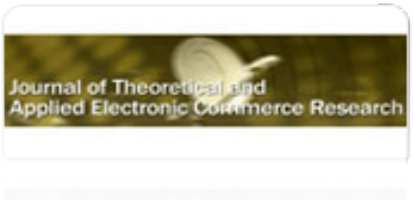

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ncerpa@utalca.cl

Universidad de Talca

Chile

Janssen, Marijn; Charalabibis, Yannis; Kuk, George; Cresswell, Tony

Guest Editors' Introduction. E-government Interoperability, Infrastructure and Architecture: State-of-the-art and Challenges

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Guest Editors' Introduction

E-government Interoperability, Infrastructure and Architecture: State-of-the-art and Challenges

Since the late nineties, most countries have released their e-government strategies and defined various approaches resulting in significant progress at all levels of public administration. Despite the progress, the level of ambition was higher which has resulted in disappointments. One of the causes of the limited progress is that many e-government efforts are confronted with a lack of interoperability and integration of systems and the need to develop or expand the infrastructure. Creating interoperability and integration is a complex endeavor [23], [28]. Service provisioning in networks is likely to fail if the systems of the public agencies are not properly integrated. The integration of systems and activities extends to greater collaboration and integration between agencies [14] and can provide substantial benefits [8]. Infrastructures provide a platform and functions as a vehicle for creating e-government [10]. Infrastructures provide not only the secure and reliable connectivity, but also more and more functions are embedded in the infrastructures which are shared by many organizations and can be used to build an online presence [10].

E-government should be viewed as more than a simple layer put on to of existing structures. In the digital era public organizations are changing their strategies, structures, processes and IT-infrastructure to fully benefit from the promises of information and communication technology (ICT). Sometimes the claim is that transformation should be reached if e-government is going to succeed [27]. Organizations and departments should collaborate, join-up, create chains of activities, operate in networks and act as an integrated whole towards the public. This requires a reshaping of the public sector and needs new business models. To make this happen, interoperability is a fundamental requirement which should ensure that diverse systems, processes and organizations are able to work together using a shared infrastructure. Government architecture (GA) is the instrument to ensure that interoperability can be achieved. GA provides an abstract description and prescription of a set of elements and the relationships among them to create a holistic view on the ICT in an organization or organizational network, which is guided by principles to support decision-making and further development. GA can be used within a single organization, but for achieving interoperability GA needs a scope that goes broader. This makes it much harder to develop a GA. The architecture efforts are aimed at improving (parts of the) infrastructure, which refers to the actual situation in operation which is used to connect the many public organizations, businesses and citizens. An advanced infrastructure is a necessary condition for accomplishing interoperability. However, despite the fact that there are huge opportunities and there is already substantial research conducted in this field, there remain many practical and research issues open.

Relating Architecture, Infrastructure and Interoperability

The overwhelming majority of citizens and businesses still have to deal with multiple public organizations. These organizations cannot operate in isolation anymore and need to collaborate with each other. In the digital era, public organizations are changing their strategies and structures and processes to fully benefit from the promises of ICT. Departments and institutions start collaborating and interoperating across organizational boundaries. E-government was initially driven by adopting e-commerce ideas, but in the last decade, it has emerged as an research area on its own, giving attention to the specific public sector characteristics. Similar to e-commerce, e-government requires multi-agency collaboration and integration of their disparate business processes and information systems. The unique characteristics of e-government, such as accountability, transparency, equal access, sharing of information and collaboration instead of competition, have played a major role and produced a new research direction aimed at meeting the broader expectations of society.

There is a tendency to mix up and broaden the concepts of architecture, infrastructure and interoperability. Although this can be explained from the need for having more interdisciplinary and holistic approaches, this results in conceptual unclearness and indistinct concepts. Having a clear vocabulary is necessary to advance our understanding of the field and to understand how the various research efforts and conceptualizations are related to each other. *Interoperability* is a multifaceted concept and refers to the ability to let independent systems communicate and exchange information with each other [23]. Interoperability is defined by the IEEE as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" [7]. *Interoperability* is the ability of diverse systems and organizations to work together [23].

