Towards e-Government Interoperability Framework

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Abstract. Over the past decade most countries with advanced economies have made major investments in various e-Government initiatives attempting to replace traditional paper-based communications between government departments, citizens and private organizations with electronic communications. Notwithstanding such costly initiatives the success of e-Government efforts has been limited. In this paper we discuss e-Government initiatives in the Czech Republic and argue that successful introduction of e-Government must be done in the context of a service-centric interoperability framework that facilitates the development of e-Government services with well-defined and stable interfaces.

Keywords: e-Government, interoperability, data integration, e-Government services, service repositories, SOA

1 Introduction

Over the past decade many countries, including the Czech Republic made major investments in various e-Government initiatives attempting to replace traditional paper-based communications between government departments, citizens and private organizations with modern computer-based systems and electronic communications. While the beginnings of e-Government in the Czech Republic can be traced to the end of the last century, it was only recently that the legislative changes that facilitate e-Government have been introduced and became the subject of public debate. State Information and Communications Policy - e-Czech 2006 [1] that incorporates the concepts the e-Europe 2005 Framework was approved in 2004, and work on a number of initiatives including the Information System of Databoxes (ISDS) [2] and the Government Portal [3] have started shortly afterward.

Currently available public sector services in the Czech Republic can be categorized into three types based on the type of interaction and on the style of interface (Table 1). The type of service consumer (i.e. end user) typically defines the style of the interface; web-based interfaces are widely used for interactions between PA (Public Authority) and citizens, while interactions between PA and business entities typically require a programming interface (i.e. API – Application Programming Interface).

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Table 1. Categorization of public sector services.

Interaction	Service Type	Service Consumer
PA -> End User	Online information on web	Citizens, Businesses
	Codebooks	Businesses
End User -> PA	Downloadable forms on web	Citizens, Businesses
	Submissions over internet	Businesses
PA <-> End User	Signed email communication	Citizens, Businesses
	Data exchange via Databoxes	Citizens, Businesses
	Marketplace for public contracts	Businesses
	Interoperable services	Businesses

The first type of services involves one way interactions between PA and service consumers. This category of services includes information published on the websites of various government departments such as codebooks for standardized data transfer (e.g. units of measure for the Customs or Data Standard for the Ministry of Health). These kinds of services are widely used and are relatively simple to implement. The second type of services involves citizens or businesses sending data to PA, typically using electronic forms that are downloaded from a website, completed by the end users and uploaded. A more sophisticated version of these types of services are services available via the Government Portal, which offers (in addition to a standard web-based interface) a set of Web Services that can be integrated into client's information system (see section 2.2 for additional discussion). Finally, the third type of services facilitates two-way interactions between PA and service consumers (i.e. citizens or businesses). These interactions can take different forms, for example using secure email with digital signatures or the ISDS [4]. Another form of interaction involves specialized electronic marketplaces for public sector e-Procurement. The most challenging type of two-way interactions involves interoperable services that enable automation of business processes between PAs and business entities. Such services should allow sharing of information among different government departments avoiding duplication and reducing the amount of unnecessary paperwork.

Similar classification of e-Government services is used by the European Interoperability Framework [5] that classifies types of services according to their level of sophistication into four stages: stage 1) publishing information online, stage 2) downloadable forms returned via email or mail, stage 3) online forms submitted electronically, and stage 4) full automation and integration of services. Alternative classifications of e-Government services can be found in the literature, for example in [6].

Implementing interoperable services between government departments and business entities involves overcoming a number of challenges, in particular standardization of data structure and semantics across the public administration domain, and specification of well-designed stable interfaces for various types of e-Government services. Notwithstanding many costly initiatives the success of such e-Government efforts has been limited [7]. There is some evidence that the focus of such initiatives has been mainly on providing technical-level interoperability (i.e. specifying data formats, data exchange and security protocols, etc.) rather than providing an overall interoperability framework for e-Government services.

Furthermore, there is a widespread tendency to use existing (paper-based) documents as the basis for developing electronic documents (i.e. XML data structures) and map the data elements from paper forms directly to corresponding XML message data structures. This is evident in data structures used for various Government Portal services, e.g. Customs Administration, Czech Social Security Administration, etc. This leads to a suboptimal solution with complex message structures that require frequent modifications as new requirements are incorporated into existing applications. This *document-centric* approach attempts to achieve semantic interoperability directly by transformation and mapping of data elements between disparate systems operated by different government agencies (see discussion in section 3).

