

MULTIDISCIPLINARY MODELS AND GUIDELINES FOR E-PROCUREMENT PROJECTS: THE DESIGN PHASE

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Abstract

We present a methodology for developing public eProcurement projects by means of a multidisciplinary approach. The set of expertises needed for the design of eProcurement systems is wide and ranging from juridical, to technological components which have to be faced in a unique vision. The methodology has two macro-phases, namely eReadiness and Design of the eProcurement solution; in this paper we focus on the design phase. Our aim is to bring out a number of issues, which are currently challenging many eGovernment projects, through an integrated approach by encompassing sociological, economic, organizational, juridical and technological factors. Technological issues consider cooperative architectures and the impact of data quality on eProcurement process quality.

Keywords: eProcurement design methodology, Business Process Reengineering,, Cooperative architectures, Data quality, eGovernment economic models

1 INTRODUCTION

eProcurement has been considered as a relevant area in eGovernment since the Green Paper issued by European Union (European Union 2006) and has been confirmed in the strategy defined at the Lisbon EU summit in 2000 and in the 2005 Action plan (see European Union 2005). While for most industrialized countries the size of public procurement varies between 5% and 8% of Gross Domestic Product (GDP), within the Middle East and Africa, the magnitude of central procurement is even larger, ranging from between 9% and 13% of GDP. Information and Communication Technologies (ICT) can play a key role in the way government acquire goods and does its business. It allows the governments to reach more easily more suppliers and, in so doing, to reduce significantly transaction costs, which in modern economies can be accounted in approximately the 45% of GDP. In emerging and transition economies, the implied savings can be of paramount importance, since their public sectors typically makes up almost half of their national economies and are strategically placed so as to affect the business environment even larger than this.

Due to the interdisciplinary nature of the area, goals and approaches for eProcurement involves a wide range of research issues, i.e. social, economic, organizational, juridical, and technological. In Figure 1 the inter-relationships among such issues are outlined, as compared with the traditional "technology centred" approach. According with the graph of influences introduced in Figure 1, the organizational structure of the eProcurement process should be coherent with the technological infrastructure, and, at the same time, should be chosen considering mainly the impact of the eProcurement process in the

economy of the country. Beside the technological dimension, the other four ones are crucial for e-Procurement systems and they have to be faced simultaneously; in fact:

- sociological issues provide an improved understanding of the interactions between citizens and users at large, the business sector and public administration, and prevent or buffer possible conflicts between the uses of different modes of interaction and the various established cultures;
- economic and organizational issues provide predictions and evaluation of impact of the effects of eGovernment projects on economic growth. Furthermore, they allow identifying the implications of socio-technical processes and effects for citizens, businesses and institutions;
- juridical aspects are crucial in every project involving Public Administrations (PAs), since the organization of PA and the administrative processes are deeply influenced by the general legal framework and by the specific laws and rules enacted for the new initiatives to be undertaken.

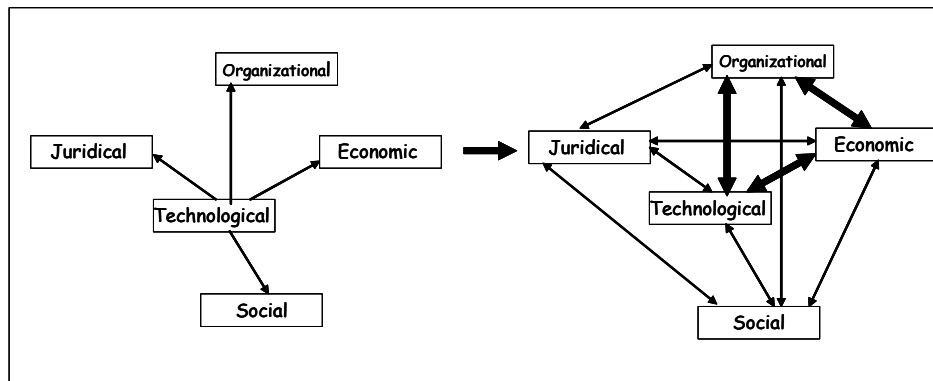


Figure 1. The technology centered vision and the multidisciplinary one

This paper presents guidelines to steer the sustainable and effective development of eProcurement systems for the PA. Guidelines can be applied in a wide spectrum of contexts; we aim in the future to apply them especially in the context of the Mediterranean area. In fact, this work is a first result of the “eGovernment for Mediterranean Countries” (eG4M) Project (www.eg4m.net). The aim of eG4M is to investigate new methodologies for supporting Mediterranean Countries (MCs) in establishing and consolidating the most suitable eGovernment solutions for their specific context; more specifically, it focuses on extending, completing, and eventually improving the eGovernment Reference Model issued within the ‘eGovernment for Development Initiative’ by the Italian government (see e-model 2002), with a special focus on key activities for good Governance as eProcurement.

The main contribution of our guidelines is the use of a multidisciplinary approach, considering the social, economic, organizational, juridical, technological dimensions. For the sake of brevity, we put special attention on the relationship among economic, organizational and technological issues (see Figure 1); with regard to technologies, we are specifically concerned with cooperative architectures and data quality, which are usually seen as relevant issues in innovative eGovernment projects. Guidelines concern two macro-phases of the eProcurement design activity, namely a. eReadiness, and b. Design of the eProcurement solution. The first macro-phase is in charge of collecting, reconstructing and assessing the current state of the procurement system (either electronic or paper-based). In this paper we focus mainly on the latter macro phase. The reader interested in the first macro-phase can refer to (Batini et al. 2006).

