Interoperability Approaches for Enterprises and Administrations Worldwide

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Abstract. During the last few years, research and practice worldwide have shown that enhancing interoperability among organizations, systems or software applications is a multi-disciplinary issue of critical importance, touching upon processes, data and technical standardization. Fortunately, researchers and practitioners have started to realize the impact of interoperability in achieving true one-stop service provision for citizens and businesses, in fostering collaboration between enterprises or in minimizing the needed investment for maintaining complex systems. Current research results show that there exist common practices to be shared among public sector organisations and private sector enterprises, in attempts related with aligning organisation and processes, tackling semantic and technical shortcomings, building relevant architectures and finally achieving the legal interconnection and co-operation of systems. The identification of such common areas between eBusiness and eGovernment can then lead to a joint exploration, enhance reuse of the real paradigms and real exploitation of results by enterprises and administrations. Also future interoperability research directions, as emerging from relevant strategies and research roadmaps of important stakeholders, and also from relevant research workshops, are outlined. Furthermore, it is argued that interoperability research should be extended towards 'knowledge interoperability' as well, and deal with the development of methods and architectures enabling the exchange of knowledge among co-operating organizations.

Keywords. Interoperability, Enterprise systems, Architectures, eGovernment, eBusiness

1. Introduction

Interoperability has emerged as one of the most vivid research areas in electronic business and electronic governance, promising a significant increase in productivity and efficiency of information systems, enterprises and administrations. This fact has been recognized both by the industrial world, governments and the European Union in their struggle to achieve better services for citizens and customers worldwide [1,2]. As a consequence, the research communities of electronic business and electronic governance have been structuring their research agendas taking seriously into account the key challenges, the main research directions and the targeted results in the continuously growing interoperability area [3,4].

Interoperability is defined as the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge [3]. Enterprise Interoperability (EI) is a field of activity aiming to improve the manner in which enterprises and organizations, assisted by means of ICT, interoperate with other enterprises, organizations, or with other business units of the same enterprise, in order to conduct their business [5].

This enables enterprises to build partnerships, deliver new products and services, and become more cost efficient. In seeking to characterize the current problem space of EI from a business perspective, the following dimensions can be identified:

- Managing rapid change and innovation in intra-enterprise and inter-enterprise collaboration.
- Adapting to globalisation and ensuring profitable development through partnerships.
- Reducing system integration and interoperability costs.
- Adopting new business models for collaboration through the use of ICT.

On the other side, Interoperability in eGovernment has been recognized as a key factor in the quest of administrations at national, local and international level to achieve the provision of one-stop services to citizens and businesses [1]. From a policy perspective, the main dimensions of interoperability in the electronic government domain can be seen to be:

- The organisational and process alignment of public sector organisations, towards collaborative service provision.
- The transformation of diversified data representations using commonly accepted standards.
- The adoption of technical standards that will ensure cost-effective development, maintenance and interconnection of platforms and systems.

Researchers and practitioners have started to realize the impact of interoperability in achieving true one-stop service provision for citizens and businesses, in fostering collaboration between enterprises or in minimizing the needed investment for maintaining and interconnecting complex systems. Within this context, the aim of this Special Issue of the Electronic Journal for e-Commerce Tools and Applications (eJETA) on "Interoperability for Enterprises and Administrations Worldwide" is to bring together researchers and practitioners investigating the organizational, semantic and technical aspects of interoperability in the worlds of eBusiness and eGovernment, so that common patterns and practices can be identified and pursued.

The remainder of the present article is structured as follows: In the following section 2 interoperability research directions, as emerging from relevant strategies and research roadmaps of important stakeholders and also from relevant research workshops, are discussed. In section 3 the need for extending the interoperability research towards the 'knowledge interoperability' as well is discussed and some foundations for this research are proposed. An introduction to the topics of interest and the papers of this Special Issue are given in section 4, while section 5 proceeds with the conclusions and recommendations for further research.

2. Interoperability Research Directions

As a policy directive, interoperability is identified as one the main challenges that needs to be overcome in order to create a unified and sustainable European Information Space. The i2010 Strategic Framework [1] recognizes that "businesses are getting productivity gains from ICT but still face a lack of interoperability, reliability and security, difficulties to re-organize and integrate ICT into the workplace and high cost of support".

