3

ARCHITECTING AN UBIQUITOUS & MODEL DRIVEN INFORMATION INFRASTRUCTURE

J.B.M. Goossenaerts
Eindhoven University of Technology, the Netherlands
Em: J.B.M.Goossenaerts@tm.tue.nl

Abstract: A model driven architecture (MDA) approach is applied to the architecting of a Ubiquitous and Model-driven information Infrastructure (UMI). Our focus is on the stakeholders of the ubiquitous infrastructure, the distinction between the infrastructure, the enterprises and applications accommodated by it, and the dependencies among the conceptual models at different levels. A small example illustrates the proposed concepts and constructions.

Keywords: Model Driven Architecture, Information Infrastructure, Ubiquity

1. INTRODUCTION

There is an increasing understanding of modeling techniques and their support for communication with the stakeholders in (information) systems, prior to systems implementation and deployment. As a result, methodologies and tools come available for the model driven building and deploying of information systems and software applications. The recent OMG-proposed [1] Model Driven Architecture (MDA) puts the model, a specification of the system functionality, on the critical path of software development, prior to the implementation of that functionality on a specific technology platform. *"The MDA approach and related standards allow a same model to be realized on multiple platforms, and allows different applications to be integrated by explicitly relating their models, enabling integration and interoperability and supporting system evolution as platform technologies come and go."*

Accepting a model driven approach, this paper separates three levels at which to apply MDA: the enterprise, the application and the information infrastructure. Most publications on MDA [2] target application development, and publications on information infrastructure tend to focus on the ICT platform and its performance. Complementary to these other contributions, this paper focuses at models and architecting at the information infrastructure level, and at the consequences for enterprise and application development of using infrastructure level models.

2. ANCHORING ARCHITECTURE BY MODELS

Intuitively, the vision of a model driven architecture can be linked to a combination of Boehm's Win-win Spiral model [3] and Kruchten's 4+1 view model [4] of (software) systems architecture. The Win-win spiral is used to ensure that the end-users drive the architecture and development work for the whole duration of the project. The model also introduces milestones to anchor the development process, and to assess and mitigate risks. The 4+1 view model is adopted because projects are situated in an engineering context where a large portion of specifications (expressed as models), software systems and data, and hardware systems are (re-) used and/or have to inter-operate (in a software intensive system), and evolve over time.

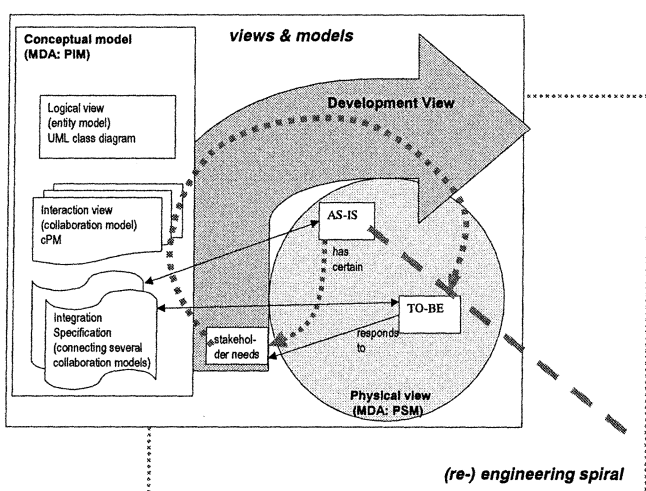

Figure 1. A re-engineering spiral anchored by views and models

The UML offers modeling constructs for each of the 4+1 views. In a modified approach we use a conceptual (pseudo) collaboration model (pCM) combining notational elements from high-level Petri nets (HLPN), IDEF-0, and UML activity diagram. Our notion of collaboration is similar to that of ebXML (http://www.ebxml.org/specs/). The hierarchy of activities is specified using a parent-child connector (⌊), which is frequently used in product structures. A swimming lane layout separates the activities to be performed in the different roles with a controlling stake in the collaboration. The input, output, control and support conventions of the IDEF-0 generic activity model are applied, they connect the activity with (Petri-net-like) places containing an expression (over the entity model) that indicates which entities are involved in the activity. Figure 3 illustrates the collaboration modeling technique. The Integration Specification deals with the integration and aligning of the different collaboration models. All models in the conceptual model block are platform independent models (PIM) in the sense of MDA. The platform specific models (PSM) are part of the physical view: the ICT platforms need them to carry out their share of the work.