In this paper we argue that interoperable e-Government services can be best achieved in the context of a service-centric framework that covers the entire services life-cycle and produces well-defined and stable interfaces for e-Government services. To achieve high levels of interoperability, e-Government services must be defined from a global perspective (i.e. not separately for each government department) and stored in a globally accessible service repository. We note that while e-Government services represent a special category of interoperable services, experience with the design of services in other domains, e.g. travel [8] can provide useful guidelines for developing a suitable methodological framework.

In the following section (section 2) we discuss e-Government initiatives in the Czech Republic with specific reference to the European Interoperability Framework (EIF). The next section (section 3) describes the document-centric and service-centric interoperability models, and in the final section (section 4) we discuss the limitations of the traditional approach to e-Government interoperability and advocate a service-based interoperability framework.

2 e-Government Interoperability Framework

Interoperability of e-Government applications has been the subject of extensive investigations recently [9-12]. There is a wide agreement that interoperability cannot achieved purely on the basis of providing connectivity at the technical level and that effective sharing of information among government departments requires the support of a methodological framework.

The European Interoperability Framework (EIF) [13] represents an attempt to provide an architectural solution to facilitate automation of business processes among public administrations, citizens and businesses within the European Union. European Interoperability Framework defines four interoperability dimensions: legal, organizational, semantic, and technical that operate within a political context. Political context is set by government strategies; two documents define strategy for e-Government in the Czech Republic. “National Information Strategy” [14] published in 1999 that proposes the creation of *information society* and advocates the integration of information systems in public administration, and “National Information and Communication Strategy” (e-Czech) [15]. This strategy incorporates the concepts of e-Europe 2005 [16], and describes the development of modern online services for the

public sector (i.e. e-Government, e-Learning, e-Health) and the creation of a dynamic environment for e-Business. The most recent document setting out strategy for the development of digital economy "A European Information Society for growth and employment" (i2010) [17] represents a continuation of efforts to build information society based on electronic services and the emerging services economy through incorporation of the European Interoperability Framework into the national framework.

Ensuring legal interoperability typically involves introducing new legislations, for example the introduction of Information System of Data Boxes necessitated approval of Act 300/2008 (Digital agenda), and the Government Portal is supported by Act 365/2000 (Information systems in public administration). Other important legislations in this area include Act 111/2009 (Basic registers) and Act 227/2000 (Digital signature).

Another aspect of e-Government interoperability that needs to be addressed is alignment of organizational structures and processes in different government departments (Organizational Interoperability). According to the EIF requirements of service consumers (i.e. requirements of businesses and citizens) need to be taken into account to minimize duplication when interacting with various government departments. Consider, for example a situation where an individual is setting up a new company and needs to provide various documents including criminal record, information about social security debts, etc. Such information is already available in various government departments and should be accessed automatically. This in practice implies business process re-engineering and alignment so that individual government departments share information, avoiding the need for the clients to provide information that is already held by different government departments. The pre-requisite for effective data sharing between government departments is semantic interoperability, i.e. the standardization of data structures and semantics of data elements used across government agencies.

2.1 Semantic-Level Interoperability

Semantic interoperability deals with the meaning of data exchanged among the various agencies in public administration and requires that data heterogeneity present in disparate information systems operated by individual government departments is resolved. To address semantic interoperability EU established the SEMIC.EU (Semantic Interoperability Centre) for member states to exchange information about the meaning of data elements, which following approval by all participants are published in a data elements repository.

At a national level, in the Czech Republic, metadata about information exchanged between various PA departments is maintained using Information System about Data Elements (ISDP) [18]. Public agencies are obligated to use data elements published in the ISDP database when communicating electronically between PA departments. However, ISDP data elements are not required for the implementation of interfaces with private sector companies. The Czech Ministry of Interior has published a document "Methodological Guidance for Creation of Data Elements" that describes data element semantics and includes recommendations about data element life cycle

management. Another related document "Method of development of XSD schemas in public administration" deals with technical issues that concern the development of XML schemas and describes basic data types, composition of basic data types into complex types and conventions for the design of schemas (e.g. namespaces, naming of elements, etc.). ISDP maintains metadata information about data elements used in public administration, but it should be noted that it is not a repository of definitions of service interfaces. Although the use of ISDP data elements is mandated for public agencies, the definition of interfaces for specific services is the responsibility of individual service providers, typically government departments. This approach is consistent with EIF, but it limits interoperability as services implemented by a given government department will be, in general incompatible with services developed by other departments, although their functionality may be identical. Another important consequence of this approach is that there is no centralized repository of e-Government services, potentially causing duplication and inconsistencies in service definitions across various agencies of public administration.

