Modelling Services for Interoperability Negotiation

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Abstract: The evolution of businesses, driven by the advent of the internet and subsequent globalisation, was very quick and sudden. Enterprises that had traditional development strategies and that were used to slow changes are suddenly feeling the urge to evolve or face obsolescence. This fast-paced evolution frequently leads to mistakes and erroneous decisions, many of which are solely detected after a long period. When this happens, frequently the only solution is to return to a previous stable business stage before proceeding. The EU co-funded FP7 TIMBUS project comprises tools and techniques to improve business continuity featuring an intelligent strategy for digital preservation of business assets and environments based on risk-management. This paper proposes the modelling of service-based negotiation strategies to help in two phases: First in the definition of the enterprise business interoperability strategy, and second, in the reasoning of assets and concepts needed for the capture of digital preservation of business assets.

1 INTRODUCTION

Technology nowadays seems to surpass all concepts related with information exchange. The market demand changed a lot from the first information systems, when interoperation was determined just by being able to consistently exchange data. Since then, Information and Communication Technologies (ICT) have evolved from little more than wired data exchange to being capable of providing complex high-performing systems that already handle data reliability over a large bandwidth.

Thus, market needs are moving towards the next step and shifting to Enterprise Interoperability. Major breakthroughs have been achieved in the near past on this subject: data networking, the Internet and web-services have contributed to the collapse of the concept of enterprise isolation and paved the way for businesses to communicate and interoperate.

This quickly led to the growth of service-provider-consumer businesses and directed companies to specialise and improve their services, moved by the rising competition. The concept of service has been generalised, as all interactions (e.g., complex computer calculations, graphics design, but also carpet cleaning, wall painting, hardware assembly) were able to be virtualised as computer-based services that companies can evoke to perform their business. The globalised world has entered the Service era, where an enterprise produces and consumes services and goods using the internet, whether these are simple services that provide specific calculations to complex platforms like Customer Relationship Management (CRM) systems with distributed databases, to producing cars, houses, tools and other products. Virtualisation and service provisioning are common means of interoperate; however, this interoperability still relies on sets of agreed message syntax exchanges and agreements that are fragile and limited in their scope.

Emerging paradigms like the Internet of Things (IoT) and the Internet of Services (IoS) ("Internet of Services," 2012), together with the evolving cloud computing concepts are gradually transforming the existing reality into a set of available commoditised virtual objects, services, enterprises and networks.

The globalised market means companies face the availability of multiple possibilities in terms of suppliers and service providers, partners and customers, but also the growth of competition.

Competitiveness is also pressuring enterprises to build better solutions with fewer resources, following new trends and supporting new platforms

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and methodologies. Business models are recurrently more complex and detailed. Quality improvements and standards evolve more frequently, as well as concerns regarding accessibility, expansion, continuous improvement and upgrade, compliance to new technologies and support of new platforms, frameworks and development paradigms. Local and global legislation and regulations are updating more frequently and deeply, and demanding rapid compliance from enterprises.

The increasing complexity of processes and interactions between businesses, companies, providers and customers means interoperability can no further be seen as a tacit and empiric science, but needs to be well established and founded, with detailed definitions, flows, strategies, procedures and interactions. Plus, the quality standards for service provisioning have risen, which means the price of losing interoperability in the current scope may mean the loss of business and credibility in an irreparable way. Strategies and decisions are increasingly more dependent on interoperability and so are also the investments and the whole business kernel.

These frequent business changes shake all the interoperability links between the enterprises, leading to periods of adaptation where business operation is not possible. The urge to rapidly regain interoperability often leads to unfounded, poorly-chosen solutions, which lead to inefficiency and rework.

Often these problems are only detected very late in the interactions of the business enterprises, due to many factors, either because there are still attempts to correct bad decisions or because of the inertia inherent to most businesses to make profound changes. The fact is that in many cases, when the decision comes to overcome such situations, the only solution is to go back to an earlier stage of the business evolution and start all over again. The problem is that this is frequently not possible anymore, due to the environment changes that in the meantime have occurred.

The EU co-funded FP7 project TIMBUS (TIMBUS, 2013) faces these problems and proposes solutions that include a reasoned Digital Preservation of business assets, where this reasoning is performed by risk management. The main innovation of TIMBUS project is therefore its focus on risk assessment based digital preservation of business processes, thus not only bringing together but also advancing traditional digital preservation, risk management and business process management disciplines. Preservation is often considered as a set of activities carried out in isolation within a single domain, without of taking into account the dependencies of third-party services, information and capabilities that will be necessary to validate digital information in the future. Existing DP solutions focus on more simple data objects which are static in nature. The unique aspect of TIMBUS is that it is attempting to advance state of the art by figuring out how more complex digital objects can be preserved and later restored in the same or different environments.

