A Cloud–Based Approach for Collaborative Networks Supporting Serviced-Enhanced Products

Bholanathsingh Surajbali, Markus Bauer, Holger Bär, Spiros Alexakis

A Cloud–Based Approach for Collaborative Networks Supporting Serviced-Enhanced Products

Bholanathsingh Surajbali, Markus Bauer, Holger Bär, Spiros Alexakis
CAS Software AG, Karlsruhe, Germany
{b.surajbali, markus.bauer, holger.baer, spiros.alexakis}@cas.de

Abstract. Collaboration through sharing competencies and resources has been a key approach to both creating new competitive environments, as well as achieving the needed agility to rapidly answer to market demands. Establishing proper collaborative networks for service-enhanced products is challenging considering the wide diversity of, business operations and involved resources. The creation of software solutions to support such collaboration is an effort-intensive task, especially when these solutions are designed to run in the cloud and when they are required to be highly customisable to different end-user scenarios. In this paper we describe how a cloud-based platform can support the creation of software solutions for the collaborative development and operation of highly customised and service-enhanced products. The platform has been designed based on numerous key requirements that have been generated from the analysis of different business scenarios from various use cases/domains, as well as general key requirements a cloud based platform should provide to support collaboration among organisations.

Keywords: Collaborative networks, Virtual Organisation, Cloud Computing

1 Introduction

There is a growing trend in manufacturing to move towards highly customised products, even one-of-a-kind, which is reflected in the term *mass customisation*. Mass customisation refers to a customer co-design process of products and services which meet the needs/choices of each individual customer with regard to the variety of different product features. The development of these products typically requires a variety of competencies and resources, hardly available in a single enterprise, which calls for collaboration among several companies and individuals. Collaboration through sharing competencies, resources and services has been a key approach to both creating new competitive environments, as well as achieving the needed agility to rapidly answer to market demands. Being able to rapidly react to a collaboration opportunity in fast changing market conditions is a key requirement for dynamic virtual organisations (VOs) [1].

The notion of *glocal* enterprise emerged to represent the idea of thinking and acting globally, while being aware and responding adequately to local specificities, namely in collaboration with local stakeholders and customers for VO.

Software that runs in the cloud has gained significant attraction in the past few years representing the emerging paradigm for distributed value added services. With cloud computing, enterprises are given new opportunities to push virtual collaborative alliances to the next level, breaking down some barriers and enabling dynamic continuous collaboration that generates globally composed business value. In this paper, we propose a cloud based platform, developed in the GloNet project [5] and providing support for the co-creation/ mass customisation of service-enhanced products. The rest of the paper is organised as follows: in Section 2 describes related work followed by Section 3 describing the main functionality required for collaborative networks. Then in Section 4, we describe the essential design principles for a cloud-based approach for collaborative networks. Next, in Section 5 we describe the main architecture of the GloNet platform. Finally we offer our conclusion in Section 6.

2 Related Work

A number of research and development work has been focusing on the collaboration platform problem. Despite the research and development work done in the last decade, the collaboration platform problem remains a practically unresolved issue, each addressing separate concerns of the collaboration domain. A number of research projects i-SURF [9], CONVERGE [10], COIN [11], SUDDEN [12] focussed on the support of collaboration across the supply chain to enhance planning, decision making and coordinate supply networks. Other research works such as ATHENA [13], SODIUM [14], COMMIUS [15], DIP [16] focused into development of web-based tools to enable interoperability of tools and applications. In addition to the web-based tools, ECOSPACE [17] offers service-oriented tools to manage complex daily work tasks in collaboration spaces. Significant research works such as LABORANOVA [18], SYNERGY [19], COIN [11], ECOLNET [20] have also looked into creating tools to enable collaboration in teams, companies, organisations, networks and social communities in general. GloNet follows a top-down research approach and build on existing results from completed and on-going research projects for a best practice in Virtual Enterprise management for complex industrial units, supply-chain management, knowledge sharing, tracking complex processes and products as well as privacy issues.

