Dynamism and Data Management in Distributed, Collaborative Working Environments

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Abstract. Due to globalization and environmental challenges, there is a growing interest in adopting collaborative technologies to support distributed virtual enterprises to work as virtual teams, reducing time, cost and need for travel. This paper presents the approach taken by the CoSpaces project [1] in developing a collaborative technology platform for distributed engineering organizations. In particular, this paper overviews the ongoing work of the "Dynamic Session Management System" which provides the dynamic integration of decision making and communication tools within the entire CoSpaces software framework. It also reports on how data management and sharing within this dynamic infrastructure is handled while addressing the security concerns of certain individual companies.

Keywords: Collaborative Working Environments, Virtual Organizations, Dynamic Ad-Hoc Collaboration, Dynamic Service Integration, Secure Data Management, Future Internet

1 Introduction

Due to an emerging globalization, many engineering companies are decentralizing their operations and working teams as distributed virtual enterprises with the objectives to optimize costs, quality and time. However, the teams working as such virtual enterprises need to come together frequently to assess the project from different engineering points of view and to ensure that the product they are producing is meeting the specifications and the set quality standards. Typically such teams have both planned and ad-hoc meetings to resolve conflicts and to finalize the design. Such meetings are usually organized as traditional face-to-face meetings involving large organizational efforts and travel costs with direct impact on the environment and the quality of life of the team members, affecting also their social and family life. Furthermore, such face-to-face meetings are difficult to organize since the diaries of individuals need to be consulted to find a suitable time, consequently delaying the decision and the time for finalizing the product.

The CoSpaces project [1] aims to develop a distributed engineering environment for remote teams to work together efficiently, securely and reducing the frequency of traveling to a single location. It also aims to support both planned and ad-hoc meetings within a distributed virtual environment with appropriate decision making

and communication tools. The key technical challenges therefore undertaken by the CoSpaces project are:

- Dynamic integration of decision making and communication tools within the distributed environment.
- Secure data sharing approach
- Multi-user visualization and interaction metaphor for collaborative working
- Creation of co-located, distributed and mobile workspaces for multi-functional teams.

In this paper, the ongoing work on the "Dynamic Session Management System", which allows the dynamic integration of decision making and communication tools within the CoSpaces software framework, is outlined. It also reports on how data management and information exchange within this dynamic environment is handled while addressing the security needs of different partners involved.

2 Overall Approach

The CoSpaces project has taken a generic approach in developing a collaborative engineering environment by driven through requirements and case studies from three engineering sectors (aerospace, automotive, construction). Given the similarities in areas such as the product life cycle management, IT requirements, and the nature of collaboration in these engineering sectors, the CoSpaces project shall develop a common software framework with appropriate services so that each industry can create a specific instance of this framework to suit their business practices, needs, and culture.

The requirements for the overall CoSpaces frameworks have been defined by analyzing the current practices through interviews and by elaborating current and future scenarios, involving end-user companies. The key scenarios considered in the CoSpaces project are distributed design reviews of aerospace and automotive assemblies, co-located design reviews of buildings, expert support for maintenance of aircrafts and solving unforeseen problems in the construction domain. These scenarios have been used to specify the objectives of typical collaborative meetings, roles of individual team members, information handling, and system as well as interface functionalities etc. The key technical requirements arising from these case studies have been recognized as: ability to identify and link up with remote experts on demand, access to context-based information, secure data access, context-dependent interfaces for collaboration, dynamic composition of services, real-time multi-user visualization and interaction. The CoSpaces project draws on the knowledge gained through other projects such as Akogrimo [2], TrustCoM [3] and BREIN [4] to provide for example the dynamic composition of trusted third party services.

The following section presents the overall approach for creating the CoSpaces framework and the concepts deployed in creating the dynamic session management and data management within the entire framework.

3 People and Technology Issues

The ongoing development of internet technologies is opening up new possibilities for people to collaborate across organizational and geographical boundaries. From the user's point of view, this means access to remote experts or colleagues, data and

services on demand at any time and from any place. However, such on demand access needs to be managed within a given context to ensure that the privacy of others is not invaded nor violated. For example, before contacting an expert the user needs to know the context of the expert. Is the expert currently available? Is he/she working or on holiday? Is he/she busy? What is the best way to approach her/him (video link, audio, chat)? This would require tracking the user context and making such information available to the rest of the team. Another context dependent issue is to understand the devices, interfaces, and services that are available to support the collaboration. By publishing such information, a collaborative working session could be initialized to suit the context with appropriate hardware and software settings.

Classically, a collaborative session is organized in advance by informing the relevant people and agreeing on a common date and medium. Additionally, the collaborative environment for supporting the meeting needs to be installed at each user site before the meeting. If such collaboration is a frequent activity, the collaborative technology infrastructure needs to be permanently installed at each partner site. However, current collaborative technologies only support access to a limited number of application services and therefore the type of discussions that could take place effectively is small. Due to the lack of integration between the applications and the collaborative environments, the users are not in a position to execute various business applications on demand for presenting their results to others and contributing to the discussion. Furthermore, current distributed environments provide little support for adaptation according to the available hardware configurations in order to provide an optimized service to the users.

The research presented in this paper presents how dynamic service management systems could be developed to overcome such limitations and allowing teams to invoke any applications on demand and bring them together within a collaborative session.

