Modelling Services for Business Knowledge Capture

Carlos Coutinho[1], Ruben Costa[2] and Ricardo Jardim-Gonçalves[2]
[1]*Caixa Mágica Software, Rua Soeiro Pereira Gomes, Lote 1-4 B, 1600-196, Lisboa, Portugal*
[2]*CTS, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, UNINOVA, Lisboa, Portugal*

Keywords: Model-Driven Development, Servitisation, Ontology Modelling, Interoperability.

Abstract: The competition inherent to globalisation has led enterprises to gather in nests of specialised business providers with the purpose of building better applications and provide more complete solutions. This, added to the improvements on the Information and Communications Technologies (ICT), led to a paradigm shift from product-centrism to service-centrism and to the need to communicate and interoperate. Traditional segments like banking, insurance and aerospace subcontract a large number of Small and Medium Enterprises (SMEs) that are undergoing this change, and must ensure the criticality and accuracy of their business is not affected or impacted in any way. This also is an excellent motivation for improving the capabilities for capturing the knowledge about businesses, not only their processes and methods but also their surrounding environment. 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 business information capturing strategies to help in the proper establishment of a knowledge base that permits a seamless interoperability between enterprises.

1 INTRODUCTION

The service globalisation perpetrated by the Internet has led to a need for change in the traditional businesses. Market terms and conditions dictate a constant need to change and adapt to new environment conditions, new paradigms and solutions, platforms and technology solutions, trends and fashions. Thus, being the best-of-breed no longer means being the most efficient or having the highest performance, it means keeping up with the look & feel trends, being available in many platforms and heterogeneous environments, i.e. implicates a continuous change. Many manufacturing enterprises currently have a very clear update and delivery schedule plan, e.g. when deploying a new car model, it is possible to know what the next version(s) of that car will look like and what it shall feature.

This heterogeneity, constant change and subsequent need for interoperability are worrying traditional business areas like finances (banking, insurance), aeronautics and aerospace, which usually tend to be very conservative towards change on account to accuracy and stability. As an example, the aerospace industry is served by a small set of large enterprises that implement projects and missions, and which then subcontract several Small and Medium Enterprises (SMEs) for supporting their development, thus creating a network of dependencies. The need for interoperability with the other players in these networks is as crucial for staying in business, as the ability to do so while maintaining the proprietary business assets protected from the competition.

The evolution of ICT permitted faster, more secure and robust data exchanges, promoting the development of solutions as result of the contributions of the several enterprises working in a network, thus allowing the gathering of multiple competences and expertise into higher-valued products and solutions. Emerging paradigms like the Internet of Things (CORDIS, 2009; Vermesan et al., 2011) (IoT, which is reshaping the world in the form of categorized discoverable items) and the Internet of Services (Cardoso et al., 2008; “Internet of Services,” 2012) (IoS), together with the evolving cloud computing’s concepts (Jeffery and Neidecker-Lutz, 2010) of Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) are gradually transforming the existing reality into a set of available commoditised virtual objects, services

Coutinho C., Costa R. and Jardim-Gonçalves R..
Modelling Services for Business Knowledge Capture.
DOI: 10.5220/0005408906260633
In *Proceedings of the 3rd International Conference on Model-Driven Engineering and Software Development* (MDE4SI-2015), pages 626-633
ISBN: 978-989-758-083-3
Copyright © 2015 SCITEPRESS (Science and Technology Publications, Lda.)

enterprises and networks.

This increase of availability and demand of combined solutions removed all traditional boundaries and allowed the specialisation of enterprises (particularly SMEs) and the building of complex and heterogeneous provider networks. This move from product-concentric to service-dispersed strategies is leading to concerns about reaching and maintaining the interoperability.

To large contractors or even final customers like banks and space agencies, which depend on the performance of this network of SMEs to conduct their business, the improvement coming from the specialisation needs to be balanced with the increase on control of the outcomes that result of multiple sources. The misunderstanding of a concept, a change in a data unit, a mistaken method on a single enterprise in the network can lead to chained mistakes on its counterparts and consequently to errors in the final result that are very difficult to detect and even more difficult to trace and resolve.

