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Computers in Industry

journal homepage: www.elsevier.com/locate/compind

Collaborative negotiation for ontology-driven enterprise businesses



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ARTICLE INFO

Article history:

Received 19 November 2013

Accepted 6 January 2014

Available online 24 February 2014

Keywords:

Enterprise Interoperability

Ontology

Conflict resolution

Negotiation

Enterprise Information Systems

ABSTRACT

The requirements from a globalised world demand that enterprises not only shift their paradigm from product-centrism to component-centrism on integrated products, potentiating the need for tight interoperability dependencies, but also that the product specifications and concepts are fully understood by customers and providers in a transparent manner that surpasses the barriers of language, culture and technology. This paper presents the NEGOSEIO framework, which enables service-based interoperability between parties, closely integrated with semantics and business understanding via the use of reference ontologies in the quest for achieving a stronger interoperability liaison. The paper's validation and discussion is performed in its application on the ontology negotiation of business environments in the scope of the EU-funded FP7 project TIMBUS for digital preservation of resources and enduring business continuity.

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1. Introduction

The advent of the globalisation and the Internet have led to the development of various forms of virtual collaboration in which the organisations are trying to exploit the facilities of the network to achieve higher utilisation of their resources. This means enterprises (particularly Small and Medium Enterprises (SMEs)) are leaving their traditional vision of having a corporation focused into the development of one or more complete products, to one where the focus is on specialisation and focus on particular business functionalities and services, which are then integrated with other providers to build complete solutions. In this collaborative networked environment, enterprises are developing business areas dedicated to finding and complying with the best set of partners and suppliers for solutions that are aligned with the enterprise's strategy. Enterprise integration, interoperability and networking are some of the major disciplines that are enabling companies to improve collaboration and communication [1].

To be able to perform, enterprises need to exchange information, whether this exchange is internal (among departments of the enterprise), external (among the enterprise or part of it and an external party), or both. Enterprise Interoperability (EI) is thus defined as the ability of an enterprise to seamlessly exchange

information in all the above cases, ensuring the understanding of the exchanged information in the same way by all the involved parties [2]. EI concerns the alignment or common understanding in various forms and levels, from middleware (e.g., signalling, interfaces, and platforms) to semantics (e.g., concepts, taxonomies, and relationships), workflows and methodologies, solutions and business visions. In an integrated, tight and interoperable environment, EI can be challenged due to various conditions and reasons, e.g., if a new enterprise which joined the ecosystem introduces new conditions, or if one of the existing parties has made a change in the existing interoperable environment.

Large corporation enterprises try to contour this problem by setting market standards and influencing the other integrating to comply with these standards. SMEs usually do not have the empowerment to do so, and are therefore more sensible to the oscillations of the environment that involves them, which leads them to the need to constantly change to interoperate with their surrounding ecosystem. As the number of integrating parties grows, and as business interactions and interactions become more complex, the amounts of information that are exchanged become very hard to handle. These assets concern various forms and formats, including e.g., abstract concepts, flows, strategies, hierarchies, culture and tacit knowledge, to more down-to-earth files, records and other business evidences. The path to success on enterprises currently includes storing as much and as detailed information as possible, in order to be able to infer conclusions, tendencies, behaviours and needs from this information. In a recent interview, the IT director from Virgin Atlantic stated their

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new 787 fleet is expected to create more than half terabyte of data for each flight [3]. As businesses grow every day, so does the amount of information that is produced. In a study conducted by IDC [4], digital archive growth will reach data amounts of 40 ZB (Zettabytes) by 2020. The main issue is that the number of options and decisions towards interoperability that need to be taken is escalating in number and importance, and these decisions have an increasing influence on the evolution of the enterprise business.

Sustainable EI (SEI) may be defined as the ability of maintaining and enduring the EI along the enterprise's systems and applications' life cycle. Achieving a SEI in this context requires a continuous maintenance and iterative effort to adapt to new conditions and partners, and a constant check of the status and maintaining existing interoperabilities [5]. This paper recommends negotiations as the proper way to resolve interoperability discrepancies. Negotiations allow a proper formalisation of the SWOT (strengths, weaknesses, opportunities and threats), while presenting the various alternative solutions. It also enables a clear definition of criteria (e.g., impact, downtime, cost, alignment with enterprise strategy, new markets) for the selection of a particular solution, providing a strong justification for reaching mature choices.