The *infrastructure* is what materialized to enable interoperability and is necessary for e-government. Public agencies, businesses and citizens make use of the infrastructure to connect, provide services and engage in policy-making and participation. The Next Generation of Digital Information Infrastructure (NGDII) provide not only interconnectivity, but also a range of functionalities that are used by large numbers of users [10]. Infrastructure refers to the current structure which is used by many organizations to enable interoperability. Infrastructures are aimed at making it easier for organizations to collaborate, to provide services and to interact with each other. Many stakeholders are involved

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in developing the complex infrastructure which makes this a typical socio-technical development endeavor characterized by emergence, evolution, self-organization and openness [10].

Any functioning organization using ICT has either an explicit or implicit 'Architecture'. Generically, a government architecture is the conceptual description of the set of elements and the relationships between them [2] and is aimed at creating a coherent and consistent set of relationships among (sub)systems [5, 13]. Similar to enterprise architecture, which refers to the scope of an enterprise [22], we opt for using the term 'government architecture' to refer to the scope of government. A commonly used definition is that of the architecture working group as described in the IEEE Std 1471-2000 "Architecture is the fundamental organization of a system embodied in its components, their relationships to each other, and to the environment, and the principle guiding its design and evolution" [1].

Government architectures can support a broader range of objectives and typically goes beyond the interoperability aspect [9]. Basically, GA is the overview of the enterprise as a whole, from helicopter point of view in which you not only look at the existing state but also at possible future states. GA links the strategy and policies with the technology and operations. GA is something abstract and is a frame of reference to guide the creation of new ICT (design as the creation of an artifact) and at the same time serves as a framework for positioning the design projects within a larger frame. New projects are aimed at improving (parts of the) infrastructure (the actual reality, i.e. implementations) and take into account the relationships as depicted by the architecture (or link between strategy and designers). The experiences and results of the ICT projects and insights from research efforts influence the prescriptive architecture, as new standards, architectural principles, technologies, reusable services and building blocks appear. The progression of GA should be viewed as an evolving process of accumulation. Recently governance aspects are given more and more attention and considered as complimentary to GA efforts. Governance is sometimes considered to be part of architecture, blurring the original conceptual meaning. We argue to separate the governance of architecture, i.e. architectural governance, from architecture to avoid conceptual unclearness. IT-Governance mechanisms determine how communication, responsibilities and decision-making structures are formalized [29]. In a similar vein architecture governance deals with how the architecture is used by assigning responsibilities, introducing decision-making structures and ensuring communications. In this way it should be clear who is responsible for maintaining the architecture, how projects should use the architecture, what the procedures are to deviate from the architecture and so on.

The Context

As more governments move to online activities and look for ways to innovate their service provision and citizens engagements they are confronted with the bundling of services, working in supply chains, opening their data and creating new service offerings. Instead of just making use of their own internal data, systems talk to each other and public organization must now link their systems with others. Interoperability is one of the most critical issues facing government that need to access information from multiple information systems. Interoperability might again gain more importance with the advent of open data movement. By viewing interoperability as the ability of divers systems and organizations to work together, we implicitly suggested that that there are various levels of abstraction. Apart from the systems and organization level, it is possible to distinguish the following levels.

- *Organizational interoperability* aims at ensuring that organizations collaborate in a harmonized way together. In this way collaborating in networks and joined-up government can be reached.
- *Interoperability of processes* aims to make various administrative and policy-making processes work together. In this way cross-agency processes or supply chains can be created.
- *Interoperability of services* aims at creating new services or systems by discovering and composing services and sharing these services with each other. In this way new services can be created out of already existing parts.
- *Interoperability of applications* aims at integrating application with each other in such a way that they work in concert, functioning virtually as one.
- *Interoperability of data* aims to make work together different data models with different query languages to share information coming from heterogeneous systems. In this way data and information can be exchanged, combined and made available.

Each level of abstraction requires that the lower levels of abstraction are accomplished. Joining-up among government organizations involves all the above levels. It is not necessary to accomplish the highest level of abstraction, as interoperability initiatives might often be limited to the simple exchange of data.

Improving interorganizational interoperability involves addressing many challenges outside the hierarchical control of the managers within a single agency. Collaboration requires the chained execution of tasks by different organizations that are responsible for these tasks and are often part of different hierarchies as depicted in figure 1. At the bottom of

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this figure is shown that the agencies are connected by a shared infrastructure. The agencies work together in a loosely coupled structure, where the overall performance depends on the weakest chain and the process of collaboration needs to be managed. There are many legal and organizational impediments as agencies are accountable and responsible for their roles and functions to the higher levels in the hierarchy, but not to the agencies involved in the cross-agency processes. As a consequence, there is often no straightforward way to establish which agency is responsible for the whole cross-agency processes, whereas the managing requires the monitoring of the workload, progress, service levels, taking measures to maintain and improve the performance. New governance mechanisms are required to give direction to the development, coordinate the efforts and decision-making, and control the chained execution. In such a network there are various forms of interoperability.

