



New trends on e-Procurement applying semantic technologies: Current status and future challenges



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ABSTRACT

The present paper introduces and reviews existing technology and research works in the field of e-Procurement. More specifically this survey aims to collect those relevant approaches that have tackled the challenge of delivering more advanced and intelligent e-Procurement management systems due to its relevance in the industry to afford more timely, adaptable and flexible decisions in purchasing processes. Although existing tools and techniques have demonstrated their ability to manage e-Procurement processes as a part of a supply management system there is a lack of interoperability among tools, tangled dependencies between processes or difficulties to exploit existing data and information to name a few that are preventing a proper use of the new dynamic and data-based environment. On the other hand semantic-based technologies emerge to provide the adequate building blocks to represent domain-knowledge and elevate the meaning of information resources through a common and shared data model (RDF) with a formal query language (SPARQL) and accessible via the Internet Protocols. In this sense the Linked Data effort has gained momentum to apply the principles of the aforementioned initiative to boost the re-use of information and data across different tools and processes. That is why authors review both existing open issues in the context e-Procurement with special focus on public procurement and semantic-based approaches to address them. To do so a preliminary research study is conducted to assess the state of the art in the context of e-Procurement and semantic-based systems. Afterwards main drawbacks of existing e-Procurement systems are presented to narrow down in semantic-based approaches applied to this field. Once the current status in both areas is reviewed, authors purpose the use and creation of an e-Procurement index to evaluate the quality of service of procurement systems. In this light the Analytical Hierarchy Process (AHP) method is used to set up an initial weight for each indicator in the index and to perform a first comparison between traditional and semantic-based approaches. Finally some discussion, conclusions and future challenges are also outlined.

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1. Introduction

The term e-Procurement refers to the use of electronic communications to deal with business process between sellers and buyers. It can be considered as the linking and integration of inter-organization business process and systems with the automation of the requisitioning, the approval purchase order management and accounting processes through Internet-based protocols [1].

The use of e-Procurement in business transactions [2] is not a mere transition from based-papers systems to electronic ones. It should have the potential to yield critical improvements in the efficiency of individual purchases, the overall administration and the functioning of markets. Thus e-Procurement is considered to be a strategic tool for improving the competitiveness of organizations and generating scale economies for both sellers and buyers. Critical success factors emerge in this context to tackle existing problems in two main areas: (1) the legal framework that can ensure a trustworthy environment in which business process can be executed under certain and specific secure circumstances and (2) the technical issues to be addressed in order to afford the proper coordination of processes in a heterogeneous environment in which integration and interoperability is a key-enabler for the

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deployment and management of the e-Procurement workflow. Furthermore there is an emerging necessity of gaining the right understanding of what e-Procurement is or should be. In this way organizations are trying to create the required awareness in their resources (human and non-human) to ease the transition and ensure a simplified operational environment with the aim of being cost and time effective. Thus the combination of the legal framework, the technical environment and the awareness within organizations has the potential of fulfilling the requirements of the new eco-digital system in which features for supply chain management and complex auctions should be included making it possible the automation of e-Procurement key-processes.

In this sense there is a growing commitment to boost the use of electronic communications and transaction processing by different kind of institutions and with special emphasis inside public sector organizations. E-Procurement defined as the business to business purchase and sale of supplies over the Internet can be found in a variety of ways from public marketplaces involving many firms to private exchanges [3]. In general, electronic purchasing processes are expected to apply new technologies with the aim of reducing costs, providing a more intelligent environment to make decisions in more timely and accurate fashion and improving the overall efficiency of the process. To do so some barriers [4] for the full development of an e-Procurement management system have been identified such as lack of interoperable and standard-based infrastructures (data and services), legal uncertainties including the necessity of improving trust, privacy and provenance of data and information and lack of transparency, accessibility or usability to name a few. More specifically in the context of public procurement the European Union has outlined some advantages [5] in the wider use of e-Procurement such as increase of accessibility and transparency, benefits for individual procedures, benefits in terms of more efficient procurement administration and potential for integrating European procurement markets. However several interlinked challenges to achieve a successful transition to e-Procurement are still missing in the public context: overcoming inertia and fears on the side of contracting authorities and suppliers, no means to facilitate mutual recognition of national electronic solutions, onerous technical requirements, particularly for bidder authentication and managing multi-speed transition to e-Procurement.