The paper is organized as follows. In Section 2 a short description of the whole methodology is provided. Section 3 focuses on the Strategic Planning phase, while Section 4 describes the eProcurement Process Reengineering. Section 5 concerns the final phase of our guidelines, that is the Design of the technological solution. Section 6 presents related work and, finally, Section 7 draws conclusion and future work.

2 THE GUIDELINES AT A GLANCE

According to the multidisciplinary vision, we propose a set of guidelines, which are drawn from a corpus of models, lessons learned and best practices. As described in the introduction, two are the main macro phases of an eProcurement development project: eReadiness, and Design of the eProcurement solution. eReadiness macro phase includes the Context Reconstruction and Context Assessment phases while the Design of the eProcurement solution includes the Strategic Planning, eProcurement Process Reengineering and eProcurement Design phases (see Figure 2).

The first macro-phase is in charge of collecting, organizing and evaluating the existing eProcurement solution according to a multidisciplinary approach. The result of this macro-phase is a quali/quantitative evaluation of the actual system, together with the collection of wider knowledge on the environment in which the eProcurement system will operate.

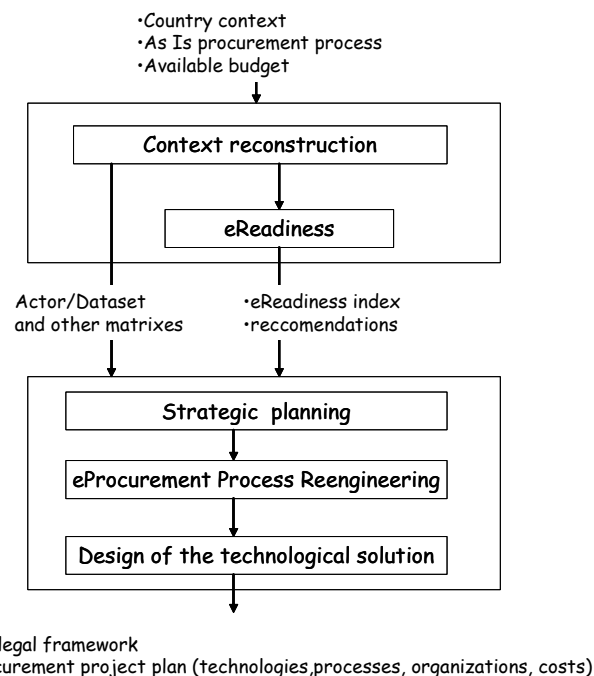


Figure 2. Methodological framework for eProcurement projects

During the first macro-phase, the knowledge on the social-economic context, the legal framework, the organizations, the administrative processes, and data bases is collected and related. The outputs of the first macro phase are: i) the eReadiness Index, which is a comprehensive indicator of the capability of a system to introduce an eProcurement solution, ii) a set of recommendations and iii) a set of matrixes showing the inter relation among the entities described before. Examples of such tabular representations are: i) the Actor/Dataset matrix, where each cell specifies whether an organizational unit either creates (i.e., owns) or just consumes (i.e., uses) a set of data such as good orders, contracts, tenders, and ii) the Process/Actor matrix, where each cell specifies whether an Actor either leads or participates in the procurement sub-processes (e.g. order collection, tendering, contracting). In Table 1 we report an example of Actor/Dataset matrix, applied to the Italian procurement system, see (Consip 2006). The matrix describes the flow of data that several organizations have to exchange. In the Italian procurement system the Chambers of commerce provide the complete list of business actors (the Business registry) to the ordering subject (namely, the agency Consip), which publishes a Request for

Quotations (RFQs) about the tender to suppliers, they then produce product quotations which are sent to the ordering subject.

Actor/ Data Set	Business registry	RFQs	Product quotations
Ordering Subject	Uses	Creates	Uses
Suppliers		Uses	Creates
Chambers of Commerce	Creates		

Table 1. Example of the Actor/Dataset matrix

The second macro-phase is in charge of defining objectives, strategic and detail plans for the design (or re-design) and development of the eProcurement system. Even in this macro phase, multidisciplinary models and tools help the designer to understand and choose the best instruments to use in order to obtain an effective project.

3 STRATEGIC PLANNING

During this phase the strategic decisions on the organizational, technological, economic, and legal issues have to be taken, and priorities have to be established among activities. The design of eProcurement systems requires a set of specific models and paradigms facing the multidisciplinary dimensions defined in the introduction; this section presents existing models we have extended and new ones we developed that can be used by the designer.

With regard to organizational issues, eProcurement can be realized in different forms which are referable to two models, the *Indirect Procurement System* (IPS), and the *Direct Procurement System* (DPS). Such models can be described on the basis of two organizational roles: the *Contracting unit*, namely the public administration which purchases goods and services and bears the relative costs, and the *Ordering subject*, which manages the purchasing phase of the eProcurement process.

In the IPS model, the Contracting unit makes the demand estimation, the budget definition and the need notification. The sourcing activity is handled by a different subject, which does not coincide with the Ordering subject. In the IPS model, adopted for example in Italy (Consip 2006) and in Lebanon (OECD 2006a, OECD 2006b), the Ordering subject can be a corporate body, which can be either public or private. The other phases of the eProcurement process are managed by the Contracting unit. Differently, in the DPS model, adopted, for example, in Morocco (OECD 2006c), the Contracting unit coincides with the Ordering subject. Here the public administration which purchases goods or services manages the purchasing procedure.