- *Network, supply chain or interorganizational interoperability* concerns the interoperability which is necessary to ensure interoperability among organization working together to make services available;
- *Vertical or policy-making interoperability* is the interoperability necessary to translate laws and policies into operational processes that can be executed and to ensure the working of the hierarchical structure;
- *Internal, intra-organizational or internal horizontal interoperability* is the interoperability among departments within one organization to work together.

Whereas internal interoperability is the most advanced in practice and interoperability for working in chains/networks has gained a lot of research attention, vertical interoperability is the least researched area. This process often involves many partners and organizations. The automatic translation of changed or new legislation is a cumbersome and long-lasting process which has hardly been given the attention it deserves from both practitioners and researchers.

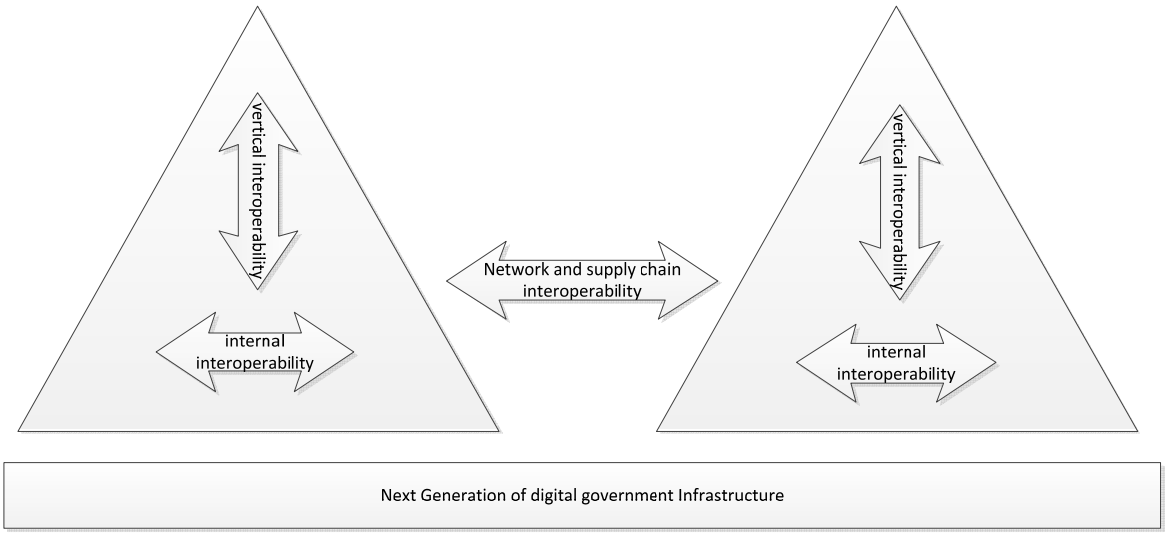

Figure 1: Cross-agency Processes and Hierarchical Control

Interoperability is a highly complex research field as it covers many aspects. The creation of interoperability among systems is easier said than done, as it covers a wealth of different areas and aspects ranging from organizational to technical functions. Obstacles that impede the rapid creation of organizational chains are not merely technological in nature. In fact, the technological aspects may turn out to be far less of a challenge than the organizational, legal, political and social aspects [12]. The siloed and fragmented nature resulted in heterogeneity, the lack in insight among the dependencies among organizational and technical aspects hamper progress.

The technical complexity combined with the complexity of managing a process in which many diverse stakeholders are involved result easily in failure. Organizations have different absorptive capacity and resources and part of large institutional arrangement. Infrastructure and interoperability benefits are highly dispersed across many stakeholders. The negative network externalities, institutional context and first-mover disadvantage penalize early adopters, as at a later stage other standards might be adopted. Institutions ensure stability to reduce uncertainty, but complicates change [16]. Institutional environment facilitate or retard processes of technical and structural [15], which complicates the introduction of new infrastructures and enabling interoperability. Creating interoperability and developing infrastructures requires new capabilities to select and integrate partners and their services and to monitor the execution. This process of incremental development is still ill-understood.

