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Yannis Charalabidis

University of the Aegean, yannisx@aegean.gr

Fenareti Lampathaki

National Technical University of Athens, flamp@epu.ntua.gr

Dimitris Askounis

National Technical University of Athens, askous@epu.ntua.gr

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A REVIEW OF INTEROPERABILITY STANDARDS AND INITIATIVES IN ELECTRONIC GOVERNMENT

Charalabidis, Yannis, University of the Aegean, Karlovassi, Samos, Greece, yannisx@aegean.gr
Lampathaki, Fenareti, National Technical University of Athens, 9 Iroon Polytechniou Street,
Athens, Greece, flamp@epu.ntua.gr
Askounis, Dimitris, National Technical University of Athens, 9 Iroon Polytechniou Street,
Athens, Greece, askous@epu.ntua.gr

Abstract

Being important at organizational, process and semantic levels, interoperability became a key characteristic of the new electronic government systems and services, over the last decade. As a crucial prerequisite for automated process execution leading to “one-stop” e-Government services, interoperability has been systematically prescribed, since the dawn of the 21st century: Standardization frameworks, that included guidelines ranging from simple statements to well defined international Web-Service standards started to appear at National and Cross-Country levels, powered by governments, the European Union or the United Nations. In parallel, most international software, hardware and service vendors created their own strategies for achieving the goal of open, collaborative, loosely coupled systems and components. The paper presents the main milestones in this fascinating quest that shaped electronic government during the last 10 years, describing National Frameworks, key Pan-European projects, international standardization and main industrial and research achievements. Moreover, the paper describes the next steps needed to achieve interoperability at technical, semantic, organizational, legal or policy level – leading to the transformation of administrative processes and the provision of low-cost, high-quality services to citizens and businesses.

Keywords: *e-Government, Interoperability, Electronic Government Interoperability Research, National Interoperability Framework*

1 INTRODUCTION

Electronic Government refers to government's use of technology, particularly web-based Internet applications to enhance the access to and delivery of government information and service to citizens, business partners, employees, other agencies, and government entities (Layne & Lee, 2001). Virtually unknown a decade ago, e-government as a term, as an identified activity, and as a topic for research has grown dramatically (Heeks & Bailura, 2006). However, the promise of e-government is not, as some suppose, putting existing paper-based processes of bureaucracy into digital form. Rather, the promise is really nothing less than a profound transformation of the way the government does business (Garson, 2004) and it is not an objective per se; more it has to be seen as means in organizing public governance for better serving citizens and enterprises (Traunmiller & Wimmer, 2004).

During the last decade, all countries across Europe and internationally have spent a lot of money in e-Government and the modernization of the public sector, as total (including central, regional and local layers) public administration ICT expenditure in 2004 for EU25 is estimated at about € 36.5 billion, with € 11 billion devoted in e-Government reforms (eGEP, 2006). Since the benefits of e-government became apparent, the number of worldwide e-government projects has also increased in the time period between 1996 and 2001 from three to more than five hundred national initiatives (Al-Kibsi et al., 2001). Throughout these years, e-Government has gone an evolutionary, yet controversial path: from the initial enthusiasm and e-ecitement spiraled out of proportion to losing its magic (Scholl, 2006) and

being at a crossroads between a number of other research domains, particularly computer science, information systems, public administration, and political science (Heeks & Bailura, 2006). Despite the fact that government reality today is explicitly seen as what "would have seemed a utopian dream just a decade ago" (Garson, 2004), e-Government is claimed to have fallen short of its potential to transform government service delivery and trust in government (West, 2004).

In this context, interoperability appears as a key enabler to unlocking full potential for the public sector. Since its inception as "The ability of systems, units, or forces to provide services to and accept services from other systems, units, or forces and to use the services so exchanged to enable them to operate effectively together" (DODD, 1977) and through the years, interoperability tends to obtain a broader, all-inclusive scope of a repetitive, well organized, and automated at ICT level feature of organizations, as indicated in the definition of the draft EIF 2.0 (IDABC, 2008): "Interoperability is the ability of disparate and diverse organizations to interact towards mutually beneficial and agreed common goals, involving the sharing of information and knowledge between the organizations via the business processes they support, by means of the exchange of data between their respective information and communication technology (ICT) systems".

Eliciting the 4-stage models of Layne and Lee (Layne & Lee, 2001) and the EU Measurement Reports (Cappemini, 2007), e-Government evolution is now measured against a five stage model which designates interoperable governmental agencies as the last stage (Connected-Stage V). Without interoperable E-Government systems, today's public administrations struggle to keep pace with rapid evolving economic alterations, advancements in technologies and regular emergence of new legal settings (Ziemman et al., 2008). Improved interoperability among public organizations and between public and private organizations is of critical importance to make electronic government more successful (Pardo & Tayi, 2007; Gottschalk, 2009), while according to (Benamou et al., 2004), interoperability is a key concept for understanding the changes in progress in e-government which are made gradually and with a phased implementation.