This paper proposes a solution for two distinct problems described previously: by establishing a formal model, framework and strategy for negotiation, the authors propose a methodology to improve the definition of new solutions for interoperability between enterprises, and also to improve the reasoning behind the risk-management analysis to select business assets for digital preservation. These methods and framework are being evaluated in the scope of the TIMBUS project.

Section 2 presents the background analysis on literature over the proposed solution. Section 3 presents the proposed solutions and how they are being applied to the determined scope. Section 4 presents the validation in the proposed use-case, and Section 5 presents the conclusions and future work.

2 LITERATURE REVIEW

The proposed methodology is based on the kernel aspect of negotiations, proposing formal models and strategies, supported by a framework which includes several concepts inspired by the work of project Manufacturing SErvice Ecosystem (MSEE), a consortium project of the ICT Work Programme, of the European Community's 7th Framework Programme (FP7) ("MSEE Project," 2012), including Model-Driven engineering, SOA, but extending it to Cloud-based solutions.

2.1 SSME and MSDE

The term Services Sciences, Management and Engineering (SSME) was coined by IBM (Maglio et al., 2006) to deal with an holistic approach stating that businesses can be the result of a set of services – the conjunction of people, technology, and organisations to create value, towards becoming very adaptive and flexible, reusable and commoditised. The SSME aims to improve the sustainability of the development processes, monitoring and controlling assets e.g., the quality, productivity and innovation of services and the exchange and widespread of services.

SSME vision states that to define a business, more than dealing only with its tangible assets (hardware, software, and related documentation) – hence Technology, businesses should also be analysed according to their processes, environment, procedures, quality standards, towards achieving the business optimisation that is needed for being competitive.

SSME also notes that an important asset of businesses is the human factor, i.e. the capabilities of its human resources and their interactions determine the agility and flexibility of a business. Issues like motivation, skills, team building and development, leadership, personal involvement and achievements are leading the priorities of enterprises.

All these aspects must be developed in the scope of a business vision and strategy, which itself can be analysed, studied and optimised by statistical methods and Ishikawa (cause-and-effect) diagrams and analysis towards the creation of servitised strategies that can be reused as business development frameworks.

The MSEE project targets to pave the way for service development in Europe, with the creation of virtual manufacturing factories (Factories of the Future), which shall make use of extended servitisation for the shift from product-centrism to product-based services, distributed in virtual organisations and ecosystems.

This project proposed a Model-Driven Service Engineering (MDSE) architecture, largely inspired in the concepts of SSME, which accounts enterprise services to be modelled into three major aspects (views): IT, Machine (and operation) and Human Resources. The MDSE models are developed using various specifications, e.g., the EN/ISO 19440 standard, the GRAI modelling language (Doumeingts et al., 2006), the POP* language (Athena Consortium, 2011) and the Unified Service Description Language (USDL).

2.2 Model-Driven Architectures

The term Model-Driven Architectures (MDA) was coined by the Object Management Group (OMG), and promotes the evolution of solutions through successive transformations of higher-level models into lower-level models, which eventually may result in going down to the level of code generation (OMG, 2011). This represented a change of the undergoing paradigm that professed that system architectures are built by designing and maintaining its code. In this case, the changes are performed in the models, which are then transformed into code.

This means that interoperability may start from the very enterprise foundations, where it is easier to discuss business-related concepts and ideas, and then the progressive steps of transformation into lower-level models may also be synchronised to refine this interoperability, so that the overhead of transforming the concepts into code is performed by automation tools.

The development paradigm of MDA allows the definition of multiple levels of abstraction in the modelling of businesses, using descriptive languages and schemes e.g., Unified Modelling Language (UML), Object Constraint Language (OCL), and Unified Enterprise Modelling Language (UEML) to define the solution foundations. Applications should be designed right from a high-level abstract Computation Independent Model (CIM) where all business related functionalities, objectives, methods, context, requirements and definitions are specified regardless of any implementation (i.e., pure design).

Then, this model shall be subject to transformations into a more detailed Platform Independent Model (PIM), where the business concepts and rules are converted into activities, tasks, ontologies, structures and algorithms, although still independently of the underlying platform.

Finally, other vertical transformations and conversions shall turn the PIM into a Platform Specific Model (PSM), which provides the foundations for the development of the application, now targeted to a specific platform. Using the proposed framework, changes to any model (CIM, PIM) may trigger alterations in the other parties' models, which then, by transformation towards new PSMs, swiftly change the application towards compliance with the new model.

2.3 Model-Driven Interoperability

The Model-Driven Interoperability (MDI) concept derives from MDA: it comprises the same abstraction layers, but in this case the target to be modelled is the interoperation between the involved parties. The idea behind MDI is to define models for each MDA level that allow the exchange of information. If the MDA can be described as a set of vertical transformations from a conceptual high-level model to a progressively detailed model, then MDI may be seen as a set of horizontal transformations to allow interoperability at each MDA level, e.g., Process, Product and

Organisational models with the System Requirements at CIM level and transformations of these models into interoperability models.

