Preparing the Future Internet for ad-hoc business networks support

Marten van Sinderen*, Robert Lagerström**, Mathias Ekstedt** and Pontus Johnson**

*University of Twente
Information Systems Group
Department of Computer Science
PO Box 217
7500 AE Enschede, The Netherlands
m.j.vansinderen@ewi.utwente.nl

**KTH the Royal Institute of Technology
Industrial Information & Control Systems
Osquldas v. 12
10044 Stockholm, Sweden
{robertl, mek101, pj101}@ics.kth.se

ABSTRACT: *The generally agreed upon basic architecture for the Future Internet contains Internet of Things, Internet of Services, and Internet of Contents and Knowledge. The main contribution presented in this paper is an extension to this architecture, which includes three additional components, namely Business-specific Knowledge and Services, a Business Network Evaluator, and a Business Network Coordinator. These three components are needed in order for the Future Internet to be able to support the dynamic creation and coordination of ad-hoc business networks.*

KEY WORDS: *Future Internet, Ad-hoc business networks, Architecture modeling*

1. Introduction

The Future Internet development is concerned with an improved Internet that will overcome the limitations of the current Internet (Zahariadis *et al.*, 2011, Stuckmann *et al.*, 2009). It aims at achieving increased performance and experience (e.g., in terms of speed, efficient use of resources, dynamic scalability, technology independence, and usage-based billing) through the adoption of advanced networking technology and associated architectural principles.

The Future Internet offers great potential for enterprises, but it is unclear how enterprises will be able to fully use this potential. The Internet developments are largely technology-driven, whereas enterprises are business-oriented: they require specific solutions to support their operation driven by business objectives and market opportunities. The current trend is that enterprises become more and more dynamic and adaptive, forming loosely coupled business value networks –or extended enterprises– to increase competiveness and to permit new value propositions. It is still on open question how can this be supported with emerging technology, e.g. for real-time querying and controlling 'things', or for on-demand finding, using and managing services and knowledge. A situation where different organizations embark on independently developing technology patches, which are likely to be non-interoperable, should be avoided.

Therefore, this paper argues that explicit attention should be given to enterprise requirements when defining the Future Internet. A business network[1] support 'layer' as an integral part of the Future Internet Architecture is proposed. This support layer primarily targets Internet of Services, but is also concerned with the seamless integration of real and virtual worlds for the purpose of realizing business goals, through the use of Internet of Things and Internet of Contents/Knowledge.

2. Proposed Architecture for the Future Internet

This section presents the basic Future Internet Architecture (FIA), as well as its proposed extension.

2.1. *Basic Future Internet Architecture*

FIA features a few important components, namely Internet of Things, Internet of Services, and Internet of Contents/Knowledge (Papadimitriou 2009).

Internet of Things is based on a vision of a world instrumented with sensors and actuators. It allows monitoring many real world parameters and phenomena, e.g. the location of people and objects, the context conditions of people and objects (temperature, humidity, presence of gasses), the status of processes, the status of

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[1] We use the term business network to denote a construct where actors come together to co-produce value for their own or mutual benefit.

environments (pollution, weather conditions), etc. Conversely, the same parameters and phenomena may be controlled via appropriate actuators.

Internet of Services assumes that all functions provided by information technology systems can be packaged as services. A service is a composable functional unit, which can be searched, used and managed via standard interfaces, without knowledge about its technical implementation. Special (infrastructure) services exist for searching, using (e.g., coordination) and managing (e.g., registration and de-registration) services.

Internet of Contents and Knowledge intends to make user created content as well as enterprise related information searchable, sharable and machine-processable. It would make it possible to transfer human knowledge to the computer domain, and exploit the knowledge in automated handling of tasks. Knowledge can be represented with domain ontologies and enterprise (meta-) models, and tasks can be handled by services.

These three components require communication, which is supported by a common networking technology foundation, sometimes referred to as the *Internet of Networks*, say the high-bandwidth, high-quality version of the current Internet.