According to an article on interoperability published in Financial Times, successful interoperability dramatically cuts the costs, risks and complexities of hooking up and represents a challenge to competition policies in Europe and America (Schratz, 2009). Yankee Group further advises IT departments to focus on interoperability technologies and skills as a core competency imperative, envisaging saving more than one-third of the cost if they succeed in achieving business and technical interoperability (Yankee Group, 2009). However, since projects involving integration, interoperation, and interoperability have been conducted from different vantage points, such projects in e-Government are multi-faceted and complex and run a high risk of failure (Scholl & Klischewski, 2007).

In this context, the present paper presents the main milestones in this fascinating quest that shaped electronic government during the last 10 years and aims to explore the advancements made by National Frameworks, key Pan-European projects, international standardization and main industrial and research achievements. Moreover, the paper describes the next steps needed to achieve interoperability at technical, semantic, organizational, legal or policy level – leading to the transformation of administrative processes and the provision of low-cost, high-quality services to citizens and businesses.

The remainder of the paper is structured as follows: In the second section, the progress in e-Government Interoperability standardisation is discussed, providing the state of the art, background and related work - leading to a discussion around the main observations. Guidelines on the way forward are presented in section 3 while section 4 proceeds with the presentation of the conclusions.

2 INTEROPERABILITY INITIATIVES IN ELECTRONIC GOVERNMENT

In the realm of time, a plethora of interoperability initiatives originating either from the public sector, the standardization organizations or the industry has emerged leading to a prevalent standards

dilemma. As depicted in Figure 1, there is a diversity of initiatives developing standards that address particular interoperability requirements at legal, organizational, semantic and technical level, but are designed on such a different basis that make the choice of a specific standard to be adopted a new challenge for organizations, which is further undermined by the fact that they are constantly changing.

In this paper, interoperability progress in Electronic Government is examined under the prism of:

- e-Government Policies and Strategic Plans at national or cross-country (i.e. pan-European) level
- Governmental Initiatives summarized into National Interoperability Frameworks and e-Government Projects implementation
- Research results emerging from academia and industry that have been disseminated as academic publications or projects deliverables.

Further initiatives indicated in Figure 1 include: Vertical standards that may conflict or move in parallel with e-Government, such as e-Health, e-Defense and e-Payments; Working Groups and Committees, such as IFIP WG 8.5 on Information Systems in Public Administration and NESSI iGov WG; Future internet envisioning initiatives, such as the EC Enterprise Interoperability Research Roadmap (EIRR). Finally, as far as most international software, hardware and service vendors are concerned, they have already created their own strategies for achieving the goal of open, collaborative, loosely coupled systems and components with IBM, Microsoft, Oracle and SAP being the typical examples following this path.