Projects like the Advanced Technologies for Interoperability of Heterogeneous Enterprise Networks and their Application (ATHENA) defined a framework that supports interoperability throughout the various abstraction levels and business aspects of enterprise software engineering (Athena Consortium, 2007). (Lemrabet et al., 2010) provide simplified views over the MDI concept and the ATHENA Interoperability Framework (AIF) concepts and solutions on actions to develop each level of interoperability:

- Interviews, workshops and BPMN choreography diagrams for CIM levels;
- Diagrams, definition of business goals and BPMN collaboration diagrams for PIM levels;
- Service Oriented Architectures (SOA) and BPEL implementations at PSM levels.

(Chen et al., 2008) define a roadmap on the possible approaches towards the development of enterprise architectures accounting interoperability.

3 FRAMEWORK FOR NEGOTIATION

The proposed framework, presented on (Coutinho et al., 2013), defines three main pillars for its feasibility: a development methodology, a negotiation model and an operative framework.

3.1 Methodology

The proposed methodology consists in the steps described on Figure 1:

Figure 1: Development Methodology.

According to the proposed methodology, the steps for business enterprise interoperability development are:

- Knowledge: Acquisition of the information about the target business and interoperability requirements;
- Modelling: Through the development of models using MDA and MDI, the enterprise interoperability becomes predictable, transparent and flexible to changes;
- Servitisation: The resulting artefacts from the models are shaped in the form of services, whether to define the foundations of the business itself or to shape the interoperability between enterprises;
- Flexibility: The deployment of platforms, infrastructure and services must be highly flexible to cope with the constant changes required by the business environment.

The central point of the proposed methodology however is negotiation. Negotiation will be used transversely in all the described steps, to reason the knowledge acquisition into understanding what to capture and to which extention of detail or granularity, to be the central element on the MDI models to perform the enterprise interoperability in all MDA abstraction levels (CIM, PIM, PSM), and to determine which are the best solutions for servitisation and flexibility/deployment, according to the past experiences.

3.2 Negotiation Model

The proposed negotiation model consists on a set of entities that will store the granular steps of the negotiation called negotiation atoms. The negotiation atoms shall rely on quintuples with the following information:

$$M = < T, P, N, R, O >$$

where:

- T denotes the timestamp of the system, assumed discrete, linear, and uniform;
- P denotes the set of participants in the negotiation framework. The participants may be involved in one or many negotiations;
- N denotes the set of negotiations that take place within the negotiation framework;
- R denotes the set of coordination rules among negotiations that take place within the negotiation framework;
- O denotes the common ontology for the set of definitions of the attributes that are used in a negotiation.

Hence, this is the basic “state” element that stores the environment state of each negotiation step.

Negotiations are therefore cycles of actions which include several strategies to perform the activities, each consisting on numerous of these quintuples. Some of the defined strategies for negotiation are:

- **Subcontracting** (resp. Contracting) for subcontracting jobs by exchanging proposals among participants known from the beginning;
- **Block** component for assuring that a task is entirely subcontracted by the single partner;
- **Divide** component manages the propagation of constraints among several slots, negotiated in parallel and issued from the split of a single job;
- **Broker** to automate the process of selection of possible partners to start the negotiation.

For each strategy, multiple steps and quintuples are defined and stored in the negotiation infrastructure, in the shape of business rules that need to be processed by a rule engine (in the proposed case, the rule engine that is being used is Drools).

The use of this formal negotiation model allows the storage of the historic negotiation data, essential to infer later and assist in the decisions to be taken in the future.

3.3 Negotiation Framework

The negotiation framework proposed in (Cretan et al., 2012) is based on three negotiation levels, as shown on Figure 2.

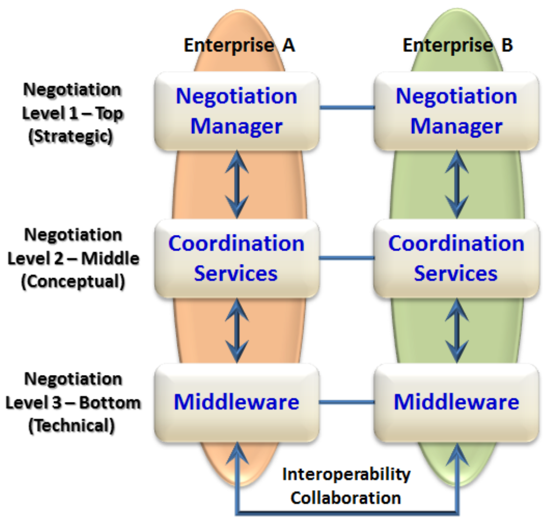

Figure 2: Negotiation Levels.

