



A review on E-business Interoperability Frameworks



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ABSTRACT

Interoperability frameworks present a set of assumptions, concepts, values, and practices that constitute a method of dealing with interoperability issues in the electronic business (e-business) context. Achieving interoperability in the e-business generates numerous benefits. Thus, interoperability frameworks are the main component of e-business activities. This paper describes the existing interoperability frameworks for e-business, and performs a comparative analysis among their findings to determine the similarities and differences in their philosophy and implementation. This analysis yields a set of recommendations for any party that is open to the idea of creating or improving an E-business Interoperability Framework.

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1. Introduction

The term “e-business” generally refers to the application of information and communication technologies (ICT) to improve business activities, including providing or enhancing services and managing business operations (Amor, 2000; Beynon-Davies, 2004; Gerstner, 2002). In the e-business context, applications and software systems should be interoperable (Berre et al., 2007a; Parazoglou, 2006). Interoperability enables ICT systems to facilitate information exchange and promote service compatibility between systems (Jardim-Goncalves et al., 2013; Mattiello-Francisco et al., 2012; Truex et al., 1999; Zwegers, 2003). Therefore, interoperability in the e-business context has become a critical issue (Novakouski and Lewis, 2012; Watch, 2005).

Interoperability in the e-business context has multiple definitions (Kosanke, 2006; Levine et al., 2003; Morris et al., 2004a), such as interoperability is defined as “Interoperability means the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge” (European-Commission, 2010; Ralyté et al., 2008; Sourouni et al., 2007).

The following four definitions of interoperability have been given by IEEE: (1) “The ability of two or more systems or elements

to exchange information and to use the information that have been exchanged” (Breitfelder and Messina, 2000; Geraci et al., 1991). (2) “The capability for units of equipment to work efficiently together to provide useful functions” (Radatz et al., 1990). (3) “The capability – promoted but not guaranteed – achieved through joint conformance with a given set of standards, that enables heterogeneous equipments, generally built by various vendors, to work together in a network environment” (Breitfelder and Messina, 2000; Radatz et al., 1990). (4) “The ability of two or more systems or components to exchange and use the exchanged information in a heterogeneous network” (Breitfelder and Messina, 2000; Radatz et al., 1990).

The ATHENA project adopts the IEEE definition of interoperability as “The ability of two or more systems or components to exchange information and to use the information that has been exchanged” (ATHENA, 2005a; Geraci et al., 1991; Hilliard, 2000; Ruggaber, 2005).

In the e-business context, “Interoperability means the ability of information and communication technology (ICT) systems and of the business processes they support to exchange data and to enable the sharing of information and knowledge” (Benguria and Santos, 2008; European-Commission, 2004; Hueppi, 2008).

Achieving e-business interoperability generates numerous benefits (Carney and Oberndorf, 2004; Choi and Whinston, 2000; European-Communities, 2008; Poppel, 1987), such as improved efficiency, transparency, accountability, and access, as well as cost effective service coordination (Curts and Campbell, 1999; Novakouski and Lewis, 2012; Schade, 2005). Lack of interoperability could cost the industry a huge amount of money (ATHENA, 2007; Ruggaber, 2005). In its investigation, the Yankee Group in the United States revealed that solving interoperability

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problems accounted for 40% of ICT project costs in majority of leading manufacturing industries (Kerravala, 2002).

Attaining interoperability requires resolution at several distinct levels. According to Carney and Oberndorf (2004), Chen (2006), de Normalisation and für Normung (2011), Heiler (1995), Kasunic and Anderson (2004), Levine et al. (2003), Morris et al. (2004b), Munk (2002), there are four levels of interoperability. The interoperability levels are technical, syntactic, semantic, and organizational interoperability.