Negotiations are sets of complex actions (e.g., creation of new proposals, evaluation of proposals by acceptance or rejection), some of which may occur in parallel. In a negotiation, multiple participants exchange and take decisions in multiple phases over a set of multiple attributes of the negotiation objects (e.g., price, size, quality). In order to formalise and model the negotiation processes, the metaphor of Interaction Abstract Machines (IAMs) is adopted [6]. This approach allows the modelling of the evolution of multiple negotiation phases in parallel and including non-deterministic aspects.

The negotiation process towards interoperability needs to be supported by a flexible and consistent set of collaboration tools. A major improvement in the last decade on this field was achieved by the development of Service-Oriented Architectures (SOA) [7,8]. Web Services have reshaped the existing concepts of solution deployment and provisioning, and paved the way for other important concepts using the same paradigm, like functional discovery and subscription in common repositories, orchestration and composition of services into more complex ones [9], thus creating highly modular and flexible solutions as required.

While SOA is meaningful in terms of solutions flexibility, it has limitations with respect to deployment. The advent of distributed computing complements SOA to deal with scalability issues, and the emergent cloud-based solutions are the exponent of this development [10].

This paper proposes a framework that offers negotiation mechanisms to support the sustainability of interoperability in business-to-business interactions, in networked enterprise environments. Additionally, the presented approach tackles the issue of semantic heterogeneity of such an environment by introducing ontologies as the main support in the negotiation process. Section 2 describes the problem space and the research questions that respond to the described problem. Section 3 presents the theoretical background for this paper (literature review). Section 4 proposes the collaborative negotiation framework in the context of EI, specifying the negotiation coordination model, the proposed methodology for sustainability of EI and the architecture of the proposed solution. Section 5 analyses the application of the proposed methodology into a real business case scenario. Finally, Section 6 presents the conclusions and final considerations.

2. Challenges and research questions

The idea proposed by this paper is to search for solutions to achieve and maintain the interoperability between enterprises, not

by imposing a new model but by negotiating the changes in the collaborative networked environment towards reaching a better solution. This approach leads to improved and mature solutions for interoperability, standards and best-practices that will benefit all players. According to the presented approach regarding the negotiation, the participants to a negotiation may propose offers and each participant may decide in an autonomous manner to stop a negotiation either by accepting or by rejecting the received offer. Also, depending on its role in a negotiation (e.g., initiator or guest) a participant may invite new participants in the negotiation process.

The business-to-business interaction context in which these negotiations take place forces us to model the unexpected and the dynamic aspects of this environment. An organisation may participate in several parallel negotiations. Each negotiation may end with the acceptance of a contract that will automatically reduce the available resources and it will modify the context for the remaining negotiations. This dynamic evolution of the context has been modelled using the metaphor of Interaction Abstract Machines (IAMs), which allows us to limit the acceptance of a negotiation to the available set of resources [11].

To respond to the problems identified above, the following key open research question and hypothesis for solution are formulated:

- Can negotiation promote the establishment of stronger ontology specifications, in order to push businesses towards improving the sustainability of the Enterprise Interoperability?

Under this consideration, a set of hypotheses is presented:

- If business parties detect that changes need to be performed to reach interoperability, negotiation provides an appropriate method to find suitable solutions;
- If negotiation proves to be an effective way to improve the definition of the knowledge ontologies, this will reduce the recovery time spent performing the (re-)establishment of interoperability.

3. Literature review

Achieving a sustainable interoperability among organisations in a networked environment is a crucial factor in order to successfully manage collaborations at all levels: abstract (business); concrete (technology), including:

- informational (information vs. data);
- functional (activity vs. service);
- behavioural (process vs. workflow).

Outlining the crucial position of information systems (IS) inside an organisation, Benaben et al. [12] state that the main issue is to ensure that the IS of the partners involved in the collaboration are able to work together to constitute a coherent and homogeneous set of IS – the IS of the collaborative situation. To address this issue, Benaben and Pingaud [13] propose the Mediation Information System Engineering Project (MISE Project) which aims at providing collaborating organisations with a mediation information system (MIS) able to support the interoperability of a collaborative network. The project takes a model-driven approach to develop a complete MIS design method, taking into account the semantic reconciliation between business and technical levels.

In the same area, Coutinho et al. [14] define a framework to support Sustainable Interoperability using Model-Driven Architectures (MDA), Model-Driven Interoperability (MDI), Service-Oriented Architectures (SOA) and Ontologies. This framework

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