Firstly, a lower Middleware level implements communication services and provides support for the aspects related with the basic infrastructures, handling the heterogeneity related with multiple negotiation players, using an Enterprise Service Bus (ESB) on interactions for dealing with technical interoperability issues.

On top of it, another negotiation level called Coordination Services (CS), has the purpose of assisting the negotiations at a global level (with different participants on different jobs) and at a specific level (on the same job with different participants). It handles the issues regarding communication at this level (synchronisation between the CSs of the parties that are taking place in the negotiation), and manages the on-going transactions and negotiation data persistence, controlling the semantic discrepancies between the negotiating parties.

Finally, at a client-side scope, Finally, the top negotiation level performs the task of Negotiation Manager, implementing the business decisions that need to be taken for the negotiation, e.g., starting a new negotiation, inviting other parties to join the negotiation, making proposals to the negotiation, and accepting or rejecting proposals.

The remaining framework, besides the above modules that implement the negotiation levels consists in modules for managing the rule-based negotiation (rule engine), a reference ontology to harmonise the terms and concepts existing throughout the various interoperability steps, and other support modules, e.g., cloud management modules, communications, storage using standard ISO 10303 STEP, and other utility services.

4 VALIDATION ON A REAL BUSINESS CASE – TIMBUS

This project is being implemented in the scope of the TIMBUS project. This project has now finished the definition of basic tools and is starting to implement its applicability on a set of use-cases.

As stated on section 1, TIMBUS aims to provide mechanisms to perform business continuity through risk analysis and digital preservation of business environment assets. The part of the project which serves as use-case for this paper is the one that relates to the capturing of business interoperation with external parties. Namingly, the information that is captured from each business can have multiple interpretations and meanings. Each asset's characteristics is much more than only a perspective of the target asset; it is related to a set of semantic interpretations which are distinct, depending on who performs them. The same objective measurement of a sensor or the output result of a particular experiment can have completely semantic meanings, depending on the sensitivity, scope or even business strategy or objectives of each analyser.

This is a problem which commonly affects the proper interoperability between systems. The negotiation model and framework presented in this paper have the objective to make these objective characteristics more transparent, by modelling them via MDA and MDI, allowing the various stakeholders to be able to understand not only what is visible but also the motivation, strategy and semantics behind each measurement and value. Additionally, the negotiation mechanisms promote that these semantics and values do not remain static, but instead are able to evolve and improve through time, allowing transformations, enhancements and the introduction of new ideas, trends, platforms and semantics.

One of these use-cases regards the analysis for business continuity and risk management towards digital preservation of the network of dams in Portugal, performed by the National Civil Engineering Laboratory ("LNEC," 2013).

A practical example of this framework relates to the measurements taken on a given set of dam sensors, related to temperature and pressure. The interpretation of these measurements varies, depending on the purpose of the selected set of sensors and their location. It also varies according to the objectives and strategies of the teams which are analysing these results.

The proposed negotiation framework and models permit the establishment of a common view, an agreed and compromising interpretation and semantic view of the results, and the negotiation model permits the analysis of the outcome of this negotiation. Whether this outcome is good or bad will influence the decisions to be taken on future, similar negotiations, hence promoting best-practices and reuse of knowledge.

The applicability of this paper may then be validated using a set of indicators and validation rules, which include the amount of different terminologies and processes that need to be harmonised throughout the different dams or the different sensor suppliers, the amount, effort and cost of the rework happening due to semantic misalignment before and after the application of the framework, the amount of time spent on harmonising these semantic issues with and without formal negotiation, the advantages in amount of time and cost of having a rich historic record of previous negotiations and negotiation steps and resulting outcomes.

5 CONCLUSIONS AND FUTURE WORK

Business complexity is rapidly increasing due to globalisation and, well, evolution. In this fast-pace, there are options and business decisions that need to be taken rapidly as well. The lack of maturity of numerous enterprises leads them to early and poorly designed solutions for enterprise interoperability, leading to some obvious mistakes that can be corrected immediately, and others that are not so obvious or detectable. When these are finally detected, some may require a reinstate of some of the business premises and environment.

While the TIMBUS project is aiming to support the development of this by performing risk management and selective digital preservation of assets, it is also based on the traditional risk management empirical analysis. This paper proposed a methodology, a negotiation model and a framework to support a mature, decision-support analysis of the business continuity, based on the modelling of the various entities and aspects related to enterprise interoperability, supported by a servitised set of supporting activities which are defined to perform the interoperability and to support it. The proposed framework's future work is to be validated in the scope of the project TIMBUS's use-cases. Additionally, the authors are seeking to enrich this framework with mechanisms which enforce contracting and the improvement of formal negotiation strategies.

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