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Standards are essential for facilitating interoperability and creating a shared infrastructure. A main challenge is the agreements on terms as often organizations have developed their own interpretations or differences are determined by law. There are many standards available that can potentially be used. Ideally data standards are published on the Internet, made accessible and have good descriptions to enable reuse by others. Despite the availability of standards many developers still neglect these and develop their own data formats and models which result in interoperability problems which become only visible in the longer run when systems need to be connected to other systems. Software vendors often prefer their own proprietary data format, as the use of open standards is by some software vendors viewed as making it easier to switch to other products, rather than using those sold by the software vendor. This does surely not hold for all software vendors, as many of them have embraced open standards. The enabling role of standards the uptake of standards have been limited research within the e-government community.

Developments and Challenges

Interoperability is a vivid research area covering a wide variety of facets. Many researchers draw a distinction between the syntactic, semantic and pragmatic levels of interoperability [20, 26, 30], in a way that is similar to the semiotic framework for interoperability (physical, empiric, syntactic, semantic, pragmatics and social) [20] and the seven levels of the conceptual interoperability model (technical, syntactic, semantic, pragmatic, dynamic and conceptual) [26]. The *technological* level refers to the transportation network, which includes elements like security, reliability, domain names and authentication, and facilitates the higher layers of interoperability The *syntactic* level refers to the structure and adherence to standards. The *semantic* layer should ensure that the communicating systems interpret the information in the same way by adding meaning. Finally, the *pragmatic* layer refers to all aspects relating to the embedding, organization and other context-sensitive aspects of meaning. Pragmatics is concerned with the *purpose* and links to the lower layers to the intention by embedding these in the context.

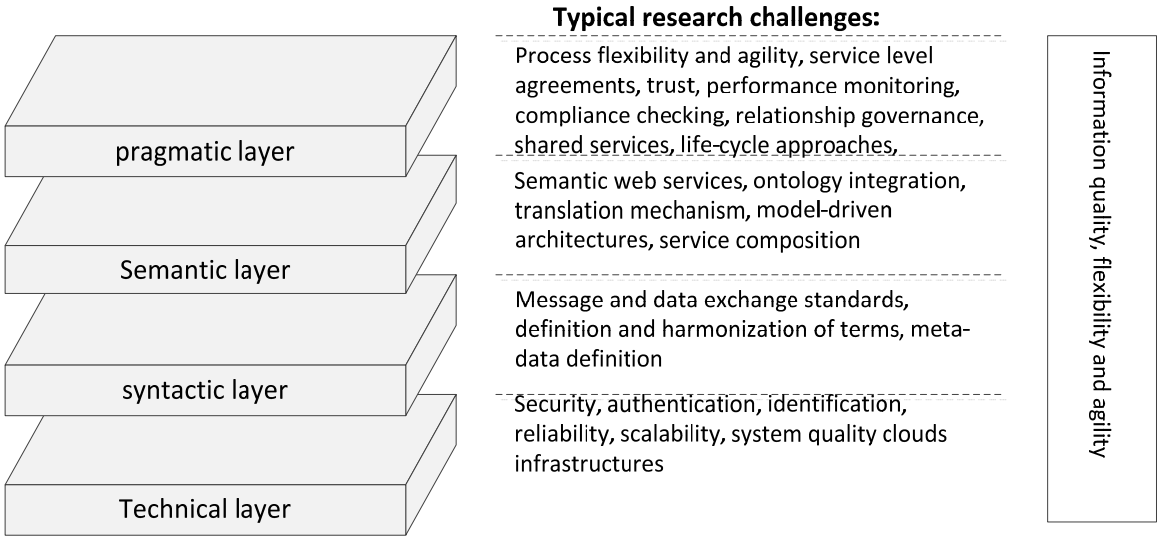

Figure 2: Classification of research Challenges

In the last years interoperability has been improved at the technological level by the introduction of Service-Priented Architectures (SOA) and web-service technology and at the semantic level by the creation all kinds of ontologies and the use of semantic technologies [11]. Figure 2 shows that many research issues remain open at these levels. There are arguments that the emphasis is shifting to the higher layers [12]. Research challenges include the following.