It is then essential that more than describing data and interface contracts, the interacting enterprises publish their models, ontologies and methods so that their partners can understand and cooperate with them easier. Moreover, it is important that a controlling entity (e.g., the prime contractor or the customer) is able to control if these models and concepts are aligned with the desired outcome.

This solution is thus essentially targeted to SMEs, so that they are more transparent in their models and interaction. It also helps their prime contractors to monitor whether their requirements are properly addressed.

The EU co-funded FP7 project TIMBUS (TIMBUS, 2013) faces these problems and proposes solutions that include a reasoned Digital Preservation (DP) of business assets, where this reasoning is performed by risk management. The main innovation of the 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 approach follows the work developed in (Jardim-Goncalves et al., 2014) to define NEGOSEIO as an architecture that handles interoperability negotiations. In this sense, the contribution in this paper comprises the detail of the first step of the NEGOSEIO methodology – The acquisition of business knowledge to develop the MDA and MDI models, establishing a formal model and strategy for capturing the information about businesses, 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 conclusions and future work.

SCIENCE AND TECHNOLOGY PUBLICATIONS

2 LITERATURE REVIEW

The proposed methodology is based on the kernel aspect of interoperability, 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 MDSE

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., UML, OCL, and 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 BUSINESS KNOWLEDGE CAPTURE

The NEGOSEIO (which regards Negotiation for Sustainable Enterprise Interoperability) Framework builds a set of MDA and MDI models that clearly describe the interoperating business assets, processes and interoperability. Hence it assumes the existence of a technology capable of capturing this knowledge and modelling it into their ontologies. This paper covers the issue of capturing business knowledge that is essential to build the models for MDA and MDI, it is essential to first develop a proper container for this information.

Considering its characteristics and the needs that were elicited, ontologies were the natural choice for performing this, because more than storing data, it is essential to also capture the relationships between the business concepts (Cretan et al., 2012). The ontology classes are capable to define concepts and interrelate them, and the ontology individuals provide the instantiation of the real artefacts of the business.

3.1 Capture Information System

A problem that comes with the ambition to provide a solution that fits all businesses regards their heterogeneity. This fact leads to a lot of difficulties in the TIMBUS intent to perform an automatic capture of the knowledge and assets about the business. This context capture needs to be very flexible and able to address different needs and requirements. It needs to address open-source and proprietary environments, new and legacy applications, and be prepared to handle new platforms and systems, as well as different types of security and secrecy demands. A study analysis performed by project TIMBUS on businesses determines that business knowledge not only spans on different machines, using multiple operating systems and running over multiple platforms, as most times a lot of this information is stored in the people's minds and personal notes, in archives and storage that needs to be also ingested, or in legacy systems that need to be addressed and instantiated, as can be seen in Figure 1.

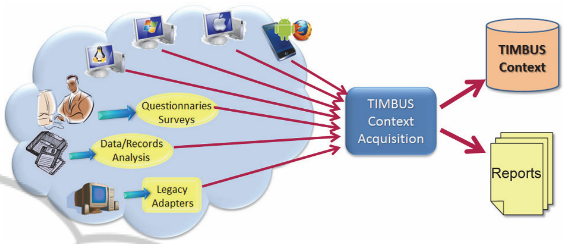

Figure 1: Heterogeneity in capturing business knowledge.

To address and resolve these challenges, a Context Model was designed and developed to systematically capture relevant aspects and elements of business processes that are essential for their preservation and verification upon later redeployment (Neumann et al., 2012). One first difficulty with this matter is that a single ontology would not be able to face the specificities of all businesses. Hence, there was the need to develop a main context model ontology which can be used as-is for all businesses, called a Domain-Independent Ontology (DIO). This ontology was authored in the Web Ontology Language (OWL) with the support of the Enterprise Architecture Modelling Language ArchiMate (The Open Group, 2012) which developed a framework specifically to address generically the modelling of information of businesses. This is then complemented by a set of other ontologies that are created for modelling specific use-case scenarios, called Domain-Specific Ontologies (DSOs) (Antunes et al., 2014).

The resulting Context Model is, then, instantiated into process-specific sub-models to provide a fine-grained set of dimensions that surround a particular use-case scenario. These relevant dimensions that surround a business process are called context parameters (Riedel, 2014). The specific scenarios chosen for TIMBUS served as clear illustrations that the Context Model is capable of supporting a vast realm of context parameters. The context model to capture a business' knowledge is then the conjunction of the DIO and the defined DSOs for that particular business (Antunes et al., 2013).