3 Functionality Required by Collaborative Networks Supporting Serviced-Enhanced Products

The driving use case in GloNet is in the Solar Park construction sector. The different stakeholders range from customers, project developers, construction and commissioning firms, equipment suppliers, service provision companies and many others, are considered to be either a member of a long term alliance of stakeholders involved in the area of the product, that is a VBE (Virtual organisation Breeding Environments) [21] member or a partner in a goal-oriented collaborative network

which is established to perform specific task for the product that is a VO partner. Based on numerous business scenarios identified in the GloNet project, focusing on product characteristics, stakeholders' characteristics, and organisational structures and collaborative tools needs an shortcomings (as described in Section 2), the following five functionalities [6] have been identified as key for collaborative networks (CN) in service-enhanced products contexts. They are:

1. **Support for setting up a collaborative space for project among different stakeholders in terms of goal-oriented network**. Platform functionalities shall facilitate setting-up a goal-oriented networks (i.e. VOs), whereby individuals and/or organisations can strategically join their competencies to rapidly respond to a business or collaboration opportunity. It should be noted that different VOs, with very different time durations, can be needed during the life cycle of a complex product. Each VO must be able to plan and schedule the collaborative work as well as the option to allow new partners to join the VO. It is also important to have a robust and reliable negotiation mechanism that supports the potential VO partners in achieving agreements during the VO formation process, reducing the amount of time spent in this process. These VO agreements will then be the basis for the governing principles of the VO during its operation phase.

2. **Supporting different roles in a CN and permissions for accessing information and knowledge resources.** The platform must ensure resources protection in terms of permissions of members accessing shared resources as well as privacy of the shared resources. Appropriate mechanisms need to be in place through the identification of the property rights per resource and provision of authorised access for network members, according to their roles.

3. **Sharing knowledge, data among stakeholders in the CN.** The platform must provide functionalities for sharing of knowledge among CN members (for example standardised product definitions and processes), software tools, and lessons learned. As such, the system must support organisations in the process of sharing their resources, allowing that each organisation inside the CN can search, retrieve and update information and knowledge about e.g. templates, standard processes, ontologies, etc. The system should also include mechanisms to implement incentive policies to increase resources sharing.

4. **Groupware related tasks (appointments, task management).** The platform must provide a collaborative environment for groupware related tasks of members within the product/service development project. This can be reflected, in terms of sharing appointments, tasks to meet the project goals within a VO.

5. **Defining and tracking workplans/processes.** VOs involved in service-enhanced products must support and promote the collaborative design of products and services as well as the emergence of innovative solutions. It includes two main aspects: i) mass customisation combined with offering value added services that improve the perceived product quality and prolong the product life cycle; and providing services based on innovation, knowledge and customer orientation; ii) emergence of new products identifying future needs, through collaboration among manufacturers and the customer and members of the customer's community.

4 A Cloud-Based Approach for Collaborative Networks

Cloud computing can provide a centralised platform [8], which can be accessed from anywhere, by any (authorised) collaborator, and at any time over the Internet. Cloud solutions are typically presented as exhibiting a number of advantages for the involved stakeholders in terms of:

- **Reduced initial costs.** Cloud computing provides cost reduction that particularly SME organisations can benefit from whereby they do not own the resources (server, storage) that produce the computing capabilities they require and pay for.
- **Ubiquitous, simple access through Internet.** With cloud computing, organisations are given new opportunities to push virtual collaborative alliances to the next level, breaking down geographical barriers and enabling dynamic continuous collaboration that generates globally composed business value.
- **Centralised platform for collaborative scenarios, integration hub.** Cloud computing provides a centralised platform, which can be accessed from anywhere, by any (authorised) collaborator, and at any time over the internet.
- **Flexible cost models.** In addition, customers benefit from the fact that cloud computing employs a *pay-per-use* model. Customers do not have to do a high initial investment in hardware and software, instead they are typically paying monthly or yearly fees depending on the number of user licenses they need and/or the resources they consume.