From the business perspective, interoperability has been long ago recognized as a key issue for achieving high productivity for enterprises regardless of their business domain and size. To meet their business objectives – may these be penetrating the market, increasing profitability or merely surviving – enterprises have to be able to engage in seamless collaboration with other enterprises both at the business and the technical level. Successful enterprises of the future will be characterized by their ability to collaborate, their ability to adapt, and their ability to interoperate with networks of other enterprises, either internally between business and manufacturing departments and externally with their

supply network [22].. Yankee Group advises IT departments to focus on interoperability technologies and skills as a core competency imperative, envisaging more than 40% productivity gains if they succeed in achieving business and technical interoperability [2].

In this direction, escalating economic and societal demands, together with the continued mainstreaming of ICT and the need to push further the technology limits, set a growing agenda for research. According to the European Commission Enterprise Interoperability Roadmap [3], four Grand Challenges that collectively constitute a long-term strategic direction for research in Enterprise Interoperability are recognized:

- Interoperability Service Utility (ISU) that provides interoperability as a technical, commoditised functionality, delivered as services, and denotes the overall system that provides enterprise interoperability as a utility-like capability. The research in such systems is currently under way, within the 7th Framework Programme (FP7).
- Web Technologies for Enterprise Interoperability seeking to apply the concepts, technologies and solutions flowing from developments in Web technology to address the problems of Enterprise Interoperability.
- Knowledge-Oriented Collaboration which builds on state-of-the-art research on Enterprise Interoperability. Data and information sharing is a clear pre-requisite to application and interoperability of knowledge oriented support for collaborative, virtual organisations, while process, service and enterprise models are also fundamental: collaboration knowledge is knowledge of how to adapt and re-combine such models as Virtual Organizations evolve.
- Science Base for Enterprise Interoperability, by combining and extending the findings from other established and emerging sciences. This fundamental advance will allow Enterprise Interoperability solution providers to engineer solutions on rigorous, scientific theories and principles, rather than craft them based on the latest technologies and rules of thumb. It is submitted that without such a foundation, future Enterprise Interoperability research will deliver only fragmented and unpredictable results that will have increasingly limited application and marginal impact.

Furthermore, the issue of commonality of the interoperability research approaches between the private sector (promoting the interoperability among enterprises) and the public sector (promoting the interoperability among administrations) have been the subject of recent specialized workshops and conferences. Within the workshop “Software Application Interoperability for Businesses and Governments” [6] more than 30 researchers and practitioners of the interoperability domain, rated the research challenges as to their cross-domain applicability in eBusiness and eGovernment, yielding the results presented in following Table 1.

Table 1: Degree of Commonality of Interoperability Research Approaches

Interoperability Research Approach for Businesses of Administrations	Score
Web Services Specifications and Standards (SOAP, WSDL, WS-Security, WS-Reliability,WS-I profiles)	9,4
XML business documents libraries (UBL, OAGIS, eBIS-XML, xCBL,etc)	9,3
Security and authentication mechanisms (e-IDs, certificates, digital signature, etc)	8,9
Core Component Technical Specification (CCTS) modelling and components definitions	8,8
Legal and Business Rules Modelling and Execution (UML/OCL, R2ML, Business rules engines)	8,7
Data Modelling – Overall Semantics (common data dictionaries, ontologies, semantic annotation of data elements - metadata)	8,6

Interoperability Research Approach for Businesses of Administrations	Score
Overall Interoperability Frameworks (EIF, eGIFs) and certification mechanisms	8,5
Legal Frameworks modelling (ontologies for managing legal frameworks and their impact on e-Business)	8,4
Formal business process modelling and management languages (BPEL, BPMN, UMM,WS-CDL,etc) specifications	8,3
Enterprise Modelling (business processes, activities, roles, workflow models, collaborative process modelling, enterprise modelling tools)	8,1
Data Modelling – Vertical Semantics (common data exchange definitions, per sector or line-of-business)	7,9
Collaboration Oriented Platforms/Architectures (BizTalk Server, ORACLE Fusion, SAP Netweaver, ebXML implementations)	7,2

As concluded from the above Table, there is a high level of communality in the interoperability research approaches between public and private sector, which showns that there exist common practices to be shared among public sector organisations and private sector enterprises. From the same Table we can see that the top-5 interoperability research areas, concerning their commonality in businesses and administrations are related with Web Services Specifications and Standards, XML Document Libraries, User Security and Authentication, Core Component Technical Specification (CCTS) Modelling and Components Definitions and Legal and Business Rules Modeling/Execution.