2.2 Technical-Level Interoperability

Technical interoperability deals with technical aspects of interconnecting PA systems, in particular with standardization of data formats and data exchange protocols (e.g. SOAP, AS2). Other technical issues include ensuring performance, scalability and security (identification, authorization, integrity, non-repudiation, encryption, time-stamping, and protection against attacks and viruses). When developing interoperable services, such issues have to be considered and resolved to provide a technical solution. Two distinct communication channels are available for e-Government applications to enable technical-level interoperability among PA agencies, citizens, and private organizations: the Government Portal and ISDS.

The transactional component of the Government Portal is a gateway that enables interactions between citizens or businesses (using Government Portal standards and protocols) with PA institutions' Department Interface Servers (DIS). Government Portal implementation platforms is MicroSoft Biztalk [19] that manages data flows between parties (including schema transformation, message routing, etc.) and can be used to implement business processes that span government departments. Secure communication between parties is achieved using transmission of XML messages over HTTPS protocol. Messages are specified using XSD schema and consist of an envelope containing routing information for a specific DIS server and data payload. While the technical aspects of the Government Portal communications are documented on the portal (Operating Rules for Community Portal for Developers), as already noted, message specifications used by individual government departments are not centrally managed.

While the Government Portal provides a standard gateway for the implementation of e-Government services, ISDS emulates an email solution. Information System of ISDS provides user interface similar to standard email and enables sending and receiving of data messages that are stored in Databoxes. All Databoxes are stored in one central location, so that sending and receiving messages does not involve data transmission, but is implemented by linking sender and receiver records. In addition

to a web-based user interface, ISDS provides an API that enables connectivity via SOAP and HTTPS. Using this public interface, users can integrate ISDS functionality into their applications. The API is implemented as a set of Web Services (e.g. CreateMessage, MessageDowload, etc.), that operate on data messages specified using XSDs and consists of an envelope containing a signature and a timestamp and data payload. In line with the ISDP approach, ISDS specification does not define the structure of the data payloads, making the automation of messages processing impossible.

3. Information-level Interoperability models

To fully appreciate the extent of the interoperability challenge and to explore alternative solutions we need to refine the interoperability framework introduced in the previous section (section 2). Interoperability has been the subject of extensive investigation in the context of B2B (Business to Business) applications [20], [21] and has been classified into three different types (levels): technical, information, and business process interoperability [22]. Technical-level interoperability deals with disparate communication protocols, language environments, and technology platforms that are used by partner organizations and directly corresponds to technical-level interoperability in the EIF framework described in section 2.2. Information-level interoperability concerns data heterogeneity, and can be further classified into: syntax, structure, and semantic heterogeneity. Syntax heterogeneity refers to differences in formats used to represent data (e.g. XML, tagged document formats, etc.). Individual organizations often use schemas with different structure of business documents to represent the same information. Such schema differences are referred to as structure heterogeneity. Semantic heterogeneity concerns the differences in the meaning of individual data items and business process-level interoperability is concerned with collaborative activities between the partners.

While technical-level interoperability is today largely resolved by adopting appropriate standards (i.e. XML, HTTP, SOAP, etc.) as illustrated in section 2, information-level and business process-level interoperability issues remain a significant challenge, in particular in environments that involve a large number of autonomous partner organizations. Discussion of business process-level interoperability is outside the scope of this paper. Focusing on information-level interoperability, two basic models have been documented in the literature: document-centric and service-centric models [23].

3.1 Document-Centric Interoperability Model

Most existing implementations (including the e-Government interoperability framework described in section 2) adopt the document-centric interoperability model characterized by shipping business documents between partner systems. The main advantage of this approach is that the use of documents as basic artifacts of business communication avoids the need for compatibility of underlying technology platforms, so that technical-level interoperability can be relatively easily achieved. Business

documents provide a level of abstraction that allows automation of inter-enterprise business processes based on a mutual understanding of the structure and semantics of documents. However, document-centric approach suffers from limited scalability associated with its reliance on document translation, i.e. as the number of partners and the complexity of their data structures increases, the mappings between individual schema elements becomes unmanageable.