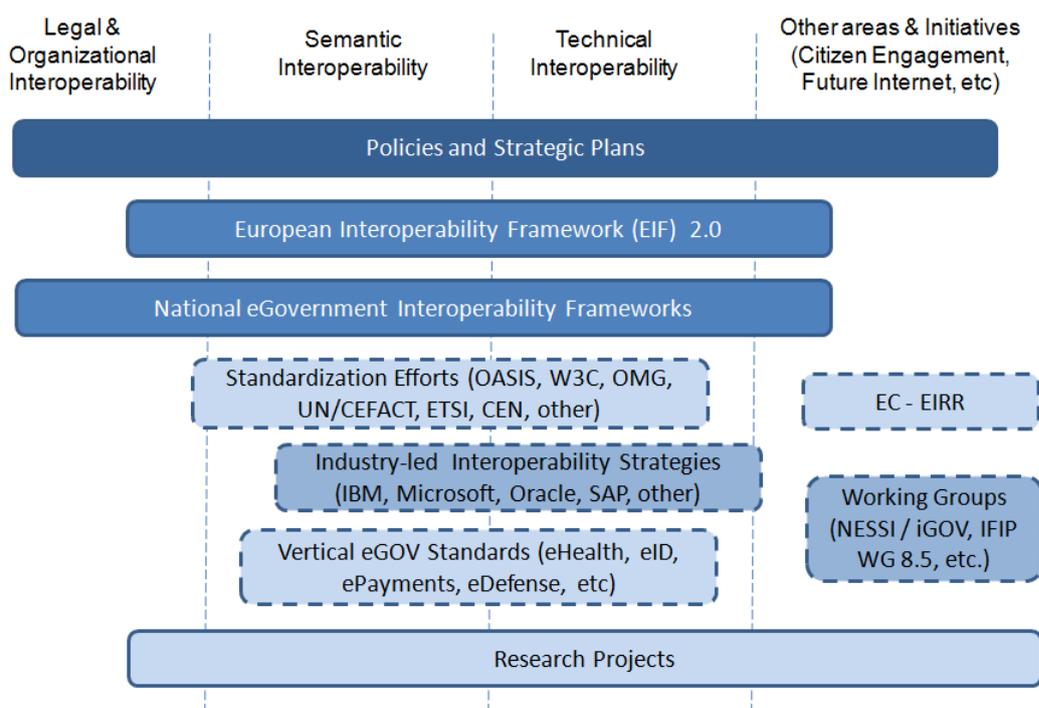


Figure 101. Interoperability-related Initiatives

2.1 Interoperability in Pan-European and International Context

Today, e-Government is well embedded in policies and strategies across the world defining their milestones and action plans at national and cross-country level. Drawing on OECD observations, governments around the world are realizing that continued expansion in e-services is not possible without some kind of integration of back end government systems. Whereas earlier the emphasis of e-Government was mostly on developing e-services, the increasing importance of cross-organizational coherence today has clearly shifted the focus towards building, and managing, integrated and coordinated government services.

In the European Union, interoperability has become the key issue in the agenda of the public sector (CEC, 2006b) since providing one-stop services calls for collaboration within and across public authorities. i2010, the strategic action plan of the European Commission which replaces eEurope initiatives and comes to fulfill the Lisbon's Strategy objectives, (CEC, 2006a), (CEC, 2006b) explicitly addresses interoperability as a prerequisite for "devices and platforms that 'talk to one another' and services that are portable from platform to platform" and identifies it as one of the main building blocks for the single European information space of eServices (SEIS). In fact, the achievement of pan-European, cross-border interoperability is a key element and prerequisite of all the EU's ambitious e-Government initiatives while new challenges (such as the EU Services Directive 2006/123/EC) appear that need novel approaches in solving long-standing cross-country interoperability issues.

In the United States of America, the "e-Government Act of 2002" (Public Law 107-347) has been regulated to enhance the management and promotion of electronic Government services and processes by establishing a Federal Chief Information Officer within the Office of Management and Budget, and by establishing a broad framework of measures that require using Internet-based information technology to enhance citizen access to Government information and services, and for other purposes.

In Australia, the 2006 e-Government Strategy charts how the government will build on progress in e-government to date, and how to progress towards the vision of connected and responsive government by 2010.

e-Government interoperability is also becoming an increasingly crucial issue, especially for developing countries that have committed to the achievement of the Millennium Development Goals (MDGs) by 2015 (UNDP, 2007).