- **Transformation and re-engineering approaches**. Information and communication technology has been heralded for the ability to transform the public sector to increase service levels and lower costs. Despite the promises, achievement has been criticized and e-government has largely been limited to the digitization instead of changes of the public sector. Extensive change is often considered as necessary to leverage the benefits of technology. Hence, context-specific transformation and re-engineering approaches are necessary to create sustainable changes at all levels. This includes the evaluation of the impact and benefits.

- **Process and organizational interoperability**. Traditionally interoperability has focused on the exchange of data among organizations. The open source movement added the transfer of software to this. Nowadays this has shifted to the exchange of services and even the exchange of complete business processes among organizations. Services and processes can be developed once and reused by others. There is a need to come to a global framework for administrations [4].

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- **Semantic service composition, integration, invocation and sharing of service.** Semantic interoperability issues still remain unsolved [17]. By merging semantics with web services new kinds of interoperability is created. New systems can be created by composing them out of existing readily available building blocks instead of building them from scratch. Service registries are an essential part to be able to have an overview of services [24].

- **Enterprise Application Integration**. An important domain within the interoperability field is enterprise application integration (EAI). This is an approach aimed at linking previously separated and isolated systems to give them greater leverage [25]. EAI is a framework for combining a variety of integration technologies, such as message brokers, adapters, web services and application servers.

- **Agility and flexibility**: The ever-increasing stream of changes driven by changes in technology, organization and legislation requires organization to continue adapt. The environment must be flexible enough to permit adding or removing individual systems from the integrated structure without major modifications. In this way increasing the time-to-market of new services and products and the adoption to legislations [6]. Rule-based systems, ontologies, event-driven service oriented architectures requires ample research.

- **Next generation Infrastructure**. Infrastructures evolve over time and adapt to new situations and should be conceptualized as socio-technical systems [10]. There is still limited knowledge about strategies to guide infrastructure development and which functions and services should be part of the infrastructure. Moreover, all kinds of infrastructures emerge having different characteristics. More research into the interplay between social and technical aspects and into which direction infrastructures develop is necessary.

- **Cloud infrastructures**. Clouds and infrastructures are interrelated as clouds are infrastructures ensuring aspects like scalability, reliability, security, speed of response and so on. There is no consensus about a definition of clouds. Generally, clouds offer resources on demand [21] from which application services can be accessed over a network [3]. In essence it concerns the pay and use of distributed, low-cost hardware. Software as a Service (SaaS) are provided over clouds and more research is necessary about the value and use of clouds and SaaS.

- **Architecture-based and model-driven approach**es. There is no consensus about what constitutes government architecture and what elements should be included. Architecture and governance aspect influence each other and one cannot do without the other [9]. Hence, not only what an architecture looks like, but also the role of architecture in interoperability and infrastructure development should be further researched.

- **Process management and life-cycle approaches.** Process management deals with the control of the administrative processes. Mechanisms for 'smart' approaches to enterprise interoperability, including performance monitoring, compliance checking and adaptive control, need to be developed.

- **Open data.** Open data refers to the making access to data sources available. The ability to capture, in an effective and formal manner, and then process them ensuring the right interpretation by understand the context and limitations becomes important. Privacy is a concern as in business and government organizations, information systems often handle sensitive data about individuals and other organizations [18]. Data management in a heterogeneous environment has been one of the most challenging problems because information lies in multiple legacy systems and is stored in multiple, conflicting formats distributed over many public organizations. Information exchange and aggregating and processing data should deal with aspects like privacy and security and ensure a proper interpretation of the results.

- **Information quality and information registries**. Infrastructures contain often many information sources which all have different data and information quality. The use of this information by others requires that information can be trusted on and that incorrect information is not shared with others. Information quality assurance requires extensive quality audits and controls. Such quality checks require new changes in the information exchange.

The need for a better understanding of all these areas is necessary.

Paper Overview

Against this backdrop, this special issue is aimed at contributing to the understanding formulation and elaboration of the issues involved in e-government interoperability, enterprise architectures, and solutions and strategies for governments, based on a combination of sound theoretical basis and empirical research. The special issue is a culmination of the papers written by experts in this area. In total 36 submissions were received from which 9 papers

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were selected for this special issue. The nine papers comprising this special issue have undergone a rigorous double blind review process. The papers can be classified in the areas of infrastructure, interoperability and the design and application.