Assume now that there is an existing system (AS-IS) that needs to be improved. Then the re-engineering spiral in Figure 1 is model enabled: problem analysis delivers additional stakeholder needs, requirements analysis and design deliver extended or new collaboration models, optionally with refinements in the entity models, and a new integration specification. The latter is an input to the development and implementation to deliver the TO-BE physical realization.

3. UMI, COMMUNITIES AND APPLICATIONS

An information infrastructure consists of the information models, data, and information processing services and tools that are shared by the different autonomous entities that collaborate or interact in a community or society. The trend towards a ubiquitous information infrastructure builds on the connectivity and low-cost high-performance computing and communication facilities provided by computers, the Internet and wireless communications, ranging from Bluetooth to satellite-based. A UMI is defined for and embedded in a society to support all the society's members and communities.

The term *society* is used here with the meaning of "all people, collectively, regarded as constituting a community of related, interdependent individuals". A *community* is "a group of people having interests or work in common, and forming a smaller (social) unit within a larger one." This definition thus covers enterprises, public bodies, sports clubs, schools, hospitals, etc. All members of a society are *persons* with equal rights and, in principle, the ability to use the UMI. Each person may belong to several communities. A community has no member outside society.

Typically, each community will enact processes and install applications to sustain its interests. Maybury for instance, describes Collaborative Virtual Environments for distributed analysis and collaborative planning for intelligence and defense [5]. The DIISM conferences have been dedicated to the design of the information infrastructure systems for manufacturing and engineering enterprises. Virtual communities in relation to Peer-to-Peer collaboration architectures are discussed in [6]. Table 1 lists products and artifacts that typically are involved when the re-engineering spiral is applied at the levels of infrastructure, community and application.

Table -1. Levels of applying the re-engineering spiral

Level	Typical services	Conceptual model	Dev. view	Physical view
infrastructure	authentication & personalization collaboration standards	market & collaboration models (e.g., ebXML, SimpleEconomy)	J2EE/EJB WSDL	SOAP/XML CORBA/CCM DCOM/.NET
community	production & services	enterprise model, process model	BPR and its tools	operational processes
application	purchasing	orders&invoicing	ARIS, DEM	ERP systems
	CAD	eng. product struct.	Rational	PDM systems
	ERP	log. product struct.	Telelogic	PPC systems
		MDA:PIM	TogetherSoft	MDA:PSM

Whereas the development and physical view components in Table 1 are working systems or accepted standards, most of the infrastructure level state-of-the-art components lack (public) models or trace-ability to stakeholders needs. In fact, we have no comprehensive and stakeholder/end-user-driven set of criteria to evaluate the infrastructure level components for their fitness to serve in an UMI. In a step towards a more rigid foundation, the further sections will highlight some of the issues. Relying on piecemeal ontological commitment[7] the focus is on simple application scenarios for a minimal societal ontology of objects and activities[8]. We do not consider the content of the entity classes[9]. In Section 4, the view and spiral model (Figure 1) is applied to UMI and some basic models are given. In Section 5 we briefly consider infrastructure-enabled application development. At the infrastructure level the focus is at members and their roles in typical collaborations. Applications support specific collaborations, which they may also partially control.

4. ARCHITECTING UMI

The current state of the information infrastructure is that physical view aspects of its architecture are better understood than the conceptual view aspects. Our position is that conceptual models are an integral part of an information infrastructure because of their role in anchoring a model-driven architecting process for the communities and the applications.