Of course, IPS and DPS models have to be considered as two opposite and extreme proposals in a spectrum of organizational solutions; *hybrid* solutions can also be possible. In particular, in real situations, the final solution is often an intermediate solution between IPS and DPS. It is worth noting that two are the key differences between IPS and DPS; the DPS model reveals more effective to increase competition; while the IPS model allows the reduction of the PA's expenses in purchasing goods and services. Figure 3 shows the trade off between competition and reduction of expenses in the case the eProcurement system is realized by using IPS, DPS, or hybrid solutions.

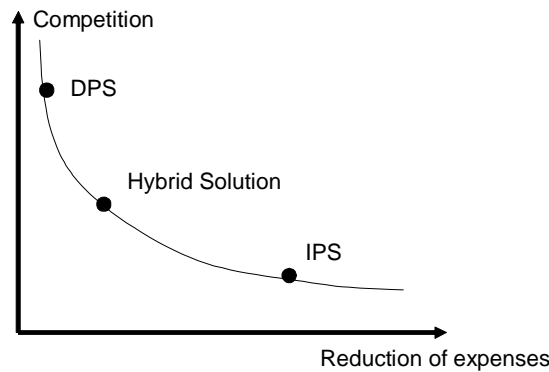


Figure 3. Evaluation of IPS, DPS, and hybrid solution benefits

From the technological viewpoint, in an eProcurement system a technological architecture is needed to coordinate information exchanges among the information systems of the several companies and the Public Authorities, trying, at the same time, to preserve the autonomy of each involved subject. The achievement of this target requires cooperation among the various administrations to develop the ICT process; also taking into account the constraints and the differences among organizations (see Batini and Mecella 2001).

In the traditional client/server transactions (see Figure 4.a), if a citizen or a business receives a service whose supplying requires the interoperation of several PAs, he/she/it has to interact separately with the different PAs involved. This result is an increase of the time for the supply of the service and a worse quality, due to the absence of an automatic process managing the operations and to problems related to the fragmentation of responsibilities, possible interruptions of services inside each agency, and for the heterogeneity of their systems. In Figure 4.b a possible technological architecture proposed to implement the improved interaction is shown.

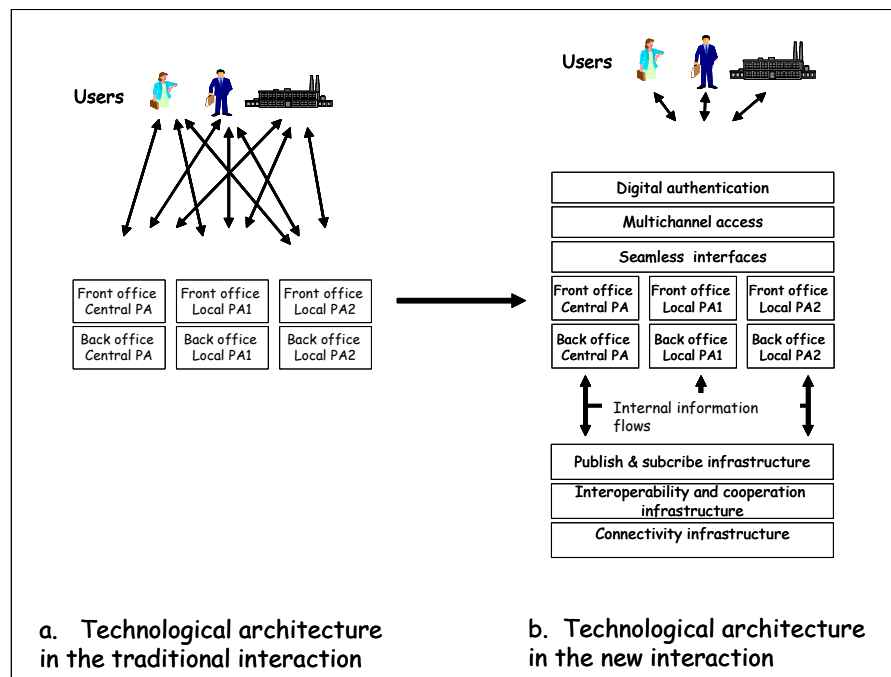


Figure 4. *The Government to citizens/businesses relationship and the new technological architecture*

The common front office layer (that is the digital authentication, multichannel access, and the seamless interface), allows a more efficient and automatic communication with the clients through the use of web based technologies (e.g. web portals), while the back-office layer is introduced to improve the communication among the different cooperating organizations. Focusing on the back-office side, through the service oriented technologies, see (Alonso et al 2004), organizations involved in a specific eProcurement process can cooperate using common interfaces, which allow the interoperable communication among them even if their internal systems are implemented with different technologies. It is worth noting that the creation of a common back office layer can be applied regardless the organizational model chosen (i.e. DPS or IPS), in fact in both cases there is the need of exchange data among different administrative office; in the DPS model such offices are members of the same public administration; while in the IPS model part of the offices involved are members of the ordering unit, while other offices are part of the contracting unit.