Along the same direction, a relevant workshop on "European eGovernment Interoperability" organized within the scope of the eChallenges 2007 Conference [8], aimed to address the current challenges in various e-Govenrment Interoperability Frameworks (eGIFs) of European Union Member States (for a good review of them see [7], [8]), providing a forum for Public Administration officers and eGIF contributors to exchange current practices and opinions. According to the workshop's audience views on today's eGovernment Interoperability Factors, the three prevailing factors that either drive or impede the evolution of eGovernment Interoperability are (in order of importance):

i. The existence of a specific policy framework for eGovernment Interoperability.

ii. The commitment and continuous engagement of administrations in the development and enforcement of Interoperability standards

iii. The creation and application of authentication mechanisms for citizens and businesses.

The complete set of results concerning the e-Government Interoperability Factors is shown in Figure 1.

Finally, in the eGovRTD2020 Project [4], the interoperability-related themes for e-Government research have been synthesized as following:

- Semantic and cultural interoperability of public services
- Cyber infrastructures for e-Government (systems interoperability issues)
- Crossing borders and the need for governance capabilities (cross-border interoperability issues)
- Ontologies and intelligent information and knowledge management (data interoperability issues)
- Data privacy and personal identity (ID-related systems interoperability)

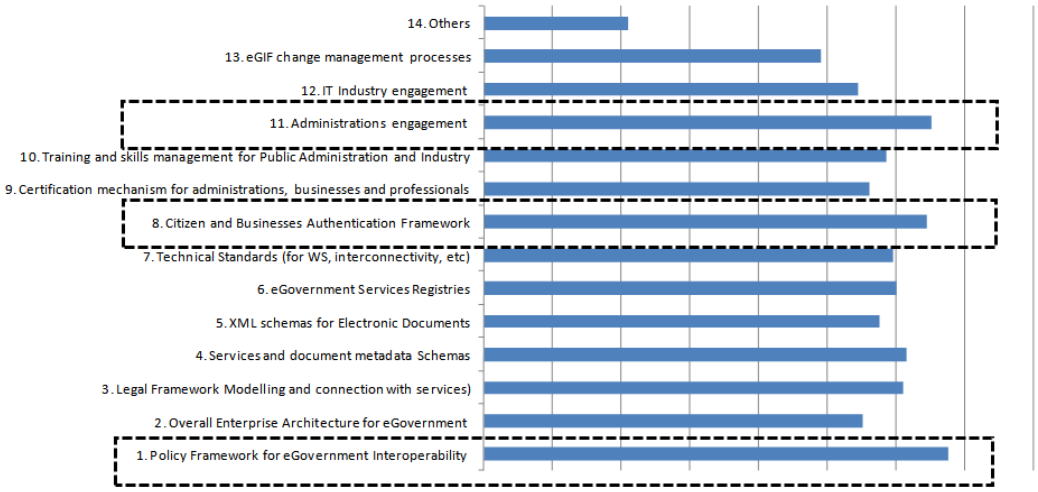

Fig. 1: e-Government Interoperability Factors

3. Knowledge Interoperability

It should be noted that most of the previous research in the interoperability area had as main objective to enable and support the exchange of data among private enterprises/public organizations, in order to support co-operation mainly at the operational level. However, today the realities and conditions of modern economies and societies necessitate the exchange of knowledge was well in order to intensify and deepen existing or emerging co-operation structures. For instance, in the public sector there is a growing need for intensive knowledge exchange bewteen public organizations having similar responsibilities (e.g. between Municipalities), concerning social problems, needs and demands, alternative courses of action for addressing them, advantages and disadvantages of each alternative, corresponding public programmes and projects they implement, etc. Similarly, the complex supply chains that have been shaped in the private sector in most industries, which include of numerous suppliers, manufacturers, wholesalers, distributors and customers-users, necessitate intensive knowledge exchanges bewteen all these enterprises, e.g. between manufacturers, wholesalers and distributors of new products concerning problems of them, alternatives for solving these problems, advantages and disadvantage of each alternative, etc. The above necessitate electronic support of knowledge exchange among private enterprises/public organizations, so that each of them can access and utilize some predefined (based on agreements between them) parts of the knowledge of others, therefore achieving 'knowledge interoperability' between them becomes gradually very important. For this reason the interoperability research should be extending towards the investigation of the 'knowledge interoperability' as well.

