] inspires us. Therefore, we define the agility of an e-government information system as the quality that determines its adaptability, flexibility and reactivity to accommodate unanticipated environment changes and evolutions. Adaptability is the capability of being suitable to a particular situation or use. More precisely, it is the feature of a system that is able to fits its behavior when external /internal changes occur. Flexibility is the ready capability of being able to be adjusted without significant deterioration or damage. More precisely, flexible EGIS is a resilient system that tolerates modifications and adjustments easily, without any type of damage. Reactivity is the speed in which the EGIS responds to changes with the equivalent technology. Finally, accommodating unanticipated changes implies that systems must be able to evolve in step with these changes. The EGIS is thus, not rigid over the time, it evolves; it adapts to the new requirements and needs; so that, the EGIS models must also evolve and adapt.

Evaluation of e-government information systems agility has not kept pace with the actual development in e-government practice. Author in [17] argues that "the absence

of established models of e-government evaluation is mirrored in the type of research that is attempted in this respect as most research tends to be qualitative, exploratory and inductive rather than quantitative, confirmatory and deductive". In this context, our contribution in this work is to propose a practical approach for the evaluation of e-government information systems (EGIS) agility. This approach conceptualizes the fundamental parts of an EGIS, that are combined together to evaluate the overall agility of this EGIS. Evaluation parameters are defined to measure agility of each one of these parts, and quantitative evaluation metrics are defined to measure each one of these parameters. Evaluation metrics may be of different natures (i) direct (ii) Adaptive (iii) Knowledge-based or (iv) Holistic [11]. So, in order to unify and facilitate the interpretation of the results and calculus, evaluation metrics are scored on a likert-5 scale.

The rest of the paper is organized as follows: section 2 gives an overview of the existing approaches treating the measurement of information systems agility. Section 3 presents our proposed approach for the measurement of e-government information systems agility. Finally, section 4 clots this paper with conclusions and perspectives.

II. RELATED WORK

In the existing state of art, multiple approaches and methods were interested in measurement of agility. Like for example, measurement of manufacturing agility [11], measurement of business agility [10], measurement of agile methods agility [2], measurement of design process agility [3], etc. In addition, multiple measurement tools were developed in these contexts. This literature has long shown the importance of measurement of agility, mainly:

- Measurement of agility gives measure of competitiveness and readiness for change in the market within the measured context;
- Measurement of agility is a sort of diagnostic that identifies less or non agile areas within the measured context and thus, it can plan for improvements;

However, despite the contribution of the information system agility to the organization agility, few approaches deal with the measurement of information systems agility. They can be mainly classified on two principle works: work on the measurement of enterprise information systems agility [16] and the work on the measurement of information systems agility in a socio technical theory [20]. It is important to emphasis that, measurement of information systems agility adds to the above paragraph dealing with the importance of measurement agility the strategic perspective. Indeed, [20] argue that measurement of information systems agility is strategic from a rational resource allocation perspective. Managers must strive to match the appropriate degree of information systems agility to enable the optimal degree of strategic agility. In other words, if the information system is over agile, resources are wasted; if the information system is under agile, the organization cannot respond to market opportunities or face challenges in a timely manner. Measuring information systems agility is a necessary precondition to making appropriate resource allocation decisions. This section presents two works on measurement of information systems agility and discusses them, in order to situate our proposed approach among them.

A. *Measurement of enterprise information systems agility*

Authors in [16] proposed POIRE methodology for the measurement of the agility and durability of enterprise information systems. POIRE refers to the five aspects of an enterprise information system: Process, Organization, Information, Resources and Environment. Fig. 1 shows the main components of POIRE approach and interactions between them.

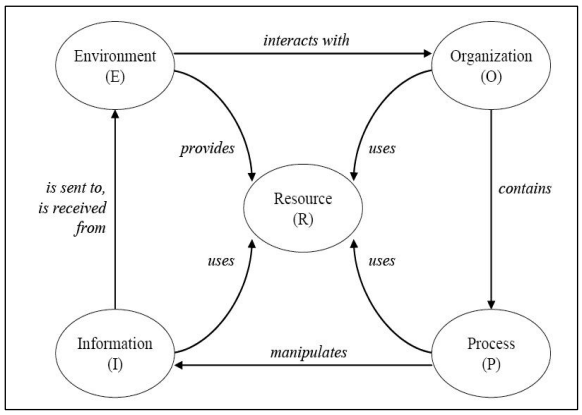

Figure 1. POIRE dimensions for enterprise information systems.