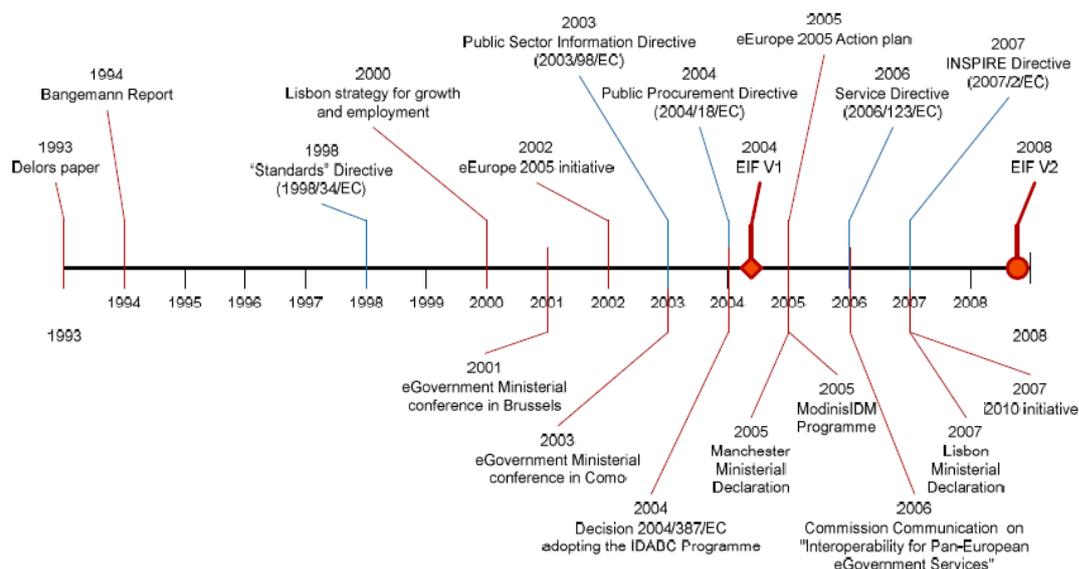


Figure 102. e-Government Interoperability in EU Policy Activities

In this context, most OECD countries are in the vanguard of a move towards efficiency and efficacy many countries are in the process of integrating e-government policies and strategies with transformation policies and strategies (UN, 2008). Since the implementation of e-government implies different objectives and levels of transformation in public services in different countries (Weerakkody et al., 2006), a future-oriented approach to e-government research is thus just beginning leading many EU Member States to revise their existing strategies for public sector modernization and e-Government transformation (Dawes, 2008). For instance, in the USA, the main objective is to automate and integrate different islands of information to simplify and maximize the benefits of technology, whereas in Europe

the emphasis is to modernize public services and offer better services to citizens (Weerakkody et al., 2006).

2.2 Interoperability in Governmental Initiatives

Interoperability research is closely linked to the topic of standardization, since the ultimate goal of standards is to ensure interoperability and integration of different systems. Today, implementation standards for e-Government have been specified and guided by National e-Government Interoperability Frameworks (NIF) that pose today as the cornerstone for the resolution of interoperability issues in the public sector and the provision of one-stop, fully electronic services to businesses and citizens. Such interoperability frameworks aim at outlining the essential prerequisites for joined-up and web-enabled Pan-European e-Government Services (PEGS), covering their definition and deployment over thousands of front-office and back-office systems in an ever extending set of public administration organizations (Charalabidis et al., 2007).

According to the European Interoperability Framework (IDABC, 2008), an Interoperability Framework describes the way in which organizations have agreed, or should agree, to interact with each other, and how standards should be used. In other words, it provides policies and guidelines that form the basis for selection of standards and may be contextualized (i.e. adapted) according to the socio-economic, political, cultural, linguistic, historical and geographical situation of its scope of applicability in a specific circumstance/situation (a constituency, a country, a set of countries, etc). NIFs further provide the necessary methodological support to an increasing number of projects related to the interoperability of information systems in order to better manage their complexity and risk and ensure that they deliver the promised added value (Ralyte et al., 2008) functioning as an umbrella for explaining the relationships among the projects and managing change (Janssen, 2007).

Current frameworks in this direction have been adopted across the European Union and internationally, as indicated in Table 1. Generally, the initiators of these frameworks have been practitioners or public administrations which are pursuing the goal of standardizing across distributed organizations and avoiding technology vendor lock-in (Klischewski, 2004; Legner & Lebreton, 2007).

Typically, a NIF includes the following sections (UNDP, 2007):

- Context with definitions, aims, objectives, principles, background, audience, benefits and relationship with other initiatives
- Technical content that mentions key technical policy statements, architectures, standards, standards categories, standards selection criteria and standards status
- Development process that describes the development and revision process, actors and responsibilities, and mechanisms for consultation
- Implementation that prescribes support tools, such as the website
- Compliance regimes, such as interoperability indicators, responsibility for compliance, stakeholders, guide tools and non-compliance

Such frameworks distinguish different layers of interoperability and provide standards and technical recommendations (Ziemman et al., 2008) for each of these layers with the most mature results emerging for technical and syntactic (as part of semantic) interoperability (Charalabidis et al, 2009b). However, interoperability research needs to focus particularly on those fields where compatibility is still low, i.e. areas with lacking or conflicting standard developments or with lacking uniform implementation of standards (Legner & Lebreton, 2007).

Country	National Interoperability Framework
European Union	European Interoperability Framework (Draft Version 2.0)
US	Federal Enterprise Architecture (FEA)
Australia	Australian Government Interoperability Framework
Belgium	Belgian Interoperability Framework (BELGIF)

Country	National Interoperability Framework
Brazil	Standards of Interoperability for Electronic Government (e-PING)
Denmark	Interoperability Framework
Estonia	Estonian IT interoperability framework
France	Référentiel Général d'Interopérabilité (RGI)
Germany	Standards and Architectures for e-Government Applications (SAGA)
Greece	Greek e-Government Interoperability Framework
Hong Kong	HKSARG Interoperability Framework
Ireland	Reach Interoperability Guidelines (RIGS)
Italy	SPC – sistema pubblico di connettività e Iceland Under investigation Cooperazione
Malaysia	Malaysian Government Interoperability Framework (MyGIF)
Malta	e-Government Interoperability Framework
Netherlands	Dutch Government Reference Architecture (NORA)
New Zealand	New Zealand E-government Interoperability Framework (NZ e-GIF)
Poland	Krajowe Ramy Interoperacyjności
Spain	Criterios de seguridad, normalización y conservación de las aplicaciones utilizadas para el ejercicio de potestades
Switzerland	Helvetic E-Government Reference Architecture (HERA)
United Kingdom	e-Government Interoperability Framework (e-GIF)