2.2. *Future Internet Architecture Extension*

In order for enterprises to dynamically form a business network, we envision that the Future Internet provides support for (i) finding information on the collaboration relevant capabilities and constraints of enterprises, (ii) constructing a model of a business network using this information, and (iii) enforcing the coordination between enterprises through execution of this model. Accordingly, we identify three components for the business network support layer of FIA, namely Business-specific Knowledge and Services (BKS), Business Network Evaluator (BNE), and Business Network Coordinator (BNC) – see Figure 1.
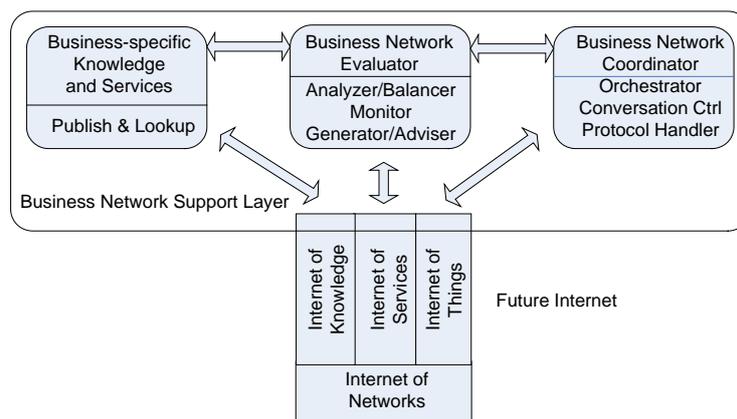

Figure 1. *Proposed Future Internet Architecture extension.*

Business-specific Knowledge and Services (BKS): Enterprises that want to participate in business networks first have to publish their capabilities on the Internet (or on an Internet-hosted virtual network confined to a specific community). These capabilities take the form of business services, represented by business service descriptions, stored by the BKS as part of the Internet of Services. Business service descriptions should contain certain information that is required by the Business Network Evaluator (described below). The information is assumed to be relatively static, applicable to any business collaboration or business network instance. The interpretation and use of services should be based on certain common understandings, captured by domain ontologies, metamodels or models. This can be seen as the knowledge part of the BKS, which is then embedded in the Internet of Knowledge. Again, what should be in the knowledge part is determined by the needs of the Business Network Evaluator. Business services and knowledge items must be published and managed by enterprises, hence a special Publish service is needed. Similarly, business services and knowledge items must be found by enterprises before they can be used, hence a special Lookup service is needed.

Business Network Evaluator (BNE): One assumption made is that there is always 'requestor' enterprise that indicates a desire or need to start a business network. The BNE has the responsibility to decide on the viability and to advice on the formation of a business network. Two extremes are distinguished here.

The first extreme is where the BNE performs a series of analyses to incrementally construct a model of the business network before the business network is initiated. The BNE starts from the requirements provided by the requestor, e.g. the requestor's collaboration goals and the prerequisites for achieving these goals. Given these requirements the BNE looks for services of potential partner enterprises that can fulfill of these requirements. With these candidate services it can analyze certain desirable properties, such as economic value, environmental footprint, trust, security and availability. The analyses use the relatively static information from service descriptions and knowledge items provided by the BKS. In addition, it may include current status information obtained from the Internet of Things or from the enterprises that provide the services. In order to achieve a viable business network, the BNE should not only fulfill the requirements of the requestor, but of all participants in the network. This requires balancing and trading. Different participants may have different priorities on goals (e.g., one participant may target immediate profit, while another prefers availability and quality in order to increase customer loyalty). Even if they have the same set of priorities, their goals may be conflicting in the particular collaboration that is being considered (e.g., more profit for one participant may lead to less profit for another participant). The business network may have a collective goal, which somehow influences the balancing of goals of each of the participants (e.g., in handling an accident with fire and looting, fire-fighting and life-saving are considered more important than thief-catching). In any case, the outcome of the analyses should be a business network model indicating: who is involved, what is (the likelihood of) the fulfillment of their individual and collective goals, and how this is accomplished.

The 'who' and 'how' parts in particular can be passed to the Business Network Coordinator.

The second extreme is when the Business Network Coordinator already has a business network, and the BNE does just-in-time analysis while the coordination process for the business network is being executed. In this case, the Business Network Coordinator may come to a stage in the execution of the coordination process where an as-yet unknown participant has to be involved in order to perform a known service (at least in terms of goals and prerequisites). A request can then be formulated to the BNE, which then basically does the same type of analyses, albeit with a smaller scope and reduced complexity.

All functions mentioned – model construction, specific analyses, goal balancing, behavior monitoring (collecting current state information) – may be offered as infrastructure services in the Internet of Services.