- (1) *Technical interoperability* is achieved among communications–electronics systems or items of communications–electronics equipment when services or information could be exchanged directly and satisfactorily between them and their users (Novakouski and Lewis, 2012). In referring to specific cases, the interoperability degree must be defined (Kinder, 2003; Kosanke, 2006). Technical Interoperability is typically associated with hardware/software components, systems, and platforms that enable machine-to-machine communication. This type of interoperability often focuses on communication protocols and the infrastructure required for those protocols to function (Rezaei et al., 2013; Van der Veer and Wiles, 2008).
- (2) *Syntactic interoperability* is defined as the ability to exchange data. Syntactic interoperability is generally associated with data formats. The messages transferred by communication protocols should possess a well-defined syntax and encoding, even if only in the form of bit-tables (Rezaei et al., 2014a; Van der Veer and Wiles, 2008).
- (3) *Semantic interoperability* is defined as the ability to operate on that data according to agreed-upon semantics (Lewis and Wrage, 2006). Semantic interoperability is normally related to the definition of content, and deals with the human rather than machine interpretation of this content. Thus, interoperability at this level denotes that a common understanding exists between people regarding the definition of the content (information) being exchanged (Guijarro, 2009; Hall and Koukoulas, 2008; Van der Veer and Wiles, 2008).
- (4) *Organizational interoperability* pertains to the capability of organizations to effectively communicate and transfer meaningful data (information) despite the use of a variety of information systems over significantly different types of infrastructure, possibly across various geographic regions and cultures. Organizational interoperability relies on the successful interoperability of the technical, syntactic, and semantic aspects (Gionis et al., 2007a; Rezaei et al., 2014b; Van der Veer and Wiles, 2008).

Therefore, as a multidimensional concept, interoperability can be viewed from numerous perspectives and approached from various directions (Rezaei and Shams, 2008b). A framework is necessary to reconcile all these perspectives, approaches, and directions, which are frequently different. Moreover, a framework is a practical tool for comparing concepts, principles, methods, standards, and models in a particular realm. Interoperability framework is specifically a mechanism for enabling interoperability between entities that mutually pursue an objective (Javanbakht et al., 2008; Kajan, 2011; Kuziemsy and Weber-Jahnke, 2009; Rezaei and Shams, 2008a). Therefore, interoperability must be recognized and conveyed via a framework (Chen, 2009; Legner and Wende, 2006).

The European Interoperability Framework defines an interoperability framework as follows: “An interoperability framework can be defined as a set of standards and guidelines that describes the way in which organizations have agreed, or should agree, to interact with each other. An interoperability framework is, therefore, not a static document and may have to be adapted over time as

technologies, standards and administrative requirements change” (European-Commission, 2004).

The ATHENA project defines an interoperability framework as follows: “An interoperability framework provides a set of assumptions, concepts, values and practices that constitutes a way of viewing and addressing interoperability issues” (Lillehagen and Solheim, 2004).

The E-business Interoperability Framework constitutes the cornerstone for resolving interoperability issues in the e-business context. These frameworks further provide the required methodological support to an increasing number of projects related to the interoperability of enterprise applications and software systems to enhance the management of their complexity and risk, and ensure that they bring the promised added value (Lillehagen and Solheim, 2004; Zutshi, 2010).

In this direction, this paper presents the existing E-business Interoperability Framework (Interoperability Development for Enterprise Application and Software Framework, ATHENA Interoperability Framework, Enterprise Interoperability Framework, and GridWise Interoperability Context-Setting Framework), and provides an overview of their main concepts and recommendations. Additionally, this paper performs a comparative analysis of the existing E-business Interoperability Framework to determine the similarities and differences in their philosophy and implementation. This analysis yields a set of recommendations for any party that is open to the idea of creating or improving an E-business Interoperability Framework.

The structure of the paper is as follows: in Section 2 the interoperability issues are outlined. An introduction to the available E-business Interoperability Framework is presented in Section 3. Section 4 compares the interoperability frameworks under study on the basis of the interoperability issues proposed in Section 2. A discussion on the findings is conducted in Section 5 leading to conclusions in Section 6.

2. Interoperability issues

This section describes a set of interoperability issues (enterprise interoperability scientific areas) observed in the results of the FP7 ENSEMBLE project (Koussouris et al., 2011). The interoperability issues are categorized into four different granularity levels. The interoperability issues that belong to a higher granularity level are regarded as super-sets of interoperability issues that belong in a lower level (Koussouris et al., 2011). According to the four granularity levels, Fig. 1 illustrates an overview of the identified interoperability issues. Each interoperability issue is further detailed in the following sections. It is required to note that the proposed interoperability issues (scientific areas) aim to promote more focused and concrete research attempts towards the goal of establishing interoperable enterprise systems, as they belong to a smaller abstraction level of that of the four fundamental interoperability layers adapted by European Interoperability Framework (European-Commission, 2004, 2010; Koussouris et al., 2011).

In accordance with the scope of this paper and in alignment with Koussouris et al. (2011) (Fig. 1), the comparative analysis of the existing E-business Interoperability Framework will be performed, and additionally extended over:

- The first granularity level of interoperability issues consists of data interoperability, process interoperability, rules interoperability, objects interoperability, software systems interoperability, as well as cultural interoperability.
- The second granularity level of interoperability issues focuses on

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