Table 1. Overview of National Interoperability Frameworks

Moving from theory to practice, the e-Government led implementation of ICT in public administration during the last ten years has offered better, faster and more transparent means for citizens and businesses to interact with government (Capgemini, 2007; UN, 2008). In this context, websites appear as the highly visited manifestations of e-government developments. According to the UN Web Measure Index (UN 2008) which provides UN Member States with a comparative ranking on their ability to deliver online services to their citizens, of the 192 UN Member States, 189 were online this year. Only three of the 12 countries (Central African Republic, Somalia and Zambia) that did not provide any services online in 2005 are still in the same situation today. It further indicates that countries must continue to improve their national and ministry portals and web sites to keep up with the demands of their citizens, since even the top-9 countries in the e-Government Readiness have not yet achieved interoperability of their infrastructures as indicated by the gap between Stages I (Emerging) and V (Connected) in the following table. Such a gap can be attributed to the fact that in most countries a wealth of independent e-government projects has been implemented, yet they have limited coherence and remain largely uncoordinated (Janssen, 2007) without solving the real systems integration problem.

Country	Stages					Total
	I (Emerging)	II (Enhanced)	III (Interactive)	IV (Transactional)	V (Connected)	
Denmark	100%	97%	89%	80%	93%	89%
Sweden	100%	95%	89%	81%	78%	88%
United States of America	100%	98%	90%	65%	78%	85%
Norway	100%	92%	90%	70%	70%	84%
France	100%	92%	73%	49%	85%	74%
Republic of Korea	100%	93%	76%	50%	59%	73%
Netherlands	100%	92%	75%	43%	52%	70%

Country	Stages					
	I (Emerging)	II (Enhanced)	III (Interactive)	IV (Transactional)	V (Connected)	Total
<i>Canada</i>	100%	91%	71%	43%	48%	68%
<i>Australia</i>	88%	92%	61%	45%	70%	67%

Table 103. UN Web Measure Index Extract for top-9 countries

2.3 Research Results

E-government (or digital government) research has been in progress since the mid 1990s. Research is most extensive and advanced in Europe and the United States, but significant work is also now being conducted in Asia, India, Latin America, and other parts of the developing world. The first phase of e-Government research focused mostly on ways to devise, implement, and evaluate online information and services to citizens, as well as on citizen involvement in the decision making processes of government. The US research “agenda” comprises an eclectic set of topics and problems, in contrast to the European approach which connects research funding to overarching governmental goals (Dawes, 2008).

According to Legner & Lebreton (2007), the discussion of interoperability within the scientific community started in the early 1990s with a significant increase of publications since 2004. A large number of e-Government-related publications on integration, interoperation, and interoperability has been published by and for distinct communities of practice encompassing all levels and branches of government, both nationally and internationally (Scholl & Kliskewski, 2007). Earlier research has mainly focused on the information structures and interfaces or the communication and transport level, whereas recent work introduces a broader perspective on interoperability on the one side, and increasingly addresses semantic aspects and business process compatibility on the other side.

Upon querying the most prominent databases ISI Web of Science, SCOPUS, DBLP (Faceted / Complete Search), Citeseer and Google Scholar for the combination of terms “interoperability” and “e-Government”, the results suggest that:

- Interoperability is recognized as an inter-disciplinary research topic with high political and technological value. In fact, according to the DBLP Faceted Search, the term is more and more debated in the research community during the last decade, since in 1998 the research papers came up to 88, in 1999 136, in 2000 185, in 2001 186, in 2002 253, in 2003 340, in 2004 452, in 2005 686, in 2006 665, in 2007 597 and in 2008 616. The semantic aspect of interoperability has attracted the most attention through the years, yet the organizational and legal aspects have also gained momentum recently.
- e-Government research constitutes a thriving research domain from all aspects – scientific, entrepreneurial, societal and political - that becomes more rigor (Gronlund, 2006) and flourishes during the last years. In DBLP Faceted Search, the e-Government – related papers have increased from 39 in 1998 to 716 in 2008.
- Recently, interoperability in e-Government is acknowledged as the main driver for delivering effective cross-country electronic government services towards citizens and businesses. Consequently, there has been increasing pressure on the academic and practitioner communities for research that focuses on bridging the gap between e-government and interoperability theory and practice and this attitude is anticipated to be more and more reflected in emerging research results in the forthcoming years.