At the infrastructure level three kinds of stakeholders are identified: *society*, *member* and *community*. The stratification of the common context for these stakeholder's requirements is addressed in another paper[10]. Some generic win conditions are given here.

The society as a whole pursues compliance to its enacted models and agreed upon policy goals (e.g. fair trade and protection of property in the global society). With goals such as rapid implementation of new "laws" or charters, it could use the subsidiarity principle to organize its institutions and ensure that each problem is addressed at the level at which it is common for all the lower-level stakeholders.

The success of a community depends on the support that its members receive for their relevant actions, conform the processes enacted and the society's law or rules. E.g., the certification of a new type airplane by the relevant authorities, or the carrying out of tax payments and elections. Change, i.e. improvements of the operational processes, must happen smoothly, without disruption of the community's services, and with a minimal burden to its members.

The member's win conditions include a.o. empowerment, legal security, efficient operations, optimal propagation of change, minimal risk of inconsistencies, data protection and privacy [11]. Infrastructure facilities that contribute to enabling these requirements include personalization [12] everywhere and anytime.

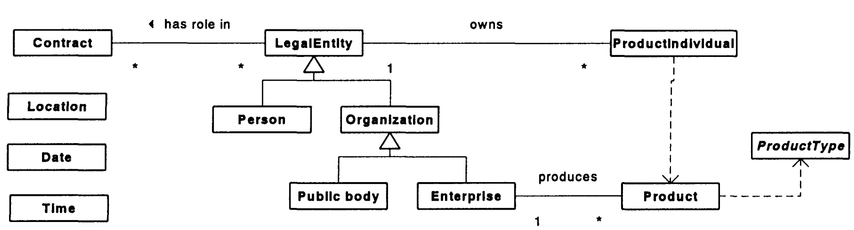

Figure 2. A SimpleEconomy entity-model

A platform independent model of an UMI includes a model of the persons and communities interacting in society. Because quite a few of these interactions are concerned with the production, exchange and consumption of goods or products, it is evident to also include classes for products. Persons can join or leave communities (e.g., organization) (Figure 2). The Sale collaboration illustrates the SimpleEconomy interactions (Figure 3). Collaborations in SimpleEconomy must meets market rules that are part of the integration specification and constrain the choices of the entities involved in combinations of collaborations.

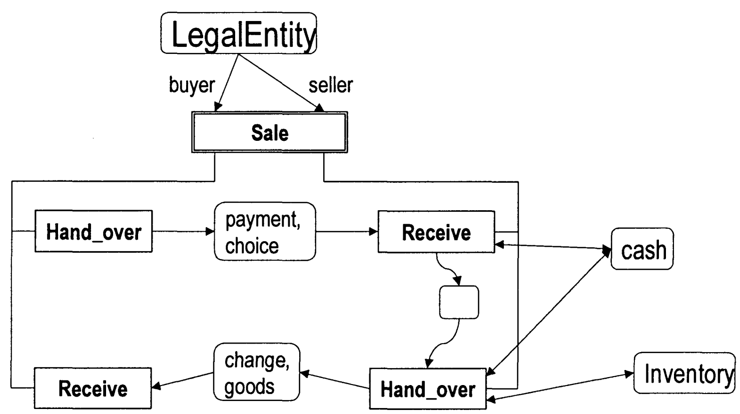

Figure 3. The Sale collaboration in SimpleEconomy

The above models are part of the conceptual view. A model driven infrastructure requires also the elaboration of a physical view. The infrastructure should manage a "proxy", or unique representant, for each instance (entity) in society. In one of many possible implementations, this proxy could be an XML document instance that is conform to the schemas expressing the ontological and collaborative commitments shared in society.

5. UMI ENABLED COMMUNITIES

Given the ontological commitment of the society domain, any community, e.g. a company, will be the result of the execution of community formation steps (Join, Exchange, Leave activities) as well as proprietary formation steps and refined ontological commitments, which are not shared with society as a whole. For instance, a company may decide to source parts from several suppliers, to assemble them, and then exchange them for money.