It is essential for a cloud–based software solution to be designed considering the fundamental requirements of a collaborative workspace environment. As such we believe the following five key design principles [7] are essential in building a collaborative environment support platform:

1. **Modularity and extensibility.** In cloud-based software solutions, software sub-systems are typically consolidated having a code-base that works for all customers. However in collaborative networks, this approach is not feasible, since customer specific configurations, data models, business rules and workflows, need to be tailored to each individual user need. As such, software solutions need to support programmatic extensible and customisable features, namely allowing the addition and removal of modules for specific needs.
2. **Multi-tenancy.** Multi-tenancy is the capability of a software system to serve multiple customers or tenants (which in turn comprises multiple users). In essence, having a cloud-based approach, two potentially conflicting requirements need to be addressed. That is on one hand the cloud-based approach needs to leverage the economy of scale principle by employing a consolidated architecture that handles all customers uniformly, and on the other hand customers demand that the software they use can be tailored to meet their specific requirements and match with their highly-individual business and the processes they work with. This implies that both data and customisations have to be *isolated* on a tenant-based level by the cloud-based platform.

3. **Scalability and Availability.** For any collaborative environment, coming up with a scalable software architecture is a major concern. For cloud-based systems, this is even more critical. The software will be used by thousands of users in parallel, namely the expected average number of concurrent users per customer, multiplied by the number of customers having licensed the software. There are different ways to achieve scalability. One way is to *scale-up* the system, that is to move the software to more powerful servers (for example having more processing power, more RAM, more and faster storage) when the need arises. For a cloud software approach, a *scale-out* strategy is much more suitable. This means that the workload of the system can be distributed among several servers. A scaling-out architecture offers two main advantages. First, standard and cheap off-the-shelf servers can be used instead of expensive high-end servers. Second, it offers higher availability, since many instances of the same application server are deployed.
4. **Security and Trust.** An important issue in adopting a cloud approach is ensuring data security. For collaborative solutions security mechanisms need be designed in a way that they still allow for data sharing among users that want to collaborate.
5. **Network access.** Cloud architectures need to be designed for network access from the ground up. This concerns the end-user interfaces (web-based UIs) as well as programmatic access (web services).

5 The GloNet Platform

The GloNet platform is built according to functionality required by collaborative networks as discussed in Section 3 and the five key principles a cloud-based approach should take into consideration. It uses a framework-based approach: it defines an application architecture and provides a number of components that implement the basic building blocks of this architecture. In addition, the platform is extensible, providing customisation mechanisms as well as extension and integration mechanisms for additional modules and services that may complement the basic features of the platform.

5.1 GloNet Platform Architecture

The GloNet platform follows a layered architecture [2], whereby a system is decomposed into several distinct layers or *tiers* that can be developed, maintained and (often) deployed independently from each other. Figure 1 shows the GloNet three layers, and zoom into the Cloud-based platform, which is also composed of 3 layers: the presentation layer, the application layer and data layer. The *presentation layer* focuses on interacting with the user through a graphical user interface. It displays data and collects user input and commands. The application layer or *business logic layer* provides operations that implement the processes and operations that the software solution provides. The *data layer* encapsulates the storage and provides access to the

persistent data of the solution. In most cases this layer makes use of a database management system.

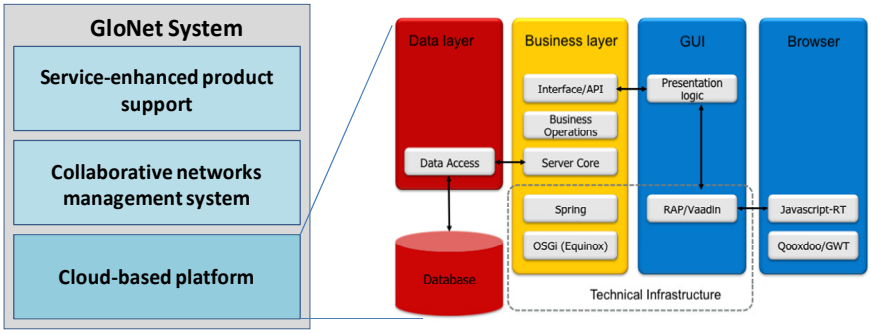

Fig. 1 - GloNet system overview

The most important modules of the GloNet cloud-based platform are the following:

