Building the Next Generation of Digital Government Infrastructures

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ABSTRACT

Digital Government Infrastructures provide generic functionalities that are used by large numbers of users. Typically, they have no central authority, are governed by networks and contain both emerging and purposefully designed parts. Their use varies over time, and a large number of individuals use them for different purposes. The basic digital government infrastructure has evolved over time and the development towards the next generation of digital government infrastructure (NGI) is under development. In this introduction, we discuss aspects of infrastructure development and this special issue contains papers contributing to the development of the NGI in various fields including customs, crisis management, legislation and regulation, providing a number of possible functions and services that may become part of the NGI. We argue that policy-makers should view the NGI from a complex-adaptive systems (CAS) view and that the next generation of infrastructures will provide not only technological services, including connectivity and security, but also shared information and knowledge in various fields, thus making it easier to participate, translate legislation and manage collaboration between public and private parties and in this way advancing digital government.

Keywords: Infrastructure, Digital Government, Complex Adaptive System, Enterprise Architecture, Emerge

Introduction

Infrastructures are a kind of public and quasi-public utilities and facilities that are typically used by large numbers of different users. In daily life, people usually assume that the infrastructures exist and operate as expected. Typical examples of digital government infrastructure include Internet, which allows users to connect to each other in a robust way and dedicated information exchanges networks, which make it possible to exchange structured information between the systems. A third example is operating systems that provide a platform on which the applications function. Another, perhaps less obvious, example is that of information registries containing information about citizens, businesses or other kind of information that are used by large numbers of government organizations.

An essential characteristic of infrastructures is that they are used by many different users, with the usage evolving over time, as may the type of users. Another characteristic is that the infrastructure offers value to the users only when a certain critical mass of users has been reached. A large user-based contribution sharing information is often necessary for its existence. This requires the use of open and standardized interfaces to enable large numbers of different users to make use of the infrastructure.

A general feature of infrastructures is that they are so deeply embedded in our daily activities that we take them for granted. All too often, it is only when the Internet does not function or when it is not possible to retrieve the data one needs that one becomes aware of its existence. We assume that the infrastructure is there and that it works properly. Moreover, infrastructures evolve over time to meet to changing needs by adapting and reorganizing. Such infrastructures are large and complex and continually adapt to situations that are usually not known in advance, and they need to be robust and flexible enough to allow for adaptations. These changes often cannot be predicted in advance, as deviations from the intended use of a system influence the development of the next infrastructure. This underlines the path-dependent nature of infrastructure developments: past experience, use and actions by various stakeholders shape the next generation of digital government infrastructures (NGI). The basic digital government infrastructure consists of a network of computers and communication systems providing facilities for a worldwide exchange of data between systems and users, whereas the vision on the NGI is that tit will be

flexible, intelligent and less vulnerable. It will provide the functionalities, data, and shared services needed to enable digital government.

This special issue contains seven papers related to the next generation of digital government infrastructures. The papers cover various domains and various applications that may become part of the NGI. By covering various aspects we hope to increase our understanding of NGI and at the same time contribute to its further development. Infrastructures can be viewed as socio-technological systems that emerge and evolve through the interplay of technology, users, and policy-makers. In the following section, we address the basics of infrastructure development, after which we discuss aspects that may become part of the NGI. We close by presenting an overview of papers in this special issue.

Understanding infrastructure development

Many public organizations ignore the fact that they are dependent on others in their development projects and that needed functionalities might already have been developed by other organizations. Individual decision-makers frequently make local design decisions, which may influence further developments. These path dependencies may act as barriers, but also provide opportunities. Infrastructures evolve through the contribution of individual parties, whose actions may change the infrastructure. New elements can be engineered and access provided to other users. In most cases, managing an infrastructure transcends the boundaries of centralized, hierarchical control of individual resources. Infrastructures are typically owned and operated by multiple parties working together and often users are important stakeholders who influence the development of the infrastructure. Because an infrastructure is used my multiple types of users, it is a shared resource that depends on a shared decision-making. Most infrastructures are in part engineered, after which they evolve. They are engineered in the sense that organizations may develop systems, and they evolve when users adopt new services and functions provided by these protocols and applications. On the Internet, various payment methods have been engineered in the past. Only a few of these payment systems are still in use and many of them have disappeared because they were not adopted. As a result of these developments, the Internet itself has evolved from being an information-sharing platform to an e-business platform where products can be sold and bought.