With regard to the economic perspective, regardless the eProcurement model chosen, the use of ICT in the procurement process may lead to benefits; for example, the costs and time reductions for managing information, and the enhanced integration, comparability and quick update of data coming from different sources. Clearly, there exist economic and social barriers to the achievements of these targets, and the possibility of achieving them is correlated with the model of eProcurement chosen by a government.

Our economic model (Figure 5) considers five main channels through which eProcurement projects increase the productivity of the public sector: the market enlargement or Smith's Effect, the substitution or Ricardo's effect, the back-office reorganization effect, the Investments-led or Schumpeter's effect, and other take-up driven effects (Corsi et al 2006). These five components enter into the estimation of the public sector productivity specifically related to eGovernment, or π_{PS} , which in turns produces an impact of the share of GDP accounted for by the public sector.

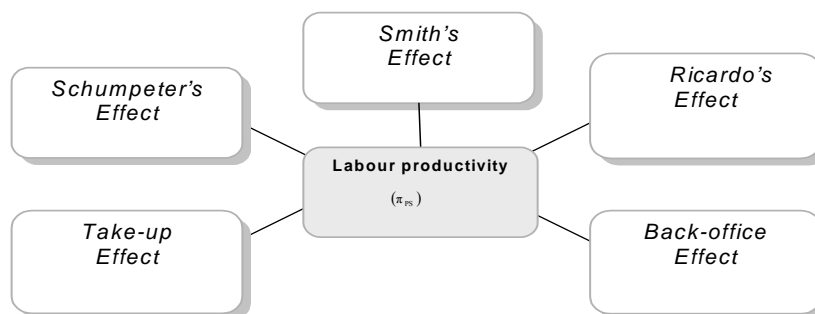


Figure 5. *The eGEP Economic Model*

In general, the crucial belief of our model is that eProcurement programs result into an improvement of labour productivity in the public sector and, as a consequence, contributes to a number of intermediate outcomes such as better services, cost savings, etc., and to GDP growth. Undeniably, the contribution of public sector to GDP can be adequately estimated as equal to the labour productivity of the public sector multiplied by the total number of public sector employees. In other words, ICT investments can induce, as a direct effect, an increase in labour productivity (more capital per worker and reorganization of the back-office procedures both in public and private context) and as indirect effect, through the well-known accelerator/multiplier effect, GDP growth. It must be stressed that our

view is a complete turn around with respect to the orthodox one of economic theory which considers public sector contribution to overall economic development, mostly focusing on the reduction of its burden to set free market forces. Our model does indeed take into account the purpose of administrative burden reduction, but it goes one step beyond to estimate how, through ICT driven innovations, the public sector can proactively enhance its capability to generate a positive impact on general growth. Our assumption is simply that the target of user centred public administrations is achieved first of all through an increase in productivity enabled by reorganization, training and ICT technologies.

With regard to organizational issues, the most effective organizational solution among IPS vs DPS vs hybrid solutions can be found in strategic planning after an evaluation of the five effects outlined above. Once they have been estimated under the different forms of eProcurement, a public administration can choose among them taking into account the following criteria. In an evaluation between IPS/DPS, a public administration should consider, for instance, that the IPS model allows i) better inventory coordination and cost control, namely, economic rationality, ii) more simplification, due to the high procedural management uniformity, and iii) improved accountability, due to the reduced decision maker units and to standardized decision making. On the other hand, the IPS model may lead to less competitive markets because not every enterprise may be able to supply all the goods and services ordered by the central administration to cover all the needs identified. In particular, there may be a stronger loss of competition if both central and local public administrations are obliged to purchase through a single subject (as in the IPS). The DPS model, instead, allows the achievement of a high autonomy of the single administrations and enables the access of new suppliers, even of the smallest and local ones; hence they may have a strong impact on competition and enable eCommerce among small and medium enterprises. However, the DPS induces a loss of control due to the improved number of decision maker units.

Concerning the juridical dimension, the new legal framework has to guarantee some fundamental juridical principles (European Commission 2004) such as equal treatment, transparency, security and confidentiality. In order to guarantee such principles, changes at organizational level (e.g in the case there is a shift from a IPS-oriented solution to a DPS-oriented one) or at technological one (in the case we decide to assign legal value to electronic document) have to be performed. In the latter case, the new legal framework and the technological strategic decisions have to be related, in order to discover the better technology to use, and new laws to be enacted (see Section 5).

4 E-PROCUREMENT PROCESS REENGINEERING

Business process reengineering is a well established practice in the design of new administrative or business processes. This phase aims at identifying a set of possible scenarios taking into accounts the current best practices in the rationalization and digitization of government activities with respect to the procurement domain and the organizational framework. That notwithstanding, in the literature as well as in field applications, there are many evidences that just putting ICT besides traditional processes, especially in contexts where the government machine is organized for functions and its operations is highly dependent on quite rigid organizational structures, may fail and even backfire. For this reason, according to the case, migration to eProcurement (as any migration from traditional ways to accomplish tasks to computer-supported modalities) could require a deeper reflection on how processes are accomplished within or across different sectors of the public administration. Hammer and Chapy (2000) introduced the concept of "Business Process Reengineering" (BPR) as a radical analysis and redesign of workflows and processes towards the achievement of new quality and performance standards according to the context. Oliveira and Amorim 2001, Henriksen and Mahnke 2005 conceived the role of ICT in BPR as that of "key enabler" (McConnell 2000) in order to obtain significant result.