- The *data access* module that encapsulates database specifics. It enforces tenant isolation and implements a permission system, thereby strictly controlling the access to the data stored in the databases. As a clean interface, it provides a database and platform neutral simplified SQL-like language for data access including a number of helper functions to simplify the access to more complex data structures.
- The *server core* module, which builds the backbone of the backend implementation of the GloNet platform. It provides mechanisms to register and unregister additional modules, which in turn may provide additional operations. It is also responsible for enforcing a strict security policy by providing and verifying security contexts (for example, based on user and tenant credentials) when executing any kind of operation. Furthermore, it makes use of the data access module to manage generic (extensible) data objects.
- A number of *business operation* modules provide implementations for the basic services of the GloNet platform. Such operations include infrastructure-related operations (user and tenant management, permission management), but also operations concerning more end-user related features (e.g. document management, calendar management). New modules can be registered using mechanisms provided by the server core module, creating an extensible platform.
- Any operation from the business operation modules or the server core with a publically defined interface is exposed via a number of *external interfaces*, namely in-process method calls, RMI and SOAP-style web services. A subset of those is also accessible as REST-style web services. This way, the GloNet platform provides a service-oriented *application programming interface (API)* suitable for a large variety of use cases and implementation technologies.

- The presentation layer of the GloNet platform provides a framework for creating and presenting a web-based user interface. The *presentation logic* module provides generic user interface functionality like reusable controls, the application frame, and configurable list and form views.

The other layers of the GloNet system are not addressed in this paper. The platform supports customisation facilities on all layers of the software system:

- *User interface*. The GloNet platform allows users to define and customise their user interface to match with their corporate branding, that is adapt rather simple things like logos, colours and fonts, or to better reflect their internal nomenclature. Users can also modify the layout and ordering of the presented information in order to put an emphasis on business critical information.
- *Business logic*. The platform allows users to implement their daily business needs, by supporting customisation of business logic layer rules. For instance, a VO member in could define rules that are used to evaluate the rating or potential of a customer. In such situation, one CN member's rating rule might be based on the yearly turnover with that customer, whereas another CN member might prefer to make that rating dependent on the number of sold licenses for a software company or the overall value of profitable insurance contracts for an insurance company.
- *Data model extensions*. The platform allows CN member users to store additional information in the system. In these cases, the platform supports extensions of the data model using custom objects or custom fields for each user.

5.2 GloNet Users Roles and Permissions

The GloNet platform provides a framework for the authentication and authorisation of its users. These are classified in three main categories:

- *Users, groups and resources*. These are called permission owners. Users can authenticate themselves with the platform's authentication methods. Users can be organised into groups. For each user, the platform maintains some basic attributes.
- *Security contexts*. After authenticating a user login, the platform creates a security context. Any operation runs within this security context. The platform provides different classes of security contexts, with user contexts always associated with an authenticated user and a user can only perform privileged operations based on the , privileged contexts set to the user.
- *Permissions*. Most data elements and operations are associated with permissions. Permissions are used for authorising the access to data or the invocation of operations within the platform. For example, for permissions related to financial details, such as an employee's salary, the platform ensures only people from the HR department can be granted the permission to change the salary; however the platform ensures administration members are able to read the value in order to give out the pay checks.