Furthermore, it needs to be taken into account that in order to enable a cooperation of public administrations and to cross-link the corresponding information systems, the European Commission has launched several research projects in the area of interoperability (i.e. the FP6 Interoperability Cluster Projects, such as ATHENA-IP, Interop-NoE, GENESIS, FUSION, etc.) or with interoperability aspects, such as the FP7 COIN, NEXOF-RA, iSURF and G.I.C.. The importance of interoperability at a pan-European

context, with the active participation of the software and services industry is also depicted in the Competitiveness and Innovation Programme (CIP) recent research initiatives to provide solutions in key infrastructures and interoperability standardization, such as the PEPPOL project (for e-Procurement at pan-European context), STORK (dealing with eIDs) and SPOCS (that aims to implement the Services Directive 2006/123/EC) projects.

2.4 Observations

By looking at how policy making, national and international initiatives, research and standardization on interoperability has evolved over the last years, one can draw significant conclusions as also mentioned in relevant recent studies (Gerson, 2008; MODINIS, 2007; PricewaterhouseCoopers, 2009) on the current shortcomings at national and international level. Such observations cover the full spectrum of organizational, semantic and technical aspects of interoperability in governmental services provision and are as following:

- Although interoperability is well-sought for at a national context, powered by National Interoperability Frameworks and country-wide initiatives for one-stop electronic service provision, cross-country collaboration issues are an important barrier. Initiatives at pan-European or International level do not yet have the necessary momentum to shape solutions that will break the national barriers and provide citizens and businesses with the ability to obtain or provide services outside their home country in a seamless way.
- The transformation of the national legal structures is posing as an important gap that needs to be bridged, so that the necessary processes and final service outputs become an everyday practice for citizens and businesses. Organizational and semantic interoperability solutions usually ask for significant changes in the legal system, if to be embodied into the everyday practice of public sector officials. This fact is becoming more of a problem than a mere challenge, as the systematic support needed for managing and guiding this legal transformation is not yet a common practice.
- The diffusion of needed basic infrastructure, such as electronic ID's, base registries and fundamental governmental web services has not reached the minimum needed threshold – directly affecting the adoption and sustainability of otherwise novel and applicable approaches, springing out from the research community or the industry. Despite the fact that e-Government investment is still strong, prioritization and goal-setting is still not efficient enough to prevent attempts to develop highly progressed, interoperable infrastructures for final service provision, before going systematically after the basic enablers.
- Although interoperability standardization is a very active field both for the industry and the national governments, the systematic creation, maintenance, and diffusion of standards and best practices has not been achieved yet. As a result, stakeholders still fail to find their way within thousands of pages and web sites, usually yielding to lower adoption of standards or, even worse, to the reinvention of the wheel. A system-based support of interoperability standardization is clearly needed, especially as the practice communities are more and more looking for service implementation patterns, open source software components or standardized XML schemas and not for plain paragraphs of text.
- Going further in the systematic provision of solutions to complex, multidisciplinary problems, we also need a completely new approach towards the interoperability science: formalization methods, assessment metrics, complexity algebra, conceptual theory, logic and rules, ontology engineering, simulation and stochastic methods are now to show their potential within this 'discipline of many disciplines'. Adding theory to practice, and being able to generalize this new knowledge will soon be needed in e-Government interoperability. But mostly, as the first prototypes of such approaches, driven by talented researchers, are finding their ways in public administration worldwide, it has to be shown how scientific excellence leads to better services for all.

3 THE WAY FORWARD

Moving forward towards the second decade of interoperability in e-Government, the e-Government research agenda needs to expand in order to achieve resolution of interoperability at all levels, either legal and organizational, semantic or technical, and exploit the advancements achieved as Web evolves from global hypertext system to distributed platform for end-user interaction with the help of Web 2.0 tools (mash-ups, service front-ends, social software, etc.). In a research agenda for e-Government integration and interoperability, Scholl and Klischewski (2007) suggest future research projects to study the focuses, purposes, limitations, and constraints, as well as the processes and outcomes of integration and interoperation in electronic government. From the review of the existing research, four types of challenges that business interoperability researchers should tackle in the forthcoming years have also been identified by Legner and Lebreton (2007). These challenges concern: (1) interoperability of integrated value networks, (2) the economic assessment of business interoperability, (3) the determination of optimal interoperability levels as well as (4) the design of internal and cross-organizational process and system architectures for interoperability.