Often, BPR is more a necessity than an option as in all those cases where ICT would anyway end by disrupting traditional processes or functions if roles involved and the organizational structures they are framed in are not also changed consequently. In these cases, ICT would be seen as an automating or mechanizing force rather than an occasion to fundamentally reshape the way business is done and quality standards of services are met. Accordingly, the phase of our guidelines that we call eProcurement Processes Reengineering, takes inspiration from the methodologies that in the BPR field have been proposed since the seminal five-step one by Davenport and Short (1990), but must be rather seen as an occasion to see how ICT introduction could be used as a lever to assist, motivate and foster a deeper change in any single process of Procurement. Consequently, for each critical area detected within the procurement system, new quality targets that could improve the process quality are fixed, and their achievement is the driving factor for the conception of the new process.

Within this general approach, our guidelines adopt a methodology shown in Batini and Scannapieco 2006, which jointly considers well known business process reengineering methodologies and a new approach based on data quality (DQ). The methodology is described in Figure 6.

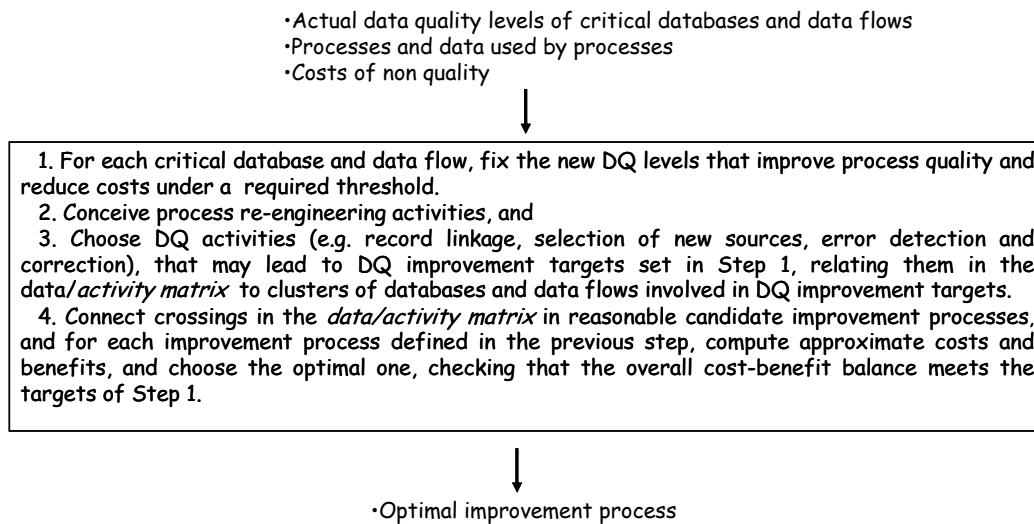


Figure 6. Guidelines for data and information management

Conceptually, the first two steps are addressed in the reengineering phase while steps 3-4 are more typical of the design phase. To explain the methodology we briefly present a real case study in the eProcurement domain. Assume that in a country a DPS solution has been chosen, and, presently, each administration manages its own business registry for procurement purposes. In Table 2 we show the result of the eReadiness phase performed on the Business registries of two administrations.

DQ dimension/ Data set	Accuracy	Completeness	Matching objects	Currency
Business Registry Administration A	90%	60%	45%	2 months delay
Business Registry Administration B	92%	40%		1 month delay

Table 2. Actual data quality levels of databases

With the term *accuracy* we refer to the closeness between values in fields of the database and corresponding true values. *Completeness* refers to the extent to which data represent the universe of businesses and *currency* concerns how promptly data are updated. Matching objects are the businesses which can be matched in the different registries; the low percentage is due to the different representations adopted, and errors in data.

Due to the autonomous management of registries, the level of completeness is low and it is the cause of a reduced number of suppliers which can be involved in tenders, leading to lower benefits deriving from competition. New data quality targets (Step 1) are to be set to at least 98% for accuracy and completeness (100% being not realistic), and 2-3 days for currency. In order to improve the effectiveness of the eProcurement process, we may reengineer the eProcurement process acting on data quality. A legislative intervention or an intra-administrative agreement can be conceived that leads to the realization of a unique certified registry of businesses, managed by a unique agency. The registry can be realized, e.g. with a record linkage activity on all registries (Step 3); such new registry can be accessed by all administrations that, depending on the specific product to be procured, may update the local database with current and complete information stored in the registry. Alternatively, the local registries can be updated from the central registry using the publish & subscribe layer of Figure 4, where the subscription service can be performed on specific business sectors (Step 2). The reengineering of the process has been pushed by the reorganization of the data architecture; see Bertoletti et al. (2005) for further discussion on a related reengineering process.

5 DESIGN OF THE TECHNOLOGICAL SOLUTION

The last phase of our guidelines is the design of the technological solution. In the spirit of the multidisciplinary approach we have to design specific solutions for all dimensions, by considering the interrelationship among them introduced in Section 1. We consider here the juridical, organizational, economic and technological dimensions.