5.3 GloNet Platform Implementation

The GloNet platform implementation employs a number of industry standards and off-the-shelf components which form the technical infrastructure of the GloNet platform. Fig. 2 illustrates the basic infrastructure for the deployment of GloNet. It consists of a *farm* of standard *Linux*-based PC-Servers that operate either as *Java* application servers based on *Apache Tomcat* or as database servers using *MySQL*. The presentation layer is currently implemented using server-side frameworks for AJAX-style user interfaces [4], Vaadin and Eclipse RAP. These components are standard building blocks of a Java based technology stack. Therefore, an instance of the GloNet platform can be deployed on almost any cloud infrastructure provider offering that allows for standard VM images as units of deployment. Adaptations to specific cloud infrastructure provider offerings are only necessary regarding the load balancing and VM administration interface. Alternatively the GloNet platform can be hosted in almost any computing centre that has some capability of operating Java-based application servers.

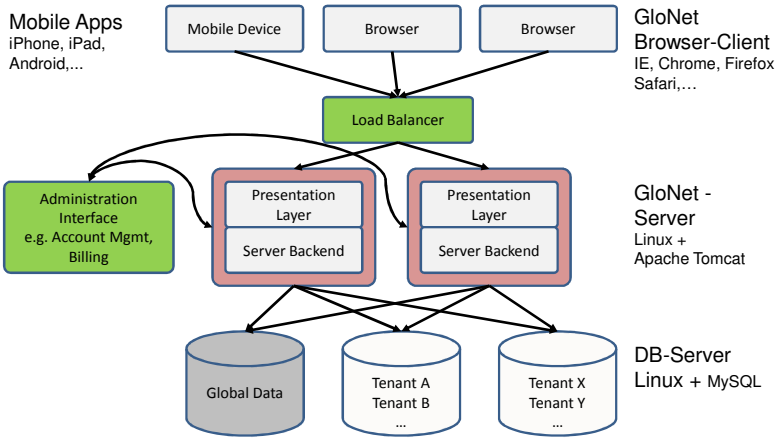

Fig. 2 - GloNet platform deployment architecture

5.4 Mechanisms for Integrating Existing Services in GloNet

The GloNet platform provides two key approaches to integrate external components or systems: *proxy-based* and *mashup-based*. In the proxy-based mechanism each external service has a proxy within the GloNet platform that performs the mapping between the GloNet platform and the external service. The mash-based approach, external services makes use of their own user interface that can be plugged-in to the GloNet platform. To exchange data with the GloNet platform, the provided web service API can be used. In order to interact with the GloNet application, basic user interface context information is exposed using a RESTful interface [3]. This approach

is used to build the upper layers of the GloNet system, namely the Collaborative networks management system and the Service-enhanced product support (see Fig. 1).

6 Conclusions

In this paper we have described the required functionality for a collaborative networks environment and proposed the GloNet platform, a cloud based framework for creating applications for the collaborative design and operation of complex service-enhanced products. The platform is built according to a tailored cloud based principle, taking into consideration specific requirements of collaborative networks. Additionally, the platform provides mechanisms for the integration of external systems and services.

We envisage enhancing the platform customisation part. In this perspective we want to investigate on meta-data based configuration that can be used to provide customisation of services across all the three layers (User interface, business logic and data model extensions) of the GloNet platform architecture. The current platform has been designed on the needs identified in the context of solar plants, and we envisage validating the approach to other context industries involved in service provisioning.

Acknowledgments. The work on this paper is funded in part by the European Commission through the GloNet project (FP7 programme-GLONET [FP7 / Project No. 285273, 2011-2014]). The authors would also like to thank the contributions of the different partners of the GloNet project.