In its proprietary conceptual model, the company's enhanced ontological commitment is embodied in a refined classification hierarchy often complemented by an enhanced meta-model, e.g. one that gives consideration also to product and facility structure or product family. Company specific resource sub-classes such as Storage and Walkway, and the Product sub-class Part, illustrate the refined classification hierarchy. The company's collaborations then refer to the enhanced ontological commitment.

In the physical view, the refined classification hierarchy and enhanced meta-model give rise to extended document instances as proxies for the entities within the context of the company. To the extent that the information infrastructure is model-driven and has a proper architecture, any community will be able to reuse society models, and to align its proprietary models with its core competences.

6. CONCLUSION AND FUTURE WORK

This paper has clarified the interwove ness of infrastructure and enterprise level conceptual models within a MDA approach. The UMI architecture description was addressed and briefly illustrated for an abstract society using a fairly simple ontology of individuals. One challenge for future work is to scale up the ontology from individuals to objects with a state-of-the-industry complexity. To this end, piecemeal ontological commitment and multi-strata conceptual modeling must be combined.

REFERENCES

1. OMG Architecture Board ORMSC (2001) Model Driven Architecture (MDA), Doc. Nr. ormsc/2001-07-01.
2. de Miguel, M., Jourdan, J., Salicki, S. (2002) Practical Experiences in the Application of MDA. In: Jezequel, J.-M., Hussmann, H., Cook, S. (eds) UML 2002, LNCS 2460, pp. 128-139, Springer Verlag Berlin Heidelberg.
3. Boehm,B., Egyed,A., Kwan,J., Port,D., Shah,A., Madachy, R. (1998) Applying the WinWin Spiral Model: a Case Study, IEEE Computer, July 1998, pp 33-44.
4. Kruchten, P. (1995) Architectural Blueprints - The "4+1" View Model of Software Architecture, IEEE Software, 12 (6)

5. Maybury, M. (2001) Collaborative Virtual Environments for Analysis and Decision Support, Communications of the ACM, 44(12) pp 51-54
6. Lechner, U. (2002) Peer-to-Peer beyond File Sharing. In: Unger,H., Boehme,T.,& Mikler, A. Innovative Internet Computing Systems, LNCS 2346, pp 229-249, Springer Verlag.
7. Borst, P., Akkermans, H., & Top, J.(1997) Engineering Ontologies. Int. J. Human-Computer Studies, 46 (1997) 365-406
8. Goossenaerts, J., Pelletier, C. (2002) Ontological Commitment for Participative Simulation. In: H. Arisawa, Y. Kambayashi, V. Kumar, H.C. Mayr, I. Hunt (eds) Conceptual Modeling for New Information Systems Technologies. LNCS 2465, Springer Verlag, pp 127-140
9. Bickhard, M.H. (2001) Why Children don't have to solve the Frame Problems: cognitive representations are not encodings. Developmental Review, 21 (2001) pp 224-262
10. Abramov, V.A., Goossenaerts, J.B.M., De Wilde, P., Correia, L. (2003) Ontological Stratification in an Ecology of Infohabitants, this volume.
11. Berkers, F., Goossenaerts, J., Hammer, D.K., Wortmann, J.C. (2001) Human Models and Data in the Ubiquitous Information Infrastructure. In: H. Arisawa, Y. Kambayashi, V. Kumar, H.C. Mayr, I. Hunt (eds) Conceptual Modeling for New Information Systems Technologies. LNCS 2465, Springer Verlag, pp 91-104
12. Popescu-Zeletin, R., Abranowski, S., Fikouras, I., Gasbarrone, G., Gebler, M., Henning, S., van Kranenburg, H., Portschy, H., Postmann, E. & Raatikainen, K. (2003) Service architectures for the wireless world, Computer Communications, 26(1), pp 19-25