In this approach, agility is measured according to a certain number of agility factors which are determined for each dimension of the enterprise information system, using a set of evaluation criteria. These criteria are measured thanks to some identified metrics that concern a given dimension of the IS. The evaluation of the metrics is practically based on the evaluation of certain number of questions that are defined within a questionnaire of the corresponding dimension. The authors argue that the overall agility of such information system is not a simple summation of the obtained scores of agility in each dimension of the IS, but it depends on their non linear relationships. For that purpose, the authors associate *weights* for each dimension in order to evaluate the overall agility of the IS.

B. *Measurment of information systems agility in the socio-technical theory*

Authors in [20] studied the agility in a socio technical perspective. In this latter, the information system is considered as composed of two subsystems (Fig. 2): a technical system and a social system. The technical sub-system encompasses both technology and process. The social sub-system encompasses the people who are directly involved in the IS and reporting the structure in which, these people are embedded. To measure the IS agility using the socio-technical perspective; the authors use the agility of the four components: (i) technology agility, (ii) process agility, (iii) people agility and (iv) structure agility.

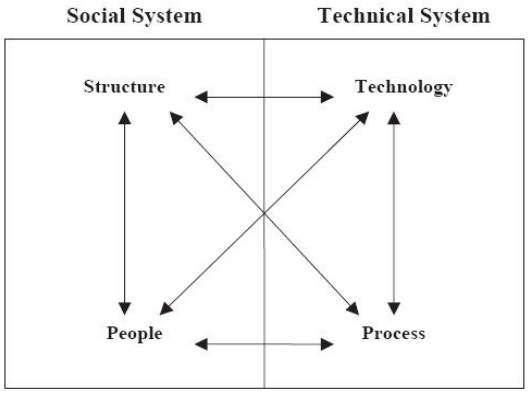

Figure 2. Information system as a socio-technical system..

Hence, the authors argued that, the agility is not a simple summing of the agility of the four components, but it depends on their non linear relationship. For that purpose, authors proposed the use of fuzzy logic to evaluate the overall agility of the IS. This choice is justified by three principle reasons. First, mathematical models are not appropriate to deal with the measurement of agility because they do require the quantification of all variables of interest. They do not allow for imprecision of observed parameters. Second, many of the agility dimensions of the information system components are not easily quantifiable. Finally, as mentioned earlier, the agility of an information system cannot be computed as the simple sum of the agility scores of its four components, and, because of systemic effects, the same degree of IS agility can be obtained with a virtually limitless blend of each component's agility.

C. Discussion

The two approaches presented in this section have common points as well as differences that we summarize in the following table (Table 1).

TABLE I. COMPARISON OF THE IS MEASUREMENT AGILITY APPROACHES

Approach	Domain	Principle of measurement	Tool
POIRE approach	Enterprise IS	Division of the IS into five inter-dependent parts in order to evaluate the overall agility of the system.	POIRE tool,
Socio-technical approach	IS in Socio-technical theory	Division of the IS into four independent parts in order to evaluate the overall agility of the system.	No tool, theoretical approach

As shown table 1, both POIRE approach and the socio technical approach have as a principle of measurement agility the division of the IS into parts more or less independent. Agility is then evaluated in each one of these parts; however the overall agility of the IS is not a simple sum of the obtained scores in each one of these parts because of the non linear relationship between them. For that purpose, POIRE approach uses "weights", while the socio technical approach uses "fuzzy logic" to calculate the overall agility of the IS. In terms of differences, POIRE is a practical approach that measures enterprise information systems agility with a software support that automates calculus, while the socio-technical approach is a generic theoretical approach that measures information systems agility in a socio-technical theory.

If we analyze these approaches within the regard of e-government domain, two main remakes are made. The first is, in these approaches, we don't find clearly the *legal framework* aspect, which is the critical element of this domain. Hence, laws describe stable and invariant concepts that are at the core heart of e-government information systems [1]. Ignoring these legal aspects may causes incomplete, inaccurate or inconsistent requirements specification when developing such IS. Evaluation of e-government information systems (EIS) agility must obligatorily include parameters that measure the compliance and the conformity of these EIS with the laws, since these last constitute the real source of knowledge that allows determining e-government services, as well as the business rules which govern the given field. The second remark, concerns -as argued [8] -the fact that e-government information systems are different from the other information systems (at least those treated by these approaches), in that they frequently encompass strategic goals that go beyond efficiency, effectiveness, and include political and social objectives such as trust in government, social inclusion, community regeneration, community well-being and sustainability. Evaluation of e-government information systems agility must include parameters that refer to all these qualities and particularities of the e-government field. The range of evaluative parameters is thus extended.