From a juridical point of view, any eProcurement model adopted must guarantee some fundamental juridical principles (European Commission 2004) such as *equal treatment*, *transparency*, *security* and *confidentiality*. The first two guarantees (see Table 3) can be insured with several possible organizational solutions; for example, creating a National eProcurement Authority, which is the subject responsible for the eProcurement programme of a country, as well as for compliancy with the legislation operation of the offered systems (European Commission 2004). Besides, the security and the confidentiality principles are particularly related to the following aspects (Cammarota 2004):

- the juridically reliable imputability of the electronic document which contains the offer declaration, related to the goods and services which the public administration is going to purchase, made by the suppliers;
- the authenticity and non-modifiability of the electronic document which contains the offer declaration;
- the secrecy of the offer which can be visualized exclusively by the ordering subject; and,
- the certainty of the reception of the offer.

These last two guarantees could be ensured using two legally regulated instruments: i) systems of advanced electronic signature, and ii) systems of certified e-mail, which insures both sending and the reception of e-mailed documents, e.g., which contain the offer by the ordering subject.

Juridical guarantee	Solution
Equal treatment	Organizational: National eProcurement Authority
Transparency	Organizational: National eProcurement Authority
Security	Technological: •Advanced electronic signature •Certified e-mail
Confidentiality	Technological: •Advanced electronic signature •Certified e-mail

Table 3. Juridical principles and organizational/technological solutions

Concerning the implementation of the legal framework, this is often a long and complex path. First of all, it is mandatory to understand which types of norms (national law, local law, decree, technical rule, etc.) have to be enacted. They have to be clearly defined and experimented in order to avoid conflicts with existing norms and test their effectiveness. An interesting and successful solution is the institution of a kind of “safe-conduct”, adopted e.g. in the US administration. In this case, in order to evaluate the new norms, selected public administrations can experiment the new eProcurement system by using the proposed legal framework. The safe-conduct allows public employers and private organizations, involved in the new procedure, to experiment the new legal framework even if there is a contradiction with respect to the existing norms. In this case there is the possibility to face with the problem before the new legal framework is transformed in a norm.

With regard to technological issues, in Figure 7 we propose a complete set of layers for an eProcurement node, which have to be adapted to the IPS/DPS/hybrid organizational solution. The architecture is a refinement of the one introduced in Section 3. The first four layers from the top on the right hand side operate in each Administration, among them Auctions, Marketplace and Quotations refer to the software components providing services for the different types of eProcurement. The four layers on the bottom allow secure cooperation and communication among administrations. We will focus in the following on the connectivity infrastructure, the cooperation infrastructure, and cost issues.

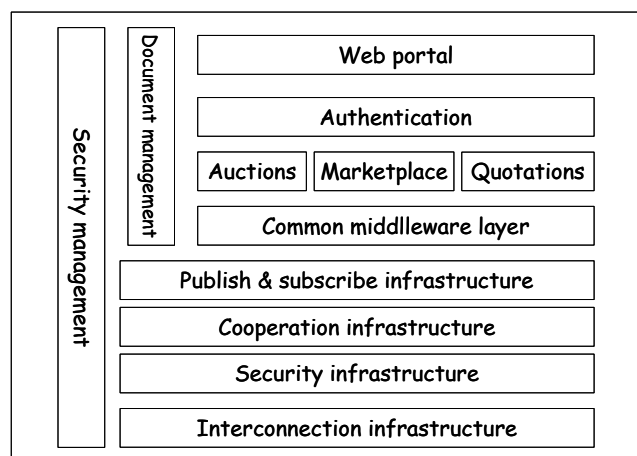


Figure 7. Technological architecture of an eProcurement node

With regard to the interconnection infrastructure, according to the degree of development of the telecommunication market of a country, it can be realized with a centralized approach or with a federated one. If the telecommunication market is developed at a poor level and is characterized by the presence of a dominant operator, it can be convenient to adopt a centralized network infrastructure. Moreover, a centralized model turns out to be useful if a country decides to implement a network by scratch. In such a model, the interoperability and communication services are managed by a unique operator who supplies all the services (local networks, access to Internet, mail, DNS, etc...) to the entities involved. This model is advantageous in terms of economies of scale, with respect to a model characterized by a (high) number of service contracts between administrations and suppliers; furthermore, it frees the administrations from the burdens related to the network deployment and management, which are outsourced to an external entity. The centralized approach introduces some considerable disadvantages that do not make it effective for a mature telecommunication market: it limits the decisional freedom of single Administrations, which are forced to choose a specific service provider, and limits the competition.

A federated approach can be followed if the telecommunication market is characterized by the presence of several providers, or else in case the network has to be implemented with an incremental procedure. The main advantages of a federated approach are: i) the high autonomy left to the single administrations, which are free to choose the service provider more suitable for their needs, on the basis of the price and of the quality of service it supplies, and ii) the push to the development of a competitive telecommunication market. The communication and the interoperability between the various entities are guaranteed through the presence of a common domain used for the inter-PA communications. In this case, the quality of service is guaranteed thanks to the collaboration of the various service providers involved: the provider of the sender, of the receiver and of the communication domain. From another side, a federated approach introduces technical and legal/contractual issues. From a technical side they are too complex to be realized to provide emergency and interoperability guarantees. From the legal/contractual side, difficulties emerge to determine the responsibility for violations among providers.

Concerning the cooperation infrastructure, in an eProcurement solution in which different organizations or PAs need to cooperate (as occurs both in the IPS approach and, to a certain extent, in the DPS approach), technological guidelines must be focused on two architectural aspects: i) the intra-organizational architecture, and ii) the inter-organizational architecture. For both issues an architectural model based on an n-tier middleware is envisioned, but while in the first case it can be only proposed a unique middleware for each organization, the design of the inter-organizational architecture reveals more complex. A three tiers architectural model based on web technology looks the best solution; from a logical point of view its main functional elements are:

- a web-based user interface implemented with Servlet and JSP technologies;
- a component managing the communication and the application logic, implemented by one (or more) web server and one (or more) application server;
- a component managing the access to data and their storage, implemented with a database server.