In the light of this discussion, infrastructures can be viewed and analyzed as Complex Adaptive Systems (CAS). A typical example of a CAS is a flock of birds in which the

individual birds continually adapt to changes in their environment, for instance the distance between the birds and the wind direction. Individual birds follow simple rules and interact with others to form a cohesive and dynamic whole. The essence of CAS is the study of systems that are built from individual agents are capable of adapting as they interact with each other and their environment (Auyang, 1998). CAS can be used to explain how individuals affect the overall system-level responses. CAS can generally be defined as "*a system that emerges over time into a coherent form, and adapts and organizes itself without any singular entity deliberately managing or controlling it*" (Holland, 1996). By conceptualizing infrastructures as CAS, policy-makers and decision-makers can gain a better understanding of the dependencies involved and develop policies (Janssen & Kuk, 2006). This conceptualization provides a better match, because it acknowledges that it is impossible to exert a hierarchical and tight control over complex systems of agencies and projects spanning multiple levels and jurisdictions. A CAS has the following system characteristics (e.g. Lewin & Regine, 1999):

1. *Emergence*: Agents in the system interact with each other in apparently random ways. From observing all these interactions, patterns can be identified that can be used to inform the behavior of the agents within the system and the behavior of the system itself.

2. *Co-evolution*: Socio-technological systems exist within their own environment, and they are also part of that environment. A socio-technological system can only be understood and optimized when we take the interdependencies among the various subsystems, technology and social into account (Bostrom & Heinen, 1977). The underlying rationale is that, as their environment changes, systems need to change to ensure a good fit with their environment. However, as they change, they in turn their environment in turn, in a continuous reciprocal process of adaptation.

3. *Self-organizing*: There is no hierarchy of command and control in complex adaptive systems. No planning or management is involved, but instead there is a constant process of re-organization to find the best fit with the environment.

4. *Coordination and connectivity*: The ways agents in a system connect and relate to each another is critical to understanding the system. Patterns are formed from the

interactions and connections, and the relationships among the agents are considered more important than the agents themselves.

According to Lewin and Regine (1999)**Fout! Verwijzingsbron niet gevonden.**, the best-run organizations function much like a flock of birds, with individuals following simple rules and interacting with others to form a cohesive and dynamic whole. Rather than being a planned or controlled infrastructure, entities form patterns to adapt to their environment. From a CAS perspective, a number of relatively simple principles can guide the development of infrastructure. A key challenge facing policy-makers who are involved in infrastructure development is to create the guidelines and conditions that provide an overall direction for the future, give space to and enable the uptake of emerging initiatives in the infrastructure, and ensure that the infrastructure is ready to adapt and evolve as the environment changes.

Decision-making often cannot be enforced and it depends on consensus through negotiation, based on mutual trust and goodwill. The main implementation-related difficulties are managing the engineered parts and stimulating emergence of new development and the adaptation of the engineered parts. To do so successfully, the technological and social elements have to be balanced. Parts of the infrastructure have been consciously designed, whereas other parts have evolved. In many cases, the evolution of an infrastructure depends on the availability of standards and on the presence of a certain critical mass. The use of the infrastructure is often not well-defined in advance and, once it is in place, the infrastructure makes it possible to add services to the existing system. The main characteristics of such infrastructures are the following

- *Evolving*. There is often no central authority and infrastructures evolve over time. The governance of infrastructures is carried out by networks of organizations and it is based on mutual understanding, goodwill and trust.
- *Emerging and designed (planned) parts*. Often, infrastructures have not been consciously designed from scratch. Over time, their purpose and use may change, which in turn may influence their development. Some parts may be designed deliberately, while others are not.

- *Use changes over time*. The way infrastructures are used typically varies over time, as they enable the development of new services, which in turn changes the way they are used. They adapt to changes in their environment by adding new features. For example, although the Internet was originally designed to guarantee robust connectivity, it has evolved into a medium for economic transactions.
- *Large numbers of different users*. Network externalities play an important role, as often a minimum number of users are needed before an infrastructure will take off. Various types of users may use an infrastructure for different purposes. Furthermore, the types of users evolve over time, which again results in adaptation and re-organization.

Because the kind of infrastructure discussed in this introduction exhibits the characteristics of CAS, the conscious development of a NGI is a challenging undertaking. When attempts are made to control the development of infrastructures too much, the desired objectives may not be realized. Typically, the development and use of the infrastructures in question can be guided by a number of simple policies that identify the overall direction and stimulate further development in that direction. There is a need to research and to develop new policy frameworks that can facilitate the development of the NGI from a CAS perspective. We can illustrate this by using an example from the Netherlands. In the past, a large number of authentication and identification systems have been developed, based on a desire on the part of policy-makers to stimulate a variety of different systems. Over time, only one system has survived to become the standard identification and authentication facility. In a truly democratic fashion, users decided which of the systems would survive, simply by deciding whether or not to use them. This example shows that it is possible to conduct various different experiments and let users choose the systems that best meets their requirements and consequently becomes part of the infrastructure. Indeed, more than one such experiment may meet with their approval.