3.2 Tools for Business Heterogeneity

Another concern that arises from the need to capture the business knowledge is the establishment of a solution for business context acquisition tool that is capable to be flexible enough to cope with these definitions of the information system (i.e., it is straightforward to develop a solution that works with a single DIO, but handling multiple DSOs that are developed specifically to handle the particular topics of each business is much more complicated). As can be seen in Figure 1 again, the challenge here is not only coping with the DSOs, but also about developing one solution per business, or one solution per instance of the business, per machine or person, operating system or platform, and so on, or alternatively, to develop a single solution and expect the businesses to adapt to the solution.

Another challenge that relates to this matter regards a different aspect of the information capture which are the changes of information with time. This aspect, which is essential to TIMBUS, is very relevant for any business because the interoperability evolves with time, as business needs change, as also the flows of information between interacting entities. Hence there is the need to maintain a permanent connection to the business to perceive any changes that may conduct to updates in the models that shape the business. However, by being permanently connected to the business this cannot mean that the updates of the business knowledge capturing solution have any impact on the business itself. Therefore, any needs to restart the whole system because of this solution are not acceptable, as so should be avoidable any downtime of the capturing solution. So a big challenge is how to update the capturing solution to cope with the business changes, or with changes in the DSOs without breaking the business itself.

3.3 Proposed Framework

Considering all these issues, the solution architected was to use a framework using the Open Services Gateway Initiative – OSGi (Alliance, 2013) philosophy. This solution provides an environment where an application server hosts the context acquisition framework, which consists in a main set of tools (context acquisition) that are able to interact with separate modules called business information extractors. These extractors are tailored pieces of software built as OSGi bundles that interoperate with the framework using a defined interface. OSGi permits these bundles to be installed, removed, started and stopped without the need to affect any of the other components of the system, hence coping with one of the demands of the desired framework.

Figure 2 shows the proposed framework for the acquisition of business information. As can be seen, it comprises a set of static base modules and a variable and flexible set of extractor modules. While the first do the standard operations of information acquisition like the aggregation of the stored information by the multiple extractors, the latter are actually the modules that perform the interconnection to the business premises. These extractors can consist of generic modules that capture standard information (e.g., the information about the hardware installed in a target business machine, or in a whole cluster of multiple machines, or the software packages in a Linux distribution, or the set of Perl modules used for a particular application), and of specific extractors tailored for the specific needs of a business.

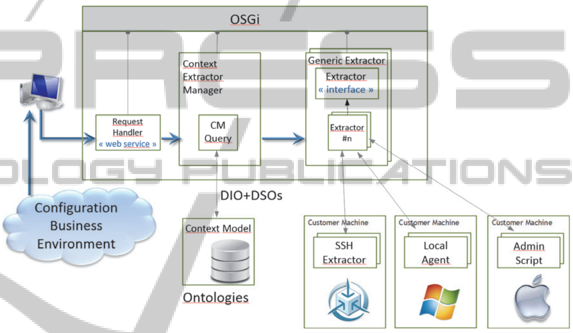

Figure 2: Business Information capturing framework.

These extractors are the instruments for retrieving the business information that is so needed for the development of the MDA and MDI models. Having this set of extractors built as OSGi bundles allows the creation at the same time of a single solution for all businesses and of a tailored solution for each business context. It allows the evolution of the context acquisition tool to comply with new business requirements or with new DSOs that are defined for storing their information. It finally allows a solution to be fully configurable regarding how to access the information, e.g., a solution may be built that accesses the target machine via SSH and has full access to that machine for retrieving information, another can be built that comprises a local agent installed on the target machine, that performs the extraction of information and publishes it via web-service, or even a solution that consists in a script to be run by a business responsible and then submit the results in the extraction framework. This flexibility permits the development of solutions that are able to be accepted by businesses that have low security demands up to those which have the strictest ones.