The components managing the application logics and providing services to clients are distributed over the different organizations involved in the eProcurement cooperative process. The communication among heterogeneous organizations should be realized in a synchronous mode (preferred) through the use of synchronous web service technology, or in an asynchronous/non-blocking mode through the exchange of messages (publish & subscribe) using asynchronous web services (or other technologies implementing message oriented middleware). In order to implement such a communication, a cooperative gateway is needed to address the problem of heterogeneity, implementing a mechanism of translation of messages, thus allowing the exchange of information among different systems.

The choice of the web service technology is due to its peculiarity in achieving the interoperability among different administrations involved in a process; this characteristic is strictly related to the

XML-based language used to describe their interfaces (Christenses et al 2001). XML, in fact, has some peculiarities which make it a de-facto standard (it is an open standard; its technological requirements are restricted being XML basically a text file, etc.). Each service can be implemented in different languages and technologies (the internal technologies of each organization), and afterwards it should be exposed through a WSDL interface, thus producing the needed decoupling to make it accessible through Internet protocols (HTTP, HTTPS).

In the eProcurement scenario each organization should publish the services it provides in a distributed and shared Repository, thus allowing the execution of queries on several archives distributed among the systems involved in the process. In an eProcurement process web services can be used for the creation of the tender workspace, to manage the registration and profiling of a client in a first step, and its authentication and authorization in a further phase, in which a user wants to access the tender workspace to search, to visualize and to download tender calls and needed documents. Moreover, they are used to support for tender submissions and, after the evaluation phase, to convey automatically the notification of results to the users.

To allow the communication among different organization, a critical issue in the design of cooperative information system is related to the presence of legacy systems in the organizations involved in the eProcurement process. Two are the possible strategies to deal with such systems:

- application engineering, consisting in the development of a new information system from scratch;
- application reengineering, that reuses some components of the legacy systems.

Our guidelines suggest the last approach. In this case there is the need to implement software components (*wrappers*) which expose legacy system functionalities as web services, but at the same time hide the internal structure of the legacy architecture.

A final element considered in our guidelines concerns cost analysis. Costs can be estimated according to different models. A cost model encompasses: i) a classification of costs, ii) criteria to reclassify cost items to the detected categories, and iii) a methodology to evaluate the amount of those items for a certain application domain, in our case the migration from a traditional procurement system to eProcurement. In the following, we will survey the most established criteria to gather costs; for sake of brevity we will only sketch guidelines to estimate them. Costs can be divided according to three main criteria: *by resource*, *by phase* (development, operational) and *by type* (fixed vs. variable and internal vs. external). Focusing on costs by resource, they can be divided in:

- technology costs (network, hardware and software); hardware costs relate to workstations, peripherals, mainframes, servers and facilities. Software costs relate to systems software, middleware and application software.
- personnel costs relate to personnel involved in developing, operating, managing and maintaining the eProcurement system as well as the customer relationship costs.
- external services costs, which refer to outsourced development and maintenance of electronic facilities, networking services, data processing and call centers; external services can be required also for strategic and high-value consultancies;
- other costs, which relate to buildings, consumable stationery, etc.

Each category of costs can be estimated once the architecture of Figure 7 has been defined and the needed bandwidth, the number of servers, workstations etc. and the size of software to be developed have been estimated. Approximate formulae are provided in our guidelines to size, e.g., human resources needed for hardware and software maintenance, hosting and help desk.

As regard costs related to organizational and regulatory change, it is important to notice that IPS and DPS can strongly differ as regard their costs structure; in fact if administrations directly manage their procurement processes, costs due to the technological infrastructure will be probably higher than the case in which one centralized agency manages procurement related activities for the whole set of

administrations. The same argument concerns organizational costs: DPS requires high training costs, as the personnel of each administration has to be trained to effectively exploit the potential advantages of electronic procurement; conversely, IPS implementation has to face costs due to reallocation of the clerks that lose their functions. Therefore, in order to estimate organizational costs, it is necessary to i) take into account the new workflow resulting from the Procurement Process Reengineering phase, ii) detect the number of resources involved and, iii) apply the estimated costs of training to the total amount of the personnel which has to be trained. From the resulting costs, the savings due to reduced personnel have to be subtracted. Unfortunately, it is more difficult to estimate both the improved productivity of the personnel due to the new modalities of work connected to the adoption of the eProcurement and the possible decrease in productivity due to personnel difficulties to adapt themselves to the new system and resistances to adopt it. When estimating training costs, it is therefore important to relate them to the different levels of involvement (ranging from awareness and understanding to acceptance and commitment) necessary to reach a desired impact on labour productivity.