The Next Generation Infrastructure (NGI)

The basic communication infrastructure has been in place for years, providing facilities for a worldwide exchange of data between systems and users. It is a network of computers and communications systems that are connected to each other. This basic infrastructure ensures that data can be exchanged among systems. Over time, the basic infrastructure has been extended and

basic facilities, like secure communication, identification, and reliable transmissions, have one by one been added to the digital government infrastructure. Information registries that are shared by many users can also be considered as part of the digital government infrastructure. More and more new facilities and shared services become part of the infrastructure and support a large user base. Furthermore, the infrastructure becomes more intelligent and the emphasis shits from data towards information and knowledge exchange. The NGI will very likely provide mechanisms to intelligently dealing with the collecting, processing and dissemination of information.

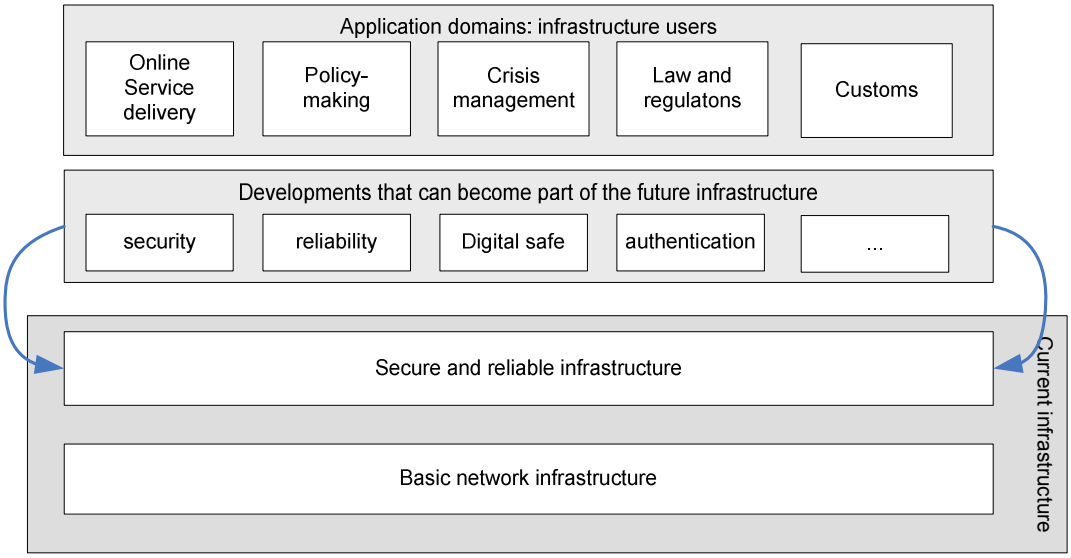
To illustrate this, a number of basic facilities, like a national authentication services (DigID), a personal digital safe and e-form generator have been developed in the Netherlands (see http://www.ictu.nl/). In 2007, the national authentication service had over three million users (out of 16 million citizens) (see http://www.digid.nl). The digital safe is used by more and more citizens and the e-form generator contains most standards service delivery forms. In addition, a number of national registries have been developed, based on the principle of information stewardship. These registries store basic information in a certain domain and are operated by a single agency, which is responsible for keeping the information up-to-date. Each time public agencies want to this information, they have to connect to the national registry and retrieve the information. A prominent example is the national citizen registry, which contains the names and addresses of all Dutch citizens.

More and more facilities become part of an infrastructure that is used by public organizations as well as by citizens and businesses. This infrastructure can be used to create complete online service provisioning in a cost-efficient and easy way by the many Dutch (semi-)autonomous agencies. The national authentication service can be used to login, new services can be added to the digital safe that is used by citizens and (standard) e-forms can be used to order a service. Furthermore, the national registries can be used to fetch this information in advance, making sure citizens do not have to provide information every single time and guaranteeing that the information is correct. More and more agencies that once used their own idiosyncratic systems now use this readily available infrastructure.

While the above-mentioned example only applies to online service delivery, similar infrastructures have evolved and are evolving in other areas like policy-making, crisis management, customers or fields outside the tradition government boundaries. There is a clear trend to add more and more facilities as part of the basic infrastructure (see Figure 1). The

infrastructure becomes more and more advanced and makes it easier to ensure interoperability, create new services, acquire and process policy information for supporting decision-making, create blogs, wiki's and other forms of knowledge exchange and probably create innovations not yet anticipated on top of this infrastructure.