For this reasons, these two approaches will not work well for measuring e-government information systems agility. The objective of the next section is to present our proposed approach for the measurement of e-government information systems agility which complements these existing approaches to IS evaluation and takes into account all the considerations discussed above.

III. PROPOSED APPROACH

The development of any evaluative framework or tool must be rooted in a chosen evaluative paradigm. We begin this section with an outline and justification of our choice of the *interpretive paradigm.* Subsequently, we describe the two main parts of our approach: the evaluative framework for EGIS agility and the measurement method for EGIS agility.

Interpretive paradigm (named also interpretivism) is the epistemology that involves understanding the phenomenon subjectively and encourages researchers to be more interpretive and inductive, thus provides valuable platform for studying IS in organizations. Interpretive paradigm generates both quantitative and qualitative results. Hence, once the quantitative results are obtained, they are interpreted. Interpretivism is made even more important when the research revolves around the study of IS from different cultural context

and also taking into account different perspectives of professionals in different organizations. Hence interpretive study would provide an excellent guideline as how interview should be conducted or more importantly how the case studies are interpreted. This is because [5] interpretive as the 'umbrella' term would assist in filtering participants' statements and actions through the lens of the researchers own subjectivity, and then produces a 'story' about the events that have occurred and some reasons for them. The research method appropriate to generating valid interpretive knowledge is field studies, as these examine humans with their social settings. And as interpretive researchers avoid externally defined categories on phenomenon, then the in-depth experiment of field studies seem to be more appropriate.

A. Evaluation framework

With the aim of evaluating the agility of an EGIS, this one is divided into two fundamental parts: FO (Front Office) and BO (Back office). FO refers to the EGIS external part and BO refers to the EGIS internal part. These parts (Fig. 3) and the interactions between them, form a horizontal architecture that we argue generic and common for all the e-government information systems deployed within public institutions/ administrations.

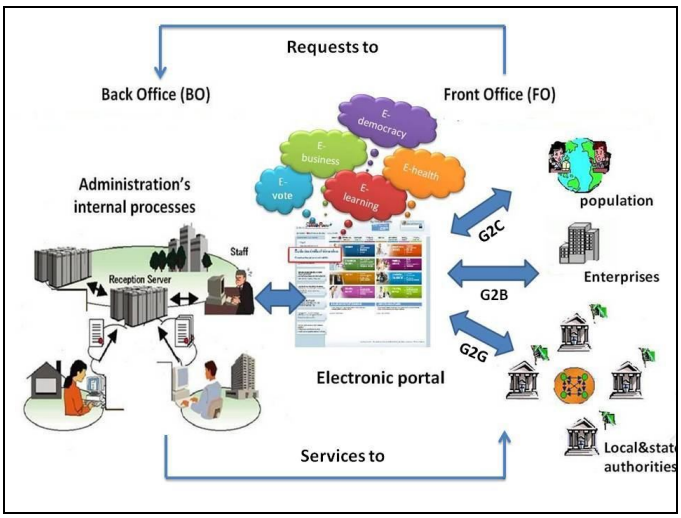

Figure 3. E-government Information system fundamental parts.

Front office (FO): this part deals with the external provision of information and services to the widest population of citizens and businesses as well as the interoperability with the other governmental agencies. This is generally done through appropriate electronic portals that can be accessed by different ways (computers, local quiosques, phones, etc.). We define Front Office agility as the ability of administration/institution to satisfy in time their customers' requirements in spite of their access possibilities, skills, cultures, motivations, etc; and enhance communication and cooperation with the other governmental agencies.The study of the front office agility asks primarily to study interactions with citizens (G2C) and businesses (G2B) and the interoperability with governmental agencies (G2G). The figure bellow (Fig. 4) shows the FO parts and the interactions between them.

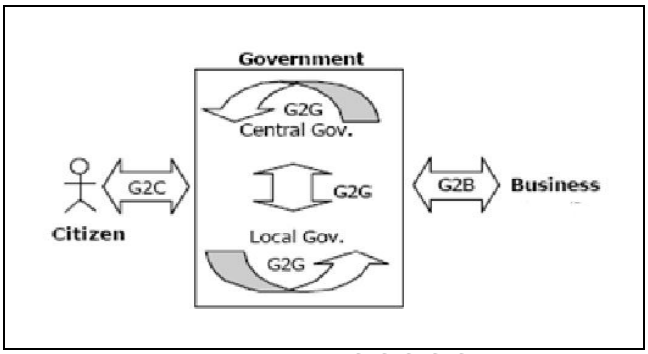

Figure 4. Interactions G2C, G2G, G2B.