6 RELATED WORK

The literature on eProcurement (Thai 2001) recognizes the necessity of an integrated effort of bringing knowledge related activities together, because public procurement is an extremely complicated function of government and requires interdisciplinary skills and knowledge including economics, political sciences, public administration, accounting, marketing, law, and engineering. Among the examples of critical issues for the successful implementation of any IT-system, Kawalek et al. (2003) stress the importance of top management support, organizational adaptation, and training of employees. Besides, Oliveira and Amorin (2001) consider an extra set of factors such as financial risk, risk of building a portal, and legislative issues necessary for the implementation of an eProcurement system. In fact, procurement is a bilateral process, and the issue of whether public eProcurement is adopted depends on the technological capabilities of public institutions and their willingness to adopt the system: whether efficiency gains are realized depends on whether potential adopters are willing to sacrifice political independency for an increase in the overall public procurement system (Henriksen and Mahdne 2005). However, the public procurement system's ability to accomplish goals or policies is influenced by its environment and, at the same time, influences the environment.

Our approach tends to stress that the use of ICT in a procurement process may lead to increased productivity of labour in the public sector because it results in a reorganization of the back-office procedures. If an effective relationship between ICTs and economic growth exists, it can be reasonable to wonder which the preconditions which make it ready are, and whether a country is more or less ready to benefit from it.

Clearly, regardless of these considerations, there are some issues in government eProcurement implementation which must be addressed. As stressed by Coulthard and Castelman (2001), a key issue for government in the design and implementation of eProcurement concerns the extent to which purchasing decisions are devolved rather than centralized, and the level at which they are devolved. In other words, a government is called to choose in terms of centralization *vs* decentralization. As governments have multiple and competing policy agendas with different stakeholders and contexts, pressures for centralization will coexist with pressures for devolution.

Another important issue regarding the design and the implementation of eProcurement in public administrations concerns the models that can be theoretically used for it. Here the choice a government must face is among public model, private model and a mixed model (Public-Private Partnership) as pointed out, among others, by Oliveira and Amorin (2001). In the public model, all eProcurement tasks (scouting, notifications, request for proposals, submission of bids, electronic catalogue, etc.) would be run by the government, which brings upon itself all the investment risks related to the project. Besides, there is a high risk due to the choice of a platform compatible with what emerges in the foreseeable future as standard technology for doing eBusiness. On the other side, in the private model all the eProcurement tasks would be run by private entities, which accept all the investment risks of the project. Clearly, this model requires more profound legislation changes than the previous

one for the simple reason that in this case a private entity will manage acts which are traditionally reserved to the public entities. Moreover, a private entity managing the public purchasing sector can raise problems in terms of competition law and transparency.

In the area of data quality, the main general-purpose methodologies are the TDQM methodology (Wang1998, Shankaranarayan 2000), and the TIQM methodology (English1999, English2002). The core concept of TDQM is to consider data as a particular output of manufacturing processes. TDQM proposes four phases to manage a generic IP along its life cycle: definition, measurement, analysis, and improvement. These phases are executed iteratively in order to implement a continuous quality improvement program. The TIQM methodology has been initially conceived for data warehouse projects, but its broad scope and level of detail characterize it as general purpose. In particular, the main contributions of TIQM are a set of specific techniques for cost-benefit analysis and a general managerial perspective. The cost-benefit analysis is conducted by analyzing non-quality information costs, finding main causes of non-quality, and conceiving projects to improve quality. A few inter-organizational methodologies have been proposed in the literature, typically designed for cooperating public institutions e.g. (BRE 2006), emphasizing the social implications of data quality. Inter-organizational domains are usually more complex, since processes and services are interrelated, competencies and functionalities are distributed across different institutions and interoperability may not be guaranteed. This greater complexity makes the assessment phase more difficult, as reconstructing the state of all data sets and flows may not be straightforward, see also De Amicis and Batini (2005).

Our approach to data quality aims at overcoming the limitations of existing methodologies. First of all, previous approaches do not tie quality improvement to explicit quality targets set by organizational management according to contingent requirements and cost constraints. These targets can be achieved with multiple quality improvement processes. The literature does not provide support to select the optimal quality improvement process which maximizes benefits within given budget limits. In our methodology the cost-benefit analysis is used to define the data quality targets on the basis of the available budget and to guide the selection of the most suitable improvement process. Our approach aims at providing precise guidelines and techniques to analyze the business contexts along all relevant aspects related to data quality issues.

Several paradigms and technologies are proposed to cope with the problem of the development of distributed cooperative systems, the most important approaches are:

- service-oriented systems (Turner et al. 2003), based on the Web service technology which allows greater interoperability (through the service composition), and reuse of software and services;
- data integration in cooperative systems which allows to achieve the transparency of data with respect to the technological heterogeneity of the systems involved (Lenzerini et. al 2001);
- intelligent agents systems and agent-based methodologies (Klush et al. 2001).

In our approach an original contribution is proposed with regard to the automatic and distributed orchestration of eProcurement process among organizations. In the presented approach, in fact, orchestration is seen as a methodology to automatize the workflow of the cooperative process among organizations involved in eProcurement, thus simplifying the process and providing better and faster services for the private sector.

7 CONCLUSIONS AND FUTURE WORK

In this paper we propose a set of methodological guidelines for building eProcurement systems in public administrations, with specific attention to the Design of eProcurement solutions phase. The key element of the methodology is its multidisciplinary approach, which considers juridical, economic, organizational, technological issues and their relationships in the design of eProcurement projects. We are now committed to practically apply the methodology in real life contexts. In fact, we are on the

point to apply the whole process in public administrations of countries such as Morocco and Lebanon. The experimentation will provide useful indications in order to better define the right balance among the theory and practical approaches, and tune the economic models.

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