Although technology makes it possible to realize these more advanced infrastructures, the implications for government have to do with organization, management and policy. The infrastructure enables all kinds of new applications and the further development of the infrastructure needs to be managed. In addition, using the infrastructure may require organizations to change. This requires changes on the part of policy-makers, organizations and management. Much more interdisciplinary research is needed to realize the NGI.



*** Figure 1: The development towards the NGI ***

In the future vision of the NGI, Information and Communication Technology (ICT) continues to be a platform that provides facilities, not only for services like voting, distributing new regulations, customs or taxation, but also for gaining policy-making information and dealing with crisis situations, to name but two examples. This requires including new kind of functionalities and services in the current infrastructure as schematically depicted by the arrows. The next generation of digital government infrastructure should make it easy to process data and support policy-makers. The

ultimate aim is to have a flexible, secure, scalable and reliable infrastructure containing functionalities and services to gather, process and disseminate information to be used by a variety public officials like policy-makers and first responders. In this way it will help safeguard the public interest and initiate systems innovations.

There is a long way to go before this vision can be realized and there are various streams of research that provide valuable contributions. Imagine an infrastructure in which legislation and regulation is automatically translated and implemented into systems, or an infrastructure that will provide voting results at the push of a button. The infrastructure needs to be reliable and secure, ensure privacy, processes information intelligently, and so on. There are many hurdles to be overcome before such an infrastructure will be realized. In addition, government agencies face the challenge of adopting the infrastructure within the complex external environments and may need to modify their structures. Furthermore, there is a need for policies that stimulate these developments and that enable the creation of the NGI.

Many efforts contribute to the NGI. The aim of this special issue is to contribute to the development of the future infrastructures and to address some of the related problems from various points of views. These include technological, organizational, policy-related and management-related issues. The creation of technological infrastructures requires not only technological facilities, but also things like management, acceptance by citizens, and a clear institutional framework, among other things. Furthermore, policy-makers need to be aware of these developments and stimulate the development and use of this NGI.

Overview of papers

This special issue contains seven papers dealing with various aspects of the NGI. The papers were selected from the papers submitted to the 9th Annual International Conference on Digital Government Research held in Montreal, Canada, May 2008. Some papers deal with the development of specific component and functionalities that may become part of the NGI, while other papers address the developments within a certain domains, including customs, crisis management, service delivery and legislation. One paper discusses research and visions concerning the next generation of digital government infrastructures.

One of the key components of the next generation digital government infrastructure is an improved facilitation of government-to-citizen and government-to-business

communication and transactions. For many businesses, complying with federal regulations is a legal and administrative nightmare. It is vital for citizens and small businesses to have the means to access and retrieve legislation when needed. In the paper *"Improving Access to and Understanding of Regulations through Taxonomies"* Chin Pang Cheng, Gloria Lau, Kincho H. Law, Jiayi Pan and Albert Jones argue that the next generation digital government infrastructure should support easy access to regulation based on the mental models of citizens and small businesses. This burden has been recognized and targeted by legislation, with the aim of creating a digital government infrastructure that would make such regulations available in digital formats.

The paper "*Electronic customs innovation: an improvement of governmental infrastructures*" by Marta Raus, Barbara Flügge and Roman Boutellier emphasizes the importance of improving government infrastructure in the area of customs applications. The infrastructure is determined by regulations concerning the boundaries of e-government elements and provides high-level functional and technical specifications. Its implementation is in the hands of the individual EU member states: the procurement of information technology and implementation of e-customs solutions have not been specified. The main goal of this study is to identify facilitators and barriers that can influence the adoption of standardized e-customs solutions.

Sharon Dawes outlines a conceptual framework for considering the future in the paper "*Governance in the digital age: a research and action framework for an uncertain future"*. She contributes to the vision for the NGI and outlines the need to take a holistic and multi-disciplinary view. The framework can assist policy-makers and public managers in considering policy options and administrative mechanisms in a much wider context. Dawes suggests that an infrastructure suited to the future of government must consider values and policies, and human, organizational, institutional, and societal factors, in addition to foundational tools and technologies. An infrastructure for digital government requires an approach that far transcends individual organizations to encompass all the elements of government as an interconnected whole operating in a complex social and economic environment.