Back office (BO): this part deals with the internal behavior of the administration/institution that makes the EGIS operational. We define back office agility as the ability of administration's internal structure to adapt and reconfigure itself in time to support the different changes of the environment (legislative changes, social changes, technology changes, etc) and to enhance the internal communication, collaboration and cooperation between the different internal departments of the institution (internal interoperability). The study of back office agility concerns its (i) organization agility (business processes and activities, business actors, business rules etc.), (ii) information agility (the circulated, processed and exchanged data and knowledge) and (iii) technology agility (the deployed platforms, architectures, implementation environments, etc.). The figure bellow (Fig. 5) shows the BO parts and the interactions between them.

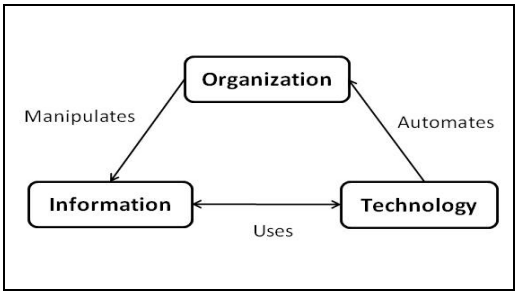

Figure 5. BO components and interactions between them.

Effectiveness, efficiency, training level, job rotation, flexibility, utility are examples of parameters that can evaluate the organization's agility.

B. Evaluation method

By method, is intended a "mean of investigation". It consists of: a way of thinking, a way of modeling, a way of working and a way of supporting. Any method is defined around a philosophy or paradigm (way of thinking), comprises models (ways of modeling) to define the product, proposes process models or steps (way of working) and is supported by software tools (way of supporting) to assist in the implementation of the method. As far as we talked about the

way of thinking at the beginning of this section (interpretive paradigm), we talk in this sub-section about the way of modeling, the way of working and the way of supporting.

1) Way of modeling

The proposed evaluation method is based on methods engineering discipline. A method -according to this discipline- treats the two aspects of engineering, the product and the process, and thus comprises two elements: one or more product models and one or more process models [4]. The product is "the result to reach". The process is "the way which should be traversed to reach the result" [21]. Indeed, the product model prescribes what the awaited characteristics of the manufactured products are. The process model prescribes a manner of making, methodological steps to reach the desired target. Fig. 6 shows the product model of our evaluation method.

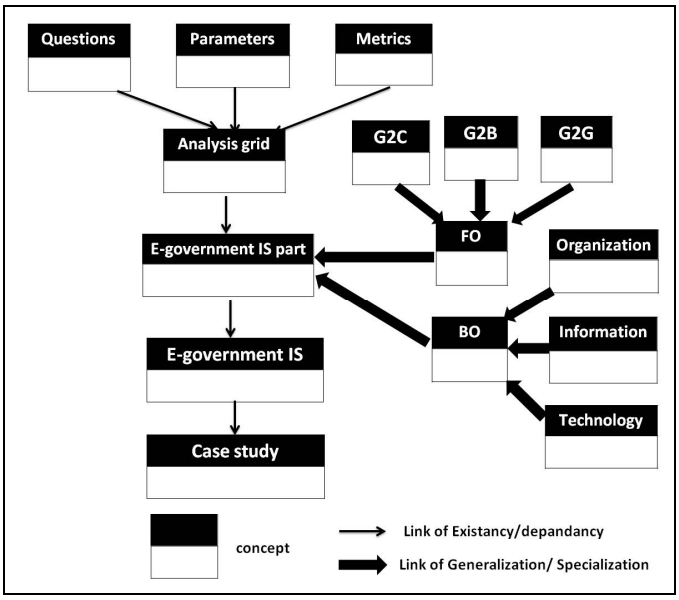

Figure 6. Product model of the proposed approach.

This product model shows the main concepts used by the method and the interactions between them. It is represented using the binary-existantially model [18] which defines two types of links between the concepts: the existency/dependency link and the generalization/ specialization link. The former links two concepts where the source cannot exist without the target. For example, the concept "E-government IS part" cannot exist without the concept "E-government IS". And the second linksa more specialized concept (the source concept) to a more generalized concept (the target concept). For example,as shown in Fig. 6, the concepts "FO" and "BO" parts specialize the concept "E-government IS part".