Finally, and most important of all, the definition of this philosophy allows the analysis of multiple disciplines for describing the business. Extractors can be built to model the business from the point of view of e.g., infrastructures, software, processes, legalities, organisation, hierarchies, and interoperability. These views can change from site to site of the business, but can also be reused on other businesses. Moreover, extractors may be developed that aggregate other extractors in order to infer information from multiple sources with a specific purpose.

Having this open architecture also allows extractors to be built according to the proper investment performed, i.e., an extractor that is built to describe a particular view of a business can be replaced by another much more thorough and that is able to extract more detailed information if it to be developed e.g., for a defence department or for an aerospace segment. Building more complex and complete extractors may then mean more investment in their development, hence the development of this business context acquisition framework allowed the fostering of another market, which is one of the development of extractors, in a business model similar to the one used in mobile apps.

As can also be seen in Figure 2, the results of the extractions, coming from multiple disciplines, with multiple sources and degrees of accuracy and time, are then compiled and stored in the context model. All the ontologies in the context model are then merged, thus allowing interesting conclusions to be achieved by reasoning and inferring the properties of the individuals after the consolidation of the various ontologies.

The extractors and reasoners are subsequently applied to the Context Model (or to an instance of it) for extracting, monitoring, and reasoning for digital preservation purposes. The technical dependencies on software and services can be captured and described via CUDF (Common Upgradeability Description Format) defined in the MANCOOSI project (Mancoosi Consortium, 2013) for systems which are based on packages. Such an approach enables TIMBUS to capture the complete setup and dependencies of a specific configuration for long-term preservation, which can be re-created, re-executed, and redeployed at a later time on modern hardware and with a different business scenario.

3.4 Use-case Validation

This research work was being implemented in the scope of the TIMBUS project. This project is now finishing, having validated its results in a set of well-defined real use-cases.

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). The applicability of this paper in this particular use-case was then 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. While unfortunately most results of TIMBUS have restrictions to their publishing regarding the proprietary rights of each business of the use-cases that were used for the project's assessment, nevertheless several evidences were published documenting the business capturing process success: (TIMBUS, 2014b) shows the whole process of capturing information for the sample use-case of preserving an open-source workflow process business, and (TIMBUS, 2014a, 2014c, 2014d) present public assessments and validation of the results of the TIMBUS tools and processes, which include the Business Capturing presented in this document.

4 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 an information 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 was then validated in the scope of the project TIMBUS's use-cases. As future work, the authors foresee improving the current framework to provide it elements to perform a better decision support with respect to which disciplines to handle, their accuracy, better ways to automate the merging of the ontologies. One possible solution to achieve this is via the use of the negotiation framework NEGOSEIO, thus closing its own loop.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the support of the European Commission through the funding under the 7th Framework Programme for research and technological development and demonstration activities, through projects TIMBUS (FP7 / 269940) and FITMAN (FP7 / 604674).

REFERENCES

Alliance, Osg. (2013). Open Services Gateway Initiative. Retrieved October 15, 2013, from http://www.osgi.org/Specifications/HomePage.

Antunes, G., Bakhshandeh, M., Mayer, R., Borbinha, J., & Caetano, A. (2014). Using Ontologies for Enterprise Architecture Integration and Analysis. *Complex Systems Informatics and Modeling Quarterly*, (1), 1. doi:10.7250/csimq.2014-1.01.

Antunes, G., Caetano, A., Bakhshandeh, M., Mayer, R., & Borbinha, J. (2013). Using Ontologies to Integrate Multiple Enterprise Architecture Domains. In *4th Workshop on Business and IT Alignment (BITA 2013)*.

Athena Consortium. (2007). ATHENA Project: Specification of interoperability framework and profiles, guidelines and best practices. Retrieved from http://interop-vlab.eu/ei_public_deliverables/athena-deliverables/A4/d-a4.2.

Athena Consortium. (2011). Athena Interoperability Framework. Retrieved December 20, 2011, from http://www.modelbased.net/aif.

Cardoso, J., Voigt, K., & Winkler, M. (2008). Service Engineering for the Internet of Services. In *10th International Conference on Enterprise Information Systems ICEIS 2008* (pp. 15–27).

Chen, D., Doumeingts, G., & Vernadat, F. (2008). Architectures for enterprise integration and interoperability: Past, present and future. *Computers in Industry*, *59*(7), 647–659. doi:10.1016/j.compind.2007.12.016.