The implementation of e-Government initiatives throughout the world has spotlighted the importance of governmental interoperability service utilities or interoperability base registries, which will facilitate the seamless exchange of information and resolve interoperability issues during electronic service provision (Charalabidis et al, 2008a). Such infrastructures are devoted in engaging the public sector in order to formally describe information that is usually dispersed in the public authorities, like:

- Service description, using extended metadata sets and formal notations and means for process modeling (Sourouni et al., 2008)
- Unified data modeling for governmental forms, using XML and UN/CEFACT CCTS methodologies and standard national or international codelists (Charalabidis et al, 2008b)
- Specification of manual and electronic (web) services execution, in a machine-retrievable way

The common understanding and the explicit e-Government knowledge ensured by such governmental interoperability service utilities or registries bridge the gap between decision making and technical realization of e-Gov services based on appropriate e-Government ontologies while supporting all phases (design, configure, deploy, run) in the lifecycle of e-Gov services. However, most such infrastructures currently play the role of information containers for the definition and retrieval of XML data templates, failing to effectively assist in service transformation and execution. Based on recent analysts reports, Interoperability Registries have to play a more active role in service execution within the oncoming landscape of new eGovernment services (Gartner Group, 2007), while their descriptive power can be further combined with Business Process Management and XML Authoring tools, filling the gap between static representation of services and dynamic, automated service transformation (Charalabidis et al, 2009a). The promised advantages from such infrastructures are ground-breaking, as they can be used for on-the-spot electronic service composition from existing web services, for managing and modifying the service flows with immediate propagation towards all involved administrations or even for controlling content federation among multiple Governmental Portals. Among the countries that have already started to move towards this direction are met: (a) Australia with its GovDex initiative, (b) Denmark that has deployed the InfoStructureBase tool, (c) Germany through its X-Repository and DVDV (German Administration Services Directory) infrastructures and (d) Greece with the help of its Interoperability Registry.

e-Government research further needs to concentrate on resolving organizational and co-ordination issues, since technical interoperability and connectivity between systems is readily addressed through the use of existing technical standards and support middleware such as Web services (Medjahed et al., 2003). Public administrations need to become more extrovert and adopt a service-driven approach, that implies binding the public administration processes with specific information exchanges among the stakeholders or systems, that take part during service provision to citizens and business according to the underlying legal framework. Furthermore, achieving a common understanding of semantics for the

governmental information exchanges needs to be put high on the agenda since it is a particularly vexing problem that has arisen due to a disagreement about the meaning, interpretation, or intended use of the same or related data.

Today, public sector process transformation is a complex undertaking involving distributed decision-making that requires a good understanding of the political context, business processes and technology as well as design and engineering methods capable of breaking through the traditional boundaries that exist between public bodies. Government Transformation thus constitutes a research area that has started recently to gain more and more momentum in the international researchers' and practitioners' scene and is highly dependent from the resolving interoperability in the public sector (Themistocleous & Irani, 2002). The Standard Cost Model (SCM) (The Standard Cost Model Network, 2009) appears as a simplified, consistent method for estimating the administrative costs imposed on business by central government, while research activity-based costing and simulation approaches either propose a model-driven transformation of service provision (Charalabidis et al, 2009a) or calculate the cost of e-Government services (Andersen & Medaglia, 2008), based on the complementary application of the IDEF0 modelling tool (Hadzilas, 2005). In order to effectively model and transform governmental services, such methodologies need to be extended and broadened in order to obtain a more profound understanding of administrative burdens since:

- Public administrations will have to calculate and reduce the cost of a service at the task or activity level both from their point of view and from the perspective of citizens and businesses.
- Transformation and re-engineering efforts in public sector organizations have to follow “longer and deeper circles” that take into account the citizens views, wishes and behaviours, since the time needed for adoption and application of changes is usually larger than in a private sector enterprise.
- The impact of legislation is just another aspect of what needs to be measured in a service-oriented approach.
- Governmental Registries can provide patterns and guidelines for systematically transforming service and document definitions and coordinate the business process re-engineering efforts in the public sector.
- A new wave of internet-based applications, which now go under the name of Web 2.0, launched with very little investment and with a disruptive impact on the social life of people, can be exploited in order to capture the public realm in government transformation efforts (Osimo, 2008).

Up to now, the principal tools for targeting the interoperability challenge appear as the various standards that try to govern information systems development and operation as indicated in Section 2. Such standards are usually linked with specific market sectors, application areas or technology trends, thus having a limited time span, a static nature and quite often different interpretations by technology vendors. Interoperability has thus to be studied and developed as a rigorous mathematical and scientifically-lawful phenomenon, following scientific practices similar to neighbouring domains – such as those of Systems/Complexity science, Information science, Services science as well as Economic and Social sciences. In this context, a scientific base for interoperability, by means of a new set of concepts, theories, and principles derived from established and emerging sciences, or associated methods, techniques, and practices for solving interoperability problems in e-Government needs to be formulated.