References

1. Camarinha-Matos, L.M., Afsarmanesh, H., Ollus, M., Methods and Tools for Collaborative Networked Organisations, ISBN: 978-0-387-79423-5, Springer, 2008.
2. Buschmann, F., Meunier, R., Rohnert H., Sommerlad, P. and Stal, M. 1996. *Pattern-Oriented Software Architecture*. A System of Patterns. Volume 1, Wiley.
3. Hoyer, V. Stanoevska-Slabeva, K., Janner, T., Schroth, C. *Enterprise Mashups: Design Principles towards the Long Tail of User Needs.* In Proceedings of the IEEE International Conference on Services Computing. IEEE Computer Society. SCC 2008.
4. Lange, F. *Eclipse Rich Ajax Platform: Bringing Rich Client to the Web*, Apress, 2008.
5. Camarinha-Matos, L. M.; Afsarmanesh, H.; Koelmel, B., Collaborative Networks in Support of Service-Enhanced Products, Proceedings of PRO-VE'11, 17-19 Oct 2011, S. Paulo, Brazil, Adaptation and Value Creating Collaborative Networks, IFIP AICT Series 362/2011, Springer, pp. 95-104.
6. Camarinha-Matos, L. M.; Macedo, P.; Ferrada, F.; Oliveira, A. I. Collaborative Business Scenarios in a Service-Enhanced Products Ecosystem, Proceedings of PRO-VE'12, 1-3 Oct 2012, Bournemouth, UK, Collaborative Networks in the Internet of Services, IFIP AICT Series 380/2012, Springer, pp. 13-25..
7. GloNet Deliverable D3.1 "GloNet Platform Design Specification", June 2012.
8. Cloud Standards Customer Council, "Cloud Computing Use Cases Version 1.0", http://www.cloudstandardscustomercouncil.org/use-cases/CloudComputingUseCases.pdf, White Paper October 2011.

9. Vieira, H., Goncalves, R-J., VALTE - Methodology for VALidation and TEsting of Supply Chain Software Components. Proceedings of the 15th International Conference on Concurrent Enterprising, ICE 2009.
10. Rasoulifar, R., Eckert, C., Zolghadri., C. The need for a tool to exchange information in non-hierarchical network of the electronic industry: an European project. In Proceedings Design 2010, 17-20 May 2010, Dubrovnik, Catvat, Croatia.
11. Kiauleikis, V., Romeika, G., Morkevičius, N., Kiauleikis, M., Collaboration and Interoperability Services vs. Traditional Communication Means. In Journal of Science and Processes of Education. Collection of periodic and reviewed scientific articles issued Klaipeda Business College, Lithuania. December 2011.
12. Weichhart, G., Stary, C., Oppl, S., Modelling of Complex Supply Networks. In Proceedings of WETICE 06, pp. 265-268, IEEE Press, 2006.
13. Goldstein, M.K. et al.: Implementing clinical practice guidelines while taking account of changing evidence: ATHENA DSS, an easily modifiable decision-support system for managing hypertension in primary care. Proc AMIA Symp. 2000.
14. Pautasso, C., Alonso, G., Flexible Binding for Reusable Composition of Web Services In: Proceedings of the Workshop on Software Composition (SC 2005), Edinburgh, Scotland, April 2005.
15. Melchiorre, C., Laclavik, M. ; Marin, C. ; Carpenter, M. A community based interoperability utility for SMEs. Published in: eChallenges, 2010, 27-29 Oct. 2010.
16. Oberle, D., Staab, S., Eberhart, A., Semantic Management of Distributed Web Applications, IEEE Distributed Systems Online, vol. 7, no. 4, 2006.
17. Prinz, W., Loh, H., Pallot, M., Schaffers, H., et al., ECOSPACE -- Towards an Integrated Collaboration Space for eProfessionals. In Proceedings of Collaborative Computing: Networking, Applications and Worksharing, 2006.
18. Mentzas G., and Friesen A., Semantic Enterprise Application Integration for Business Processes: Service-Oriented Frameworks. 2010.
19. Popplewell K., Stijanovic N., Abecker A., Apostolou D., Mentzas G., Harding JA. Supporting Adaptive Enterprise Collaboration through Semantic Knowledge Services, in Enterprise Interoperability III: New Challenges and Industrial Approaches, eds. K. Merti, 2008.
20. Witczynski, M. & Pawlak, A. Virtual Organizations Enabling Net-based Engineering, in Stanford-Smith et al., 908-915, 2002.
21. Noran, O. Towards a Meta-Methodology for Collaborative Networked Organisations. In: Virtual Enterprises and Collaborative Networks. (Luis M. Camarinha-Matos (Ed.)). pp. 71-78, Kluwer Academic Publisher. 2004