The research on 'knowledge interoperability' should be founded on appropriately standardizing knowledge representation and codification; some standard ways of representing and codifying the knowledge to be exchanged should be formulated, agreed and adopted by the co-operating private enterprises/public organizations. For this purpose the results of the research that has been conducted for long time concerning the codification and management of knowledge can be useful foundations (e.g. [9], [10]). Especially useful can be the results of the research that has been conducted on 'Issue-Based Information Systems' (IBIS), which provide a framework for the visual representation of highly complex 'wicked' problems, potential solutions and arguments in favour and against them ([11] – [14]) This framework has been successfully applied for the visual representation of such knowledge concerning complex problems in both the public sector (e.g. see [15] describing the representation of the collective knowledge about a public policy problem as a graph consisting of interconnected 'issue',

'alternative', 'position' and 'preference' nodes) and the private sector (e.g. see [16] describing various relevant frameworks and applications of them in various types of enterprises). Also very useful can be existing ontologies that provide elements and relations among them for the description of problems and alternative solutions to them (e.g. [17]). Extensive research is required for assessing, adapting, improving and synthesizing such frameworks and ontologies, or even for developing new ones if required, towards achieving and promoting 'knowledge interoperability' between various kinds of private enterprises/public organizations and investigate its drivers, barriers and critical success factors.

4. Special Issue Contribution to Interoperability Research

The purpose of this eJETA Special Issue on "Interoperability for Enterprises and Administrations Worldwide" is to bring together researchers and practitioners investigating the organizational, semantic and technical aspects of interoperability in the worlds of e-business and e-governance. This Special Issue targets novel approaches for achieving interoperability of organizations and systems in an international environment, touching on the following research areas:

- Peer-to-peer and server-based collaboration architectures
- Process and workflow execution models
- Collaborative process modelling
- Data and semantics modelling for interoperability
- Organizational interoperability approaches
- National or international interoperability frameworks
- Ontology development and querying for interoperability
- Data and service modelling for collaboration
- Service composition and integration
- Web Services specification and standardization
- Quality-driven data and service integration
- Data and service registries development
- Impact assessment models for interoperability
- Legal issues affecting interoperability for enterprises and administrations

The general submission articles in this Issue focus on interoperability issues, looking in particular at collaboration architectures, process and data modeling methodologies, organizational interoperability and assessment approaches. They offer new insights on implementation approaches, while they discuss adoption challenges faced by small businesses and governmental authorities worldwide.

4.1 Architectures for Interoperability

The paper "*Realising the Perspective Inter-Domain Interoperability: The Practical Power of Hybrid Architectural Approaches in Integrating Processes, Data and Services Between Businesses and Administrations*" [18] discusses the required characteristics of the predominant centralized and decentralized architectural patterns for e-transactions among business partners, identify the weak points of every case and proposes a hybrid architectural approach that brings together the "best of breed" of

both paradigms in providing for a centralized mapping of business semantics and a distributed execution of process logic.

In this context, an overview of the underlying state of the art in terms of enabling technologies, COTS products and initiatives for service, process and data integration is provided and specific insights, methodologies and underlying technologies are proposed with an objective to support the effective implementation of the proposed architecture and its components.

The characteristics of what signifies the Business Perspective of full scale ICT-enabled e-transactions both for enterprises and administrations are also outlined, while the main challenges in terms of service and data integration that need to be overcome are presented and the necessity for this to be realized in a systematic way across the entire chain of collaborating stakeholders is underlined.

4.2 Collaborative process modelling for Interoperability

The paper titled "*Designing Generic Municipal Services Process Models towards eGovernment Interoperability Infrastructures*" [19] demonstrates the conceptualization, design and implementation of a process modelling methodology, which not only describes in adequate terms the operation of a municipality and visualize the process flows for each service, but also creates service patterns that expose the adequate information for implementing interoperable solutions on a national-wide level between the different governmental organizations.