On the other hand, one of the mainstreams in the Semantic Web area [6] lies in the application of the Linked Data initiative [7,8] in different domains such as e-Government, e-Health, Biomedicine, Education, Bibliography or Geography to name a few, with the aim of solving existing problems of integration and interoperability among applications and create a knowledge-based environment under the web-based protocols. In this context, e-Procurement can take advantage of applying a semantic web approach based on reusing existing vocabularies and standards to elevate the meaning of information resources. In order to reach this major objective of building a re-usable data environment, the publication of information and data under a common and shared data model (RDF) and formats with a specific formal query language (SPARQL) provide the required building blocks to turn a paper-based system into a real interoperable environment for e-Procurement.

This review is intended to provide researchers, developers and practitioners a summary of the current status of e-Procurement applying semantics. Semantic technologies are therefore presented as a key driver to address this challenging environment easing the transition from paper-based systems to a real digital ecosystem for purchasing processes. To do so, the paper is structured as follows. Next section presents a preliminary study on the impact of these two areas in existing research works. Section 3 outlines the e-Procurement context with special emphasis in public procurement with the aim of presenting the necessities of this business process.

Afterwards, a brief introduction of semantic technologies is presented to continue in the next section with the review of semantic-based approaches for e-Procurement. This section is also divided into three subsections: (1) semantic-based vocabularies for e-Commerce and e-Business; (2) ontology-based e-Procurement systems and (3) semantic-based e-Procurement platforms. Finally a case study applying the Analytical Hierarchy Process (AHP) technique [9] and the Service Measurement Index (SMI) [10] is conducted to compare traditional e-Procurement systems with those based in semantics to finally conclude with some discussion and future challenges.

2. Setting the scene

This survey paper is aimed to review those works with regards to the use of e-Procurement and semantics. In order to set up the scene of research works that should be checked we have first conducted a study following the next methodology. The first stage was the design of the different queries to retrieve existing works in both areas: e-Procurement management systems and semantics. After that some typical research databases were selected to perform those queries and, thus, create a clear and quantitative measure of the impact of these areas in existing research works. Finally the third stage involved the detailed report of the results to finally identify which topics must be reviewed in the context of this survey paper. Following a detailed description of each stage is presented:

1. Design and creation of queries. In order to cover main topics in this survey: e-Procurement and semantics, a list of preferred terms have been selected to be connected through an AND connector, see Table 1. Furthermore and with the objective of restricting the search scope, a range of the last five years have been selected to retrieve relevant and most recent research works.
2. Database selection. For this first approach common bibliographic databases in the field of computer science have been selected, see Table 2. Apart from that some aggregation services such as Google Scholar and DBLP have also been checked with the aim of getting those results that can be found on other sources such as webpages or non-scientific articles.
3. Execution of the keyword-based queries on selected databases and reporting. In this stage queries have been performed in all the selected databases extracting quantitative results such as number and type of documents or search scope (title, abstract or contents). The final objective is to discover last research topics in these areas and, more specifically, those works that have implied new advances in the use of semantics to tackle existing problems in e-Procurement management systems. Here it is also relevant to highlight that as the previous section has stated the term e-Procurement refers to a set of activities that could be surveyed in separate documents. In this context, a holistic view of the process is preferred to be able to represent the whole picture of this key-process to both types of institutions private and public.

Table 3 shows the total number of articles in each database per selected year and query and it seems clear that the term e-Procurement has been widely studied during last five years. In the same way the use of “semantics” or ontologies has been successfully applied to different sectors implying a growing interest in the construction of semantic-based systems that can take advantage of domain and expert knowledge to deliver services more close to the human behaviour. However the combination of both areas: e-Procurement and semantics is still under development since few works can be found in these main databases. On the

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