According to Schratz (2009), creating cost-effective rules of engagement for customized interoperability will be a fantastic business challenge since interoperability standards can create or destroy innovation oligopolies and monopolies. To this direction, measuring effectiveness, defining metrics of success (such as ‘reuse’ of systems and improved service delivery), and using Key Performance Indicators (KPIs) to evaluate progress is a research area that needs to be further investigated in order to promote interoperability in e-Government.

Electronic Business (e-Business) presents today a series of success interoperability stories in its portfolio, proposes solutions (Gionis et al., 2007), (Bouras et al., 2007), (Gionis et al., 2008) and sets

guidelines in an environment with many similarities compared to e-Government. Applying therefore best practices from other domains and mainly from the e-Business domain appears as a worthwhile track towards e-Government interoperability.

Finally, co-ordinating efforts together with breeding interoperability best practices within the e-Government interoperability domain can be included into a governance model for interoperability in the public sector that will stimulate the application of successful interoperable cases and bring to the same page all stakeholders through dissemination, co-ordination and training activities.

Summing up, emphasis needs to be laid on: (1) design and implementation of appropriate infrastructures in the form of base registries accompanying the NIFs; (2) transformation and re-engineering efforts that fully integrate front- and back-office systems; (3) exploiting Web 2.0 tools in e-Government; (4) strengthening organizational and semantic interoperability aspects; (5) building a science base for interoperability; (6) creating interoperability value assessment models; (7) applying best practices from other domains and (8) co-ordinating efforts within the e-Government interoperability domain.

4 CONCLUSIONS AND FURTHER RESEARCH

Recent works have shown that interoperability is a very useful capacity of organizations and systems: it can assist governments and enterprises in jumping onto the next streams of service delivery. By setting and solving specific, highly repeatable patterns of interoperability problems, scientists and practitioners can now greatly assist in achieving record-time/high-quality electronic service delivery for citizens and businesses. Interoperability is now, after more than 10 years of e-Government practice, beginning to emerge as the most important capacity of systems, be them human-based or automated. Interoperability is a multi-disciplinary characteristic, affecting the provision of digital public services at policy, legal, organizational, semantic and technical level.

In this quest of public sector administrations to achieve on-line collaboration among their systems and organizational units, orchestrated by international organizations and assisted by the research and practice communities, several important steps have been made the last 10 years:

- Most countries in Europe, Asia and the Americas have established National Interoperability Standardization Frameworks, that is sets of guidelines for designing and implementing information systems that can “exchange information seamlessly in depth of time”.
- European Union has set ambitious targets for interoperable electronic ID’s, cross-country electronic procurement and pan-European electronic service delivery, while managing the deployment of the new European Interoperability Framework 2.0.
- Almost all international software and service vendors have recently been developing and maintaining their own interoperability strategies, in an attempt to show how important the new characteristic is for their products portfolio – but also in attempt to achieve successful final implementations of information systems based on their technology offerings.
- The research communities have been intensifying their efforts to come up with solution-oriented ideas on interoperability, doubling the generated knowledge every two or three years, powered by relevant umbrella programmes and research frameworks worldwide.

However, the assessment of real applications and adoption rates by citizens and businesses shows that there are still significant steps to be taken by administrations and industry worldwide, in order to achieve the interoperable delivery of services in everyday life. Further research on interoperability in digital public services provision will have, in the next years, to face the multi-disciplinary nature that interoperability problems present. Having a sound basis on information systems research, interoperability community has now to reach other systemic or social sciences and follow on new directions, such as:

- The design and deployment of federated infrastructures for managing common semantic definitions and information elements, standards and folksonomies needed for service provision at national and

international level. Such base registries, properly solving their maintenance challenge through content syndication, will soon become the key enablers of automated process execution, or executable interoperability.

- The development of simulation tools, assessment models and metrics for evaluating and forecasting the real benefits of service transformation and system-to-system collaboration - towards the reduction of administrative costs and the minimization of service yield time.
- The adoption of Web 2.0 and Enterprise 2.0 approaches for greatly assisting the adoption of new one-stop services by citizens and businesses.
- The incorporation of legal and business rules within information systems, allowing for fully automated service provision by interconnected systems and services.
- The development of formal tools for the description of the complex problem space and for associating interoperability solution patterns, thus providing scientifically sound approaches to repeating problem scenarios, found within administrations and their information systems.

Moreover, as new systems and management approaches emerge, posing more interoperability challenges and asking for proper goal-setting, a scientific base of e-Government Interoperability will have to be supported by policy-making, decision support and programme/project design tools – allowing for proper goal setting and orderly implementation of relevant initiatives.

Finally, specific attention will have to be given in developing an e-Government Interoperability training curriculum, as training of the public sectors officials has already been recognized as another key factor towards the embodiment of interoperable digital public services within public administration processes, in the everyday life.

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