The authors' analysis indicates that by populating the proposed Service Description Worksheets, extracting the gathered data facts and constructing the corresponding process models, the composition of service hierarchies and the design of interoperable Service Patterns are facilitated. The methodology has been applied in the full span of services of the Greek Municipalities in respect to the context of the emerging Greek eGovernment Interoperability Services Framework. In this paper, the Birth Certificate Issuance service has been analyzed in detail, leading to its corresponding generic process pattern.

The study concludes into a single and unified Interoperable solution that can be used by every public administration for opening up its services to the wider public and for interacting with relevant organizations at higher automation levels.

4.3 Data modelling for interoperability

The paper "*Achieving Cross-Country Electronic Documents Interoperability with the help of a CCTS-based Modelling Framework*" [20] proposes a component-based data modelling methodology aiming at enhancing business-to-government interoperability by enabling the creation of a common, standard-based repository of data components that conforms to UBL common components but with a support of the government sector's requirements.

In this study, related research efforts which reference Business Information Modelling and Data Modelling Repositories are examined and reviewed, as the scope and the objectives of the business information modeling oriented towards governmental data is overviewed. Based on UBL (Universal Business Language) and CCTS (Core Components Technical Specification), a component-based data modelling methodology enhancing business-to-government interoperability is discussed, creating the basis for a repository of governmental data models. The repository currently includes Periodic VAT Statement, Annual VAT Statement INTRASTAT Statement - Arrivals, INTRASTAT Statement – Dispatches, Social Security Statement and Declaration of a new employee in the span of four countries, i.e. Greece, Italy, Cyprus and Turkey, while the soundness of the proposed methodology is proved in this study with the help of a real world paradigm extracted from the Periodic VAT Statement document.

The approach adopted also has the potential to serve as guidelines for creating and transitioning between “generic - harmonized” and “specific - contextualized” documents.

4.4 Interoperability Assessment Models

The final paper “*Towards Standardising Interoperability Levels for Information Systems of Public Administrations*” [21] presents a novel methodology for identifying patterns and assessing interoperability levels in governmental organisations and systems. Taking into account that before administrations start restructuring processes and changing their procedures, they initially need to identify exactly where they stand and where they are aiming to be in the future, this work contributes to addressing exactly this need. It provides a method that will help the administrations to understand assess and their current position as to interoperability, identify the gap they need to fill, determine the weaknesses and deficiencies they need to improve and define their exact target position prior to formulating and implementing a full scale Interoperability Transition Plan for further adopting and implementing eGovernment initiatives.

The Government Interoperability Maturity Matrix (GIMM) proposed in this paper aims to provide administrations with a simple to use, semi-automated, self-evaluation method that can be used to assess the current status of the administrations concerning eGovernment interoperability and the steps that need to be taken in order to improve their position in respect to system implementation and services provision to citizens and businesses. The paper expands the three types of interoperability considered in the European Interoperability Framework (EIF) identifying several Interoperability Attributes that need to be taken into consideration in order to evaluate each organization positioning in eGovernment interoperability. Within this modeling context, levels of existing interoperability status of organizations are clearly defined, while certain, practices or directions lead to interoperability state changes within the maturity matrix.

5. Conclusions

Nowadays, Enterprises and Governmental Organizations seem to be, more than ever, challenged by the accelerating pace of change and innovation, since globalization is putting increasing pressure on their operational efficiency and is demanding from them to decrease their operating costs. The issue of interoperability remains high on the European Union agenda on electronic services of public interest, notably as part of the new strategic framework “i2010 - A European Information Society for growth and employment” and the various related initiatives and programmes.

Despite the development of Strategic Frameworks and Interoperability Roadmaps, the emergence of standards and the implementation of various interoperability-related projects across the world, investments in ICT research regarding interoperability need to continue attracting interest in order to achieve real integration of IS both at the intra-organizational and inter-organizational level and to take full advantage of the opportunities promised by the envisaged future for eBusiness and eGovernment. Towards this goal, several approaches show that can serve both domains, when the specificities of each domain are taken in mind.

In the present Special Issue original research works addressing process, data and organizational aspects of interoperability are presented, which aim to contribute to the current knowledge in the interoperability domain and to have an impact upon further advancements in this domain.

Acknowledgments.

The authors and editors of the Special Issue express their gratitude to the eJETA.org editorial board, the authors and the reviewers for their efforts and support, in making this issue a reality.

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