4 Infrastructure for dynamic collaborative working sessions

As shown in Figure 1, the CoSpaces framework is comprised of several components such as the Portal, Knowledge Support, Group Management, Position and Identification, Resource Management, Dynamic Session Management and Application Controller. A brief description of these components is given below:

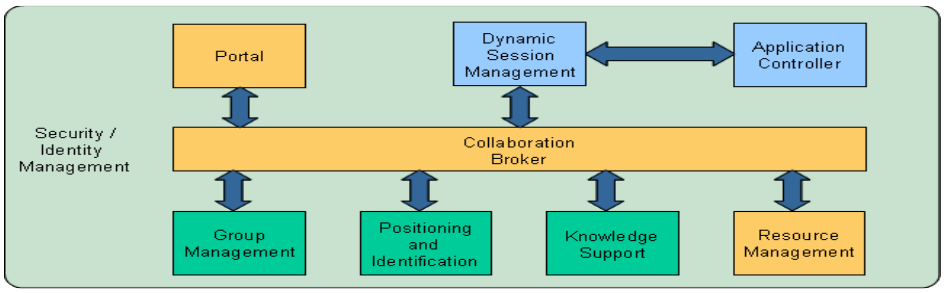

Figure 1: Conceptual View of the CoSpaces Framework

- *Portal:* This module allows the initiator of the collaboration to plan and execute a collaborative session by selecting people and resources.

- *Knowledge Support*: This module maintains information on experts and necessary documents to provide context support.
- *Group Manager*: This module maintains the information about people including personal details, access rights, roles etc.
- *Position and Identification*: This module tracks the activities of the people using various tracking technologies.
- *Collaboration Broker*: This module acts as an intermediary service between all other modules. Beside others, the collaboration broker provides the entire setup for the *Dynamic Session Management (DSM)* with all necessary information required to setup a collaborative session.

In this section, we present a detailed overview of the DSM components, which are responsible for providing the infrastructure for dynamic collaborative sessions. The entire DSM consists of two main modules, namely the DSM-Manager and the DSM-Gateway. In particular the *DSM-Manager* provides a central interface for the collaboration broker. Via this interface the latter is able to submit a configuration for a specific collaboration session, which is delegated in the subsequent step to the corresponding partner gateways.

To allow for an interoperable configuration between the parties involved, each partner has to provide a corresponding *Gateway*. A Gateway is a component being hosted in each collaboration partner's domain sharing an interface that enables the DSM-Manager to configure the hosts of the participating machines. Additionally, it is also possible that each host machine runs its own Gateway. For a detailed overview of the relationship between the corresponding DSM components the interested reader is referred to [7].

Besides the configuration capabilities, the Gateway also exposes a frontend to the Application Controller at each partner's machine, which allows the instantiation and the remote steering of different applications. Hence, all machines participating in the collaborative session hosting relevant applications need to provide a corresponding Application Controller. Next to instantiation and configuration support, the Gateway furthermore provides support for:

A notification subsystem: this notification subsystem realizes a publish-subscribe system, allowing both the propagation of events, such as changes being carried out in a document or the changed status of a participant's availability, as well as the exchange of chat messages between users and application-specific commands, enabling the bilateral communication between applications on an event-basis.

Security issues: since the Gateway allows the configuration of machines of the collaboration partners involved, it is of fundamental importance that only parties with explicit access rights are allowed to participate within the collaborative session. This subsystem guarantees that only authenticated and authorized users or components will be able to set up the corresponding user machine and also ensures the integrity of the configuration messages. A detailed description of this approach is given in [8].

A proxy: The proxy provides a local representative for the data communication of the application controller as well as for the corresponding applications. The proxy can be configured by the Gateway in such a way, that the communication is redirected to another proxy of a collaboration partner. This communication considers both the data stream of the application as well as the transfer of screenshots for the application remote control and the corresponding HID events. So, for example, in the case that

one partner is no longer available for a specific collaborative session or a new partner has been added to an already established session, the proxy does not enforce a reconfiguration of the application, since the actual setup for the application remains the same as before.

Furthermore, the proxy enables transparent message encryption according to the setup information including the corresponding references to certificates of particular users. Additionally, the proxy allows optional setting up and linking external data converters. This functionality may be needed if within a collaborative session, a heterogeneous application environment has to be plugged together, so the corresponding data needs to be transformed accordingly. Therefore, the proxy ensures also the support of heterogeneous environments at the application layer.

To allow interoperable access to the DSM components, the DSM Manager as well as the Gateway are realized based on web service technologies [10] [11]. This provides an interoperable opportunity to setup a partner's infrastructure for a specific collaboration. Since the Gateway has to handle control and configuration messages as well as proprietary data streams between applications, two communication buses are considered in this approach. The *Web Service Bus* is used to configure and setup the Gateway as well as for sending out *notifications*, whereas *the Network Bus* is used for the transmission of application specific data and video/audio stream.

CoSpaces Shared Data Space

Apart from the dynamic setup of a collaboration sessions, greater considerations have to be given for handling the business sensitive data in a secure manner. Such business data could typically be CAD data, documents, images, videos etc. During industrial collaborations, such critical business data has to be shared between the collaboration partners with appropriate security mechanisms in place. This section summarizes the CoSpaces approach for providing a secure space for sharing business sensitive information for a specific collaboration instance.

In many situations, the data produced by individual partners is protected within their own firewalls without allowing any access from