Another principal limitation of the document-centric approach is its tendency to use large and complex message structures that typically mirror the original paper-based forms. The complexity of message structures arises from designing message payloads to include all the information needed to perform the corresponding business function without any reference to information received in previous messages, making the interaction essentially stateless. While such stateless interactions reduce the number of messages needed to implement a particular business function, it results in complex and redundant message data structures making changes to message formats difficult to perform without introducing undesirable side-effects that invalidate existing applications. The message payloads form the interface between applications and therefore introduce high levels of data coupling and interdependencies by externalizing complex document data structures [24]. In effect, the document-centric approach attempts to solve a *data integration problem* for a potentially large number of participants with diverse schemas and business semantics [25], and as is evident from decades of research in the area of integration of heterogeneous databases, this problem does not have a satisfactory solution.

3.2 Service-Centric Interoperability Model

The emergence of SOA (Service-Oriented Architecture) and Web Services provides an opportunity for a new approach to addressing the interoperability challenge. Web Services and SOAP (or REST services [26]) remove the need to use document interchange as an interoperability mechanism by providing technical-level interoperability. Service-centric interoperability model relies on well-defined service interfaces that typically implement a single business function as a Web Service operation. This reduces the problem of standardizing document formats and data semantics to a more manageable task of standardizing service interfaces for a given application domain. Such domain-specific service interfaces are conceptually similar to APIs that are used extensively in programming environments. Interoperability of service-oriented applications relies on stable service interfaces used consistently across the e-Government application domain. Standardization of services ensures that service providers (i.e. different government agencies and departments) publish identical interfaces, avoiding the need to interpret interface semantics. The key difference between the document-centric and the service-centric interoperability models is that service interfaces can be designed to minimize interdependencies (i.e. coupling) between services by encapsulating message data structures and exposing method (operation) signatures that constitute a stable contract between the service provider and the service consumer. Data engineering principles can be applied to the design of service interfaces maximizing service cohesion and resulting in stable and maintainable services [27], [28].

4. Conclusions

It is evident from our discussion in section 2 that the e-Government interoperability framework adopted in the Czech Republic and based on the European Interoperability Framework provides effective solution for technical-level interoperability. However, a number of issues remain to be resolved to achieve information-level interoperability. While the ISDP system maintains metadata information about data elements, and the use of these standard elements is mandated for public agencies, the use of ISDP data elements is not prescribed for private sector companies. Furthermore, the definition of interfaces for specific services remains the responsibility of individual service providers, so that while semantic consistency at the data element level is assured, it is highly likely that individual government agencies will produce incompatible services with overlapping functionality. The absence of a centralized repository of e-Government services makes it difficult to avoid duplication and inconsistencies in service definitions.

With growing acceptance of service-oriented computing and successful application of services in application domains such travel [29] and healthcare [30], it is likely that a service-centric interoperability framework would bring similar benefits to e-Government applications. An important advantage of the service-centric approach is that service interfaces can be designed to significantly limit the exposure of metadata, considerably improving the stability and robustness of e-Government applications. Other advantages of the service-centric approach include improved software reliability simplified development, and support for evolution of interfaces [31].

A key requirement for achieving semantic interoperability in service-oriented applications is standardization of service interfaces for a given application domain (i.e. e-Government). Without such interface standards, equivalent services published by different providers will not be compatible, placing a burden for resolving the inconsistencies on service consumers.

Semantic interoperability is a necessary, but not sufficient condition for the automation of e-Government interactions. Equally, adopting the service-centric approach does not eliminate the need to agree on information and business process semantics, but it makes the problem more manageable by limiting the scope of agreement to service interfaces that typically correspond to simple operations (e.g. change of residence). Well-designed service interfaces address the equally important problem of limiting exposure of complex and often redundant data structures typical of the document-centric approach. Moving away from an interoperability model based on document interchange and adopting a service-centric approach results in a higher level of abstraction associated with the use of application programming interfaces. As experience with programming APIs demonstrates, the benefits of standardized interfaces include improved software reliability, reusability, extensibility, and maintainability, and can ultimately lead to significant application development productivity gains.

Finally, it is evident that in order to address information-level and business process interoperability issues data and business processes that are currently *owned* by different departments have to re-engineered and integrated into a consistent set of e-Government services maintained in a centralized service repository.

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