Business Network Coordinator (BNC): The BNC executes a coordination process derived from the business network model. The coordination process defines which services are to be invoked, when they have to be invoked and where they have to be invoked. It also defines the dependencies between services (e.g., output of one service contributes to the input of another service) and the conditions on the invocation of a service. In other words, the BNC orchestrates the services offered by the participants in the business network. When the BNC evaluates a condition (to determine which service to invoke next), it may use current state information provided by the Internet of Things. The BNC may also monitor compliance to protocol standards, dispatching of messages to the right local process (in case several instances of the same service are in use at a participant), or enforcing a specific protocol – in the role of conversation controller or protocol handler. The orchestration may be offered as a third party service or assigned to one of the participants. Conversation control and protocol handling probably can be seen as crosscutting aspects, but all the same may be implemented as infrastructure services.

3. Conclusions and Future Work

This paper outlines a Future Internet Architecture (FIA) with a business network support layer, aiming at providing appropriate support to enterprises when they want to set up an ad-hoc business network. It assumes that a model of the business network can be constructed through a series of analyses, and ultimately used to derive and enforce the necessary coordination between the participants in the network. Consequently, we envision three important areas for our future research:

- Conceptualization of properties (e.g., profitability, sustainability, trust, security) that matter to enterprises, and relating these to business network modeling;
- New techniques to analyze these properties, where such techniques are able to produce results that can be used in automated feedback for adapting business network models;
- Using Future Internet facilities to capture information on enterprises and their

context, for automatically setting up or correcting business network models.

As a first step, we want to explore the use of Enterprise Architecture (EA) models at run-time (Blair *et al.*, 2009). EA is a comprehensive architectural description that spans business and technology aspects, to allow understanding and analysis of enterprise properties. We intend to combine and extend existing ideas in this area, in order to make them suitable for run-time use. The following works are considered relevant: (Engelsman *et al*., 2011) present a modeling language that supports stakeholder concerns, in terms of high-level goals and requirements. (Fatemi *et al.*, 2011) introduce an approach for measuring stakeholder trust in business webs. (Buckl *et al.*, 2011, Ullberg *et al.*, 2011) suggest causality-based formalisms for EA analysis. Finally, (Barthe *et al.*, 2011) propose an approach for building a service-oriented mediation information system that can support enterprise collaboration.

4. References

Barthe A.-M., Benaben F., Truptil S., Lorre J.-P., Pingaud H. (2011), "MDI for SOA Management of a Crisis", *Enterprise Interoperability – Workshops of the 3rd Intl. Working Conference IWEI*, ISTE Ltd / John Wiley & Sons, Inc., pp. 123-133.

Blair G., Bencomo N., France R.B. (2009), "Models@Run.Time", *Computer*, vol. 42, no. 10, IEEE Computer Society, pp. 22-27.

Buckl S., Buschle M., Johnson P., Matthes F., Schweda C.M. (2011), "A Meta-language for Enterprise Architecture Analysis", *Enterprise, Business-Process and Information Systems Modeling – 16th Intl. EMMSAD Conference*, LNBIP 81, Springer, pp. 511-525.

Engelsman W., Quartel D., Jonkers H., van Sinderen M. (2011), "Extending Enterprise Architecture Modelling with Business Goals and Requirements", *Enterprise Information Systems*, vol. 5, no. 1, pp. 9-36.

Fatemi H., van Sinderen M., Wieringa R. (2011), "Trust and Business Webs", *15th IEEE Intl. Enterprise Distributed Object Computing Conference (EDOC)*, IEEE Computer Society, pp. 119-128.

Papadimitriou D. (Ed.) (2009), "*Future Internet – Cross-ETP Vision Document*". Available at: http://www.future-internet.eu/fileadmin/documents/reports/Cross-ETPs_FI_Vision_Document_v1_0.pdf

Stuckmann P., Zimmermann R. (2009), "European Research on Future Internet Design", IEEE Wireless Communications, vol. 14, no. 5, pp. 14-22

Ullberg J., Johnson P., Buschle M. (2011), "A Modeling Language for Interoperability Assessments", *Enterprise Interoperability*, LNBIP 76, Springer, pp. 61-74.

Zahariadis T., *et al.* (2011), "Towards a Future Internet Architecture", *The Future Internet – Future Internet Assembly 2011: Achievements and Technical Promises*, LNCS 6656, Springer, pp. 7-18.