CORDIS. (2009). *Internet of Things - An action plan for Europe*. CORDIS. Retrieved from http://ec.europa.eu/information_society/policy/rfid/documents/commiot2009.pdf.

Cretan, A., Coutinho, C., Bratu, B., & Jardim-Goncalves, R. (2012). NEGOSEIO: A Framework for Negotiations toward Sustainable Enterprise Interoperability. *Annual Reviews in Control*, *36*(2), 291–299. doi:10.1016/j.arcontrol.2012.09.010.

Doumeingts, G., Vallespir, B., & Chen, D. (2006). GRAI GridDecisional Modelling. In *Handbook on Architectures of Information Systems* (pp. 321–346). Springer. Retrieved from http://www.springerlink.com/content/978-3-540-25472-0/#section=658705&page=2&locus=0.

Internet of Services. (2012). Retrieved from http://www.internet-of-services.com.

Jardim-Goncalves, R., Coutinho, C., Cretan, A., da Silva, C. F., & Ghodous, P. (2014). Collaborative negotiation for ontology-driven enterprise businesses. *Computers in Industry*, *65*(9), 1232–1241. doi:10.1016/j.compind.2014.01.001.

Jeffery, K., & Neidecker-Lutz, B. (2010). *The Future of Cloud Computing: Opportunities for European Cloud Computing Beyond 2010* (No. 1.0). *Analysis*. Retrieved from http://cordis.europa.eu/fp7/ict/ssai/docs/cloud-report-final.pdf.

Lemrabet, Y., Bigand, M., Clin, D., Benkeltoum, N., & Bourey, J.-P. (2010). Model Driven Interoperability in practice : preliminary evidences and issues from an industrial project. In *First International Workshop on Model-Driven Interoperability (MDI'10)* (pp. 3–9). ACM. doi:10.1145/1866272.1866274.

LNEC. (2013). LNEC Portal. Retrieved June 10, 2013, from http://www.lnec.pt/organizacao/dbb/nmmf/estudos_id.

Maglio, P. P., Srinivasan, S., Kreulen, J. T., & Spohrer, J. (2006). Service Systems, Service Scientists, SSME, and Innovation. *Communications of the ACM - Services Science*, *49*(7), 81–85.

Mancoosi Consortium. (2013). Mancoosi CUDF web page. Retrieved March 04, 2013, from http://www.mancoosi.org/cudf.

MSEE Project. (2012). Retrieved April 10, 2012, from http://www.msee-ip.eu/project-overview.

Neumann, M. A., Miri, H., Thomson, J., Antunes, G., Mayer, R., & Beigl, M. (2012). Towards a Decision Support Architecture for Digital Preservation of Business Processes. In *Proceedings of the International Conference on Preservation of Digital Objects (iPRES 2012)*.

OMG. (2011). Model Driven Architecture. Retrieved December 20, 2011, from http://www.omg.org/mda.

Riedel, T. (2014). *Federating real world information about business processes into the TIMBUS Context Model*. Retrieved from http://www.timbusproject.net/documents/articles/188-riedel-whitepaper-context-mo-

del-edited/file.
The Open Group. (2012). The ArchiMate Modelling Language. Retrieved December 14, 2012, from http://www.opengroup.org/subjectareas/enterprise/archimate.
TIMBUS. (2013). TIMBUS Project page. Retrieved May 15, 2013, from http://timbusproject.net.
TIMBUS. (2014a). *TIMBUS D7.6: Conceptual/Technical/Business Pilots*.
TIMBUS. (2014b). *TIMBUS D7.7: Preservation of an open source workflow – Case Description and Analysis*.
TIMBUS. (2014c). *TIMBUS D8.5: Conceptual/Technical/Business Pilots*.
TIMBUS. (2014d). *TIMBUS D9.5: Conceptual/Technical/Business Pilots*.
Vermesan, O., Friess, P., Guillemin, P., Gusmeroli, S., Sundmaeker, H., Bassi, A., … Doody, P. (2011). Internet of Things Strategic Research Roadmap. In *Internet of Things: Global Technological and Societal Trends* (pp. 9–52). River Publishers.

SCITEPRESS
SCIENCE AND TECHNOLOGY PUBLICATIONS