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XML interoperability standards for seamless communication: An analysis of industry-neutral and domain-specific initiatives

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ABSTRACT

Attaining seamless interoperability among heterogeneous communication systems and technologies remains a great challenge in todays' networked world. Real time information exchange among heterogeneous and geographically distributed systems is required to support the execution of complex e-business scenarios supported by cross-organizational business processes. XML emerged as a foundation for performing e-business, receiving an increasing adoption in the new market economies. Several interoperability standards emerged, which provide specifications on performing business-to-business e-business, what information to share, when and how. The aim of this article is to present an up-to-date review of current XML-based industry-neutral and domain-specific standardization initiatives towards seamless communication, discussing their commonalities and differences, and highlighting directions for further research and development work. An overview of the main standards' elements is also made, analyzing how different initiatives address them.

As numerous standardization initiatives are quickly emerging and changing, it is not easy to understand them. By analyzing the most commonly referred XML-based standards for interoperability, this article has two main contributions. First, it provides an up-to-date review of the most relevant industry-neutral and domain-specific standardization initiatives aiming at achieving seamless interoperability among communication systems. Second, by comparing these initiatives, a set of recommendations is advanced towards improving further interoperability developments, offering a unique niche for researchers, practitioners and developers to make significant contributions.

1. Introduction

In today's dynamic networked environment, organizations strongly depend on information and communication technologies (ICTs) to exchange information and to support the execution and management of their core activities and cross-organization business processes. Similarly, the success of joint collaborative military operations relays on the exchange of critical information in real-time. As a consequence, ensuring interoperability among heterogeneous and geographically distributed systems has become of utmost importance.

Interoperability, in a broad sense, refers to the use of computer-based tools that facilitate the coordination of work and information flow among heterogeneous distributed communication systems. According to IEEE [1], interoperability represents the capability of two or more systems or components to exchange information and use it. It emerged from the need to harmonize the operational heterogeneous networked environment, real-time information sharing and the necessity to improve task coordination [2].

Enterprise interoperability, integration and networking represent major areas that enable companies to improve communication and collaboration [3]. Different data formats were developed (e.g., EDI, XML) to support information systems' interoperability. The focus of this article is on business-to-business (B2B) XML-based e-business interoperability standardization initiatives or frameworks,[1] simply referred here as *XML-based interoperability standards*.[2] This decision was made because XML is highly adopted

[1] Within the scope of this article, a framework refers here to a set of specifications, reflecting a collection of elements put together for a certain purpose, relevant for a given entity or community. According to [21] an e-business framework answers the questions of what, when and how to exchange data, dealing with business documents, business processes and messaging in e-business.

[2] According to the International Organization of Standardization (ISO, www.iso.org), a standard is a document that provides requirements, specification, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services fit their purpose. In this article, the term standard refers both to a *de facto* standard and a *de jure* standard.

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by the computer industry and the B2B e-business standards widely used in industry follow XML-based specifications.

XML (Extensible Markup Language, www.w3.org/XML/) was developed by the WWW Consortium (W3C). It represents a meta-language for e-documents management and web publishing and also a data format [21]. Its flexible data format derived from the Standard Generalized Markup Language (SGML, https://www.iso.org/standard/16387.html) ISO 8879. XML has numerous advantages[3,4] compared to other approaches: it supports the validation of a DTD document (i.e., unlike YAML), it is machine readable and also human readable,[5] it supports references (XPointer, XPath), allows many views on the one data (i.e., unlike JSON), allows integration on all traditional databases and formats, it is document-oriented, and is widely adopted by the computer industry (i.e., unlike JSON), and XML continues to be the format of choice for API developers (DOM, SAX, XQuery, XPath) – especially in the absence of well-defined standards. The SOAP and XML-RPC protocols rely on XML (i.e., to accept requests, to provide data in their responses).

Numerous XML-based standardization approaches towards seamless interoperability exist: industry-neutral initiatives (such as: ebXML http://www.ebxml.org or RosettaNet www.rosettanet.org), and domain-specific initiatives, such as: HL7 (Health Level Seven http://www.hl7.org) in the healthcare sector, papiNet (www.papinet.org) for the paper and forest products industry, or NATO STANAGs for unmanned aerial vehicles [4].

Despite the variety of reference architectures, frameworks, tools, infrastructures and technologies supporting (or claiming to support) seamless interoperability, the scientific community emphasizes this objective is not yet fully achieved and more work needs to be done [5,4,6].