2) Way of working

Within methods engineering, the decomposition of a method into components means the decomposition of its process model into guidelines. Each guideline satisfies an activity/intention within the overall method of evaluation. Fig.7 shows the process model of our evaluation method.

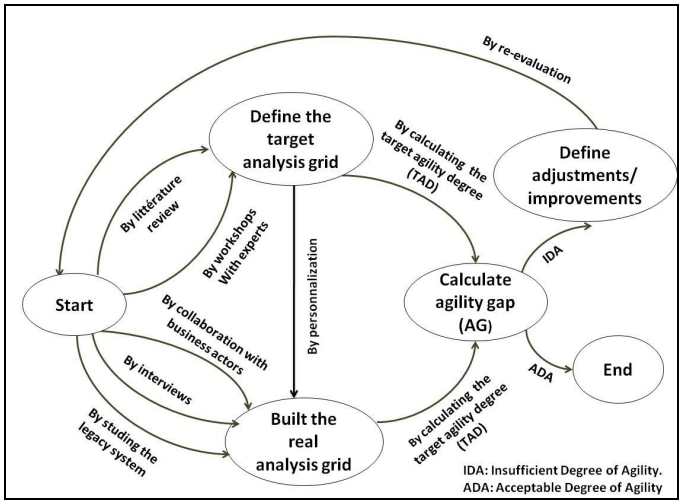

Figure 7. Process model of the proposed approach.

The MAP model which is defined as a labeled directed graph where nodes are intentions and the edges are strategies [19], is used to represent the above process model (Fig. 7). Several strategies are possible to achieve the same intention. For example, *interviews*, *collaboration with business actors*, *study of the legacy system* are the possible strategies to achieve the intention *built the real analysis grid* from the *start* intention.

As it is not possible in this paper to explain in details the appropriate guidelines of each one of the method-components, we summarize them within the overall principle of evaluation. As shown in the process model (Fig 7), the principle of our method of evaluation EGIS agility, consists in starting by defining a target degree of agility for this EGIS, i.e. a quantitative objective of agility, in the form of a desired grid, following the literature review and workshops with experts. The analysis grid contains questions that concern agility parameters. These questions are measured by specific evaluation metrics, i.e. qualitative measures determined for each agility parameter. As it had been said above, these metrics may be of different natures (direct, Adaptive, Knowledge-based or Holistic), for this reason, they are normalized in order to unify the interpretation of the results and facilitate the calculus. The normalization of metrics consists in transforming them so that they belong to the interval [0, 5]. Finally, the measurement of parameters is achieved by applying the linguistic variable of fuzzy logic to the normalized metric. The target analysis grid is then, determined. Through feedback with experts, a set of validation criteria are applied to the determined grid in order to validate it. In this case, the determined grid may be revised and re-evaluated by addition of new elements or removal of existing ones. The target grid is customized following the analysis of the legacy system, interviews and/or collaboration with the business actors in order to practically measure the parameters and then determine the real analysis grid. Once the

real grid compared with the desired grid, we can determine the Agility Gap and then conclude by the mention of Acceptable Degree of Agility (ADA) or Insufficient Degree of Agility (IDA), in which case it is necessary to bring some corrections and adjustments for the considered EGIS.

IV. CONCLUSION

In this paper, we presented a state of art of the approaches interested for the measurement of information systems agility. Mainly, POIRE approach for the measurement of enterprise information systems agility; and the socio-technical approach for the measurement of information systems agility. Hence, we presented our evaluative framework for the measurement of e-government information systems agility. The main characteristics and advantages offered by this practical framework might be summarized as follows:

- Agility is evaluated thanks to quantitative metrics which allow decision-makers to examine and compare different systems at different agility levels;
- The EGIS is divided into parts (to determine the overall agility) which allows easily to detect non or less agile components of the EGIS, on which work must be focused;
- The process of evaluation is based on a comprehensive questionnaire for the measurement of agility parameters. These questions are useful because they can be part of the knowledge acquisition procedure of any knowledge-based agility measure;
- The proposed framework is easy to be implemented with a virtual based simulation testbed which provides a situation specific measurement and it is easily expanded;
- The proposed framework is adjustable by the user, in function of the goal and the context of evaluation;
- Finally, the proposed framework is based on a collaborative approach with both, front office end users (citizens and businesses) and back office end users (administration's internal actors).

In this work, we presented only the theoretical part of our evaluative framework which is actually under application in an institutional field.

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