One of the challenges in disaster management is making sure that emergency teams arrive on site in a timely fashion. In their paper "*Using 9-1-1 Call Data and the Time-Space Permutation Scan Statistic for Emergency Event Detection"*, Hector Jasso, William Hodgkiss, Chaitan Baru, Tony Fountain, Don Reich and Kurt Warner show that information about the location and temporal extent of such disaster events can be estimated from the spatial and temporal array of all calls by identifying clusters of 911 calls. This type of application can be used by a variety of services during a disaster. Furthermore, all emergency response agencies should have access to the relevant information in order to complement their own activities. The authors provide an example of how police agents can use the information to patrol areas proactively and look for events that may not reported by individual callers. They argue that such an event detection mechanism should be part of the next-generation of 911 systems.

In their paper "*Stage models for creating joined-up government: From local to nation-wide integration"*, Bram Klievink and Marijn Janssen presents a five-stage evolutionary model of digital government that describes the progression from the stove-piped government stage, via the integrated organizations stage, the nationwide portal stage and the inter-organizational integration and demand-driven towards the interconnected government stage. They provide a practical guidance for policy-makers to stimulate development of the necessary capabilities to transform government organization from one stage to another. The capabilities are described in terms of multi-dimensional metrics, including interaction types with stakeholders, specific technologies used, whether organizational transformation is needed or not, and the availability and development of demand-driven services. This model is validated empirically and helps government agencies benchmark their position, realize their role in the formation of an interconnected government, develop the necessary capabilities and adopt centrally developed infrastructural facilities aimed at moving to the next stage.

In countries and states that regularly hit by hurricanes and other disasters, determining the rates of homeowner insurance is an important public policy issue. In their paper "*Florida Public Hurricane Loss Model (FPHLM): Research in Multi-Disciplinary System Integration Assisting Government Policy Making*", Shu-Ching Chen, Min Chen, Na Zhao, Shahid Hamid, Kasturi Chatterjee and Michael Armella address the challenges and

experiences associated with the integration of the software system assisting the design, development and integration of components for future large-scale interdisciplinary digital governance projects. The Florida Public Hurricane Loss Model (FPHLM) makes the rating evaluation process less biased. It enables the state to justify rejecting or accepting rate increases based on an independent and transparent model, rather than via a process that can be influenced politically. The authors illustrate that it is possible for a government to pool its resources to develop complex systems. The modules of the FHPLM have no fixed design and all capabilities of the modules change and evolve as the project progresses, which means they enable the emergent behavior of a CAS. In addition, companies can use the FHPLM and the module can be easily adopted to use in other states. As such, the FHPLM can be considered as an infrastructure component in itself.

The paper by Hye-Chung Kum, Dean F. Duncan and C. Joy Stewart called '*Supporting Self-Evaluation in Local Government via Knowledge Discovery and Datamining'* provides typical input for the NGI. Self-evaluation is a form of empowerment that is collaborative and participatory in nature. Through self-evaluation, a county social services agency can design, monitor and improve indicators that ultimately improve the outcomes that are relevant to the local community. Many local agencies lack the necessary resources, which emphasizes the need for an information infrastructure that provides timely and accurate data. Furthermore, these kinds of features can typically be part of the NGI and we expect the tools that enable this will be taken for granted and considered part of the infrastructure in the near future. These types of initiatives are typically part of a CAS and emerge when social problems are being solved. Although the features emerge from local initiatives, they are needed by many other users, and over time they will be integrated into the NGI.

Conclusions

Infrastructures are facilities that are typically used by large numbers of different users and they are often taken for granted. In this introduction, we have argued that infrastructures should be conceptualized as socio-technological systems that have the characteristic of complex adaptive systems (CAS). Social and technological elements

evolve together, resulting in emerging behavior and development towards the next generation of digital government infrastructures. The way infrastructures are used typically changes over time in a process of evolution and adaptation. From a CAS-related point of view, there is no central control and the key challenge facing policy-makers is to create guidelines and set conditions that merely determine the overall future direction, giving room to and enabling the development of emerging initiatives within the infrastructure, and making sure that infrastructures are ready to adapt to changes in the environment A new policy framework is necessary as the NGI develops, as the NGI will bring new policy issues like privacy, security and civil liberties.

This special issue contains seven papers dealing with various aspects of the NGI. Some papers address the development of certain component and functionalities that may become part of the NGI, while other papers look at developments within certain domains, like customs, crisis management, service delivery or legislation. One paper discusses research and visions regarding the next generation of digital government infrastructures. Infrastructures emerge and evolve, and require continuous revisions, and while it is impossible to predict the shape of the next generation of infrastructure in advance, the papers in this special issue demonstrate that the next generation of infrastructures will provide not only technological services, including connectivity and security, but also shared information and knowledge in various fields, thus making it easier to participate, translate legislation and manage collaboration between public and private parties.

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