Infrastructure

Infrastructures are utilities that are used by organizations, businesses and citizens. The first paper named "The next generation information infrastructure for international trade "authored by Stefan Henningsson, Uri Gal, Niels Bjørn-Andersen, and Yao-Hua Tan focuses on one type of digital government infrastructure for international trade. This infrastructure is addressing the challenge of simultaneously increasing control and security and lowering the administrative burden for traders.

The second paper "A flexible IT infrastructure for integrated urban planning" by Wout Hofman, Walter Lohman and Ab Schelling presents an IT infrastructure based on an event-driven architecture with the objective to decrease the turnaround time for urban planning. Event-driven service-oriented architecture promises to enable flexibility and can create customized processes [19]. The IT infrastructure developed integrates various data resources and calculation models for analyzing different scenarios.

Implementing e-government infrastructures and interoperability can be done using various strategies. In the article "Architectures for Tinkering? Contextual Strategies Towards Interoperability in E-Government" by Ralf Klischewski the case of Egypt is analyzed to examine the role of service-oriented architecture in the control and drift of the government infrastructure. Strategies towards e-government interoperability should select architectures based on reflection of the specific implementation context.

Interoperability

Seamlessly information exchange is a continuous problem in many situations which should be achieved by ensuring that divers systems are able to work together. Andreas Kuehn, Andreas Kappeler, Michael Kaschewsky, Andreas Spichiger, Reinhard Riedl describe in their paper "Interoperability and information brokers in Public Safety: An approach towards seamless Emergency Communications" propose a general architecture for overcoming the interoperability problem among emergency responders.

In the paper "Information Systems Interoperability in Public Administration: Identifying the Major Acting Forces through a Delphi Study**"** by Delfina Soares and Luis Amaral a vast amount of factors are unveiled that influence systems interoperability which contributes to better understanding the pragmatics of interoperability. This paper clearly shows that there are still many obstacles and challenges that need to be addressed to ensure interoperability. Interoperability and architecture cannot be used without proper governance mechanisms. Gianluca Misuraca, Giuseppe Alfano, and Gianluigi Viscusi analyses the role of interoperability using a conceptual governance framework in their paper "Interoperability challenges for ICT-enabled governance: towards a pan-European conceptual framework ".

Design and Application

The last section of this special issue addresses relevant research area in the field of designing architectures and interoperability. Ontologies and clear vocabularies are a key aspect of interoperability. Fred Freitas, Zacharias Candeias Jr and Heiner Stuckenschmidt analyze semantic deficiencies in two legal codes responsible for defining vehicles' categories in their paper "Towards Checking Laws' Consistency through Ontology Design: The Case of Brazilian Vehicles' Laws".

E-government requires extensive transformation and the changes achieved so far have been limited. Adamantia Pateli and Sofia Philippidou discuss business process engineering and change in their paper "Applying Business Process Change (BPC) to Implement Multi-Agency Collaboration: The Case of the Greek Public Administration".
Services are made more and more accessible based on the life events and business episode. In the last paper "Integration of government services using semantic technologies" by Ján Hreňo, Peter Bednár, Karol Furdík, Tomáš Sabol a semantic system for helping citizens and businesses is presented. Making services accessible by using semantic technologies requires that the semantics are agreed on by public administration, which poses a significant challenge.

This special issue is aimed at contributing to the understanding formulation and elaboration of the issues involved in e-government interoperability, enterprise architectures, and solutions and strategies for governments, based on a combination of sound theoretical basis and empirical research. The collection of these nine papers shows the state of the art of research and developments in the field of e-government interoperability, infrastructure and architecture. This special issue also suggests that many research directions are open, and the current research addresses only the tip of the iceberg. In this way we encourage researchers to tackle the many research questions in this area.

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Marijn Janssen[1], Yannis Charalabibis[2], George Kuk[3] and Tony Cresswell[4]
Guest Editors
[1]Delft University of Technology, Faculty of Technology, Policy and Management, The Netherlands, M.F.W.H.A.Janssen@tudelft.nl
[2]Information Systems Laboratory, University of the Aegean, Greece, yannisx@aegean.gr
[3]Nottingham University Business, UK, g.kuk@nottingham.ac.uk
[4]Center for Technology in Government (CTG), University at Albany, USA, tcresswell@ctg.albany.edu
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