Most articles addressing interoperability in the context of e-business focus on e-business frameworks, e.g., [7–9,2,10,3] are descriptive in nature. In several cases the actual use in practice of the respective framework is not addressed (e.g., [10]). The coverage of interoperability requirements is not analyzed. Domain-specific standardization initiatives receive little attention [41], although numerous advances were made. In order to attain seamless interoperability in today's networked economy, when accurate real-time information exchange is crucial for successful businesses, and spans different organizations from different industries, it is important to understand the specificities of each domain specific approach. Recent works, although aiming to review e-business interoperability frameworks [10], did not actually tackle domain-specific interoperability frameworks. Other works focus on a specific case study [11], or implementations following a certain standard specifications, as in: [12,13]. An up-to-date review or analysis of current advances of domain-specific initiatives for seamless communication is not available, although highly relevant. This article addresses this gap.

The objective of this article is to present an up-to-date review of the most relevant XML-based e-business industry-neutral and domain-specific standardization initiatives aiming at achieving seamless interoperability, discussing their commonalities and differences, and highlighting directions for further research and development work. By performing this analysis, this article has two main contributions. First, it provides an up-to-date review of the most relevant industry-neutral and domain-specific standardization initiatives towards seamless interoperability among communication systems. Second, by comparing these initiatives, a set of recommendations is advanced towards improving further interoperability developments, offering a unique niche for researchers, practitioners and developers to make significant contributions.

This article is organized as follows. The following section discusses related work. Section 3 briefly introduces relevant aspects on interoperability. Main standardization initiatives are presented next. Section 5 contains a comparative analysis and discussion of the results. The article concludes with a section addressing the need for further research.

2. Related work

Related research efforts were analyzed. A brief overview of the most relevant works is presented in this section.

A comparative analysis of five business-to-business frameworks (eCo, BizTalk, OBI, cXML, RosettaNet) concerning security, communication protocols, service discovery, repositories, message format, query mechanism, scalability and ontology aspects is presented in [14]. A special focus, however, is on security issues related to enterprise business transactions over the Internet. An overview of BizTalk, cXML, eCo Framework, ICE (Information and Content Exchange), IOTP (Internet Open Trading Protocol), OAG (Open Applications Group), RosettaNet, xCBL, ebXML and ontology.org frameworks is available in [15]. A comparative analysis of the eCo framework, RosettaNet, BizTalk, cXML and MESChain is presented in [16]. The comparison criteria concern product taxonomy support, catalog support, service discovery, document conversion, automated business process support. The eCo, RosettaNet, BizTalk and e-Speak frameworks are analyzed in [17]. The focus is on e-service components, and the criteria used for the comparison are: service discovery, service brokering, service negotiation, service mediation, service billing, service payment, service composition and service security.

Enabling technologies for B2B interactions and frameworks are discussed in [18]. The dimensions for evaluating the B2B interaction frameworks are: coupling among partners, heterogeneity, autonomy, external manageability, adaptability, security and scalability. A review of 15 XML-based supply chain integration e-business frameworks is available in [8]: AEX, BMEcat, BPEL4WS, CIDX, CITE, eBIS-XML, eBuild-XML, IXRetail, OpenTrans, PDX, PIDX, PSL, STAR, TranXML, UBL. The authors emphasize the advantages of XML, show how the frameworks analyzed solve integration problems, emphasizing that their large number of versions cause interoperability challenges as complete transformations between frameworks are not always possible.

A structure framework which lays a foundation for vertical e-business standards developing organizations is introduced in [19]. The main focus, however, is on standards developing organizations, and not on the interoperability frameworks they promote.

The properties of 12 XML-based e-business frameworks (BPEL, BPML, CIDX, cXML, ebXML, OAGIS, papiNet, PIDX, RosettaNet, UBL, xCBL, XPDL) are discussed in [9]. The analysis performed centers on the commonalities, differences and regularities between these e-business frameworks and their standardization. An evaluation of EDIFACT, RosettaNet and UN/CEFACT concerning aspects on: flexibility, maturity, common repository/dictionary, comprehensiveness, ease of implementation and degree of dissemination is available in [20]. Seven domain-specific interoperability standards are analyzed in [42]: HL7, SWIFT, Chem eStandards, papiNet, AgXML, PIDX, TexWeave. The analysis performed only provides an overview of the main elements of each initiative, and the mapping to three interoperability dimensions: technical, semantic/knowledge and business, emphasizing the need for a more in-depth analysis.

[3] https://www.w3.org/XML/.
[4] www.json.org/xml.html.
[5] i.e., unlike Apache Avro, Bencode, Binn, BSON, CBOR, D-Bus Message Protocol, MessagePack, Smile, Structured Data eXchange Formats, UBJSON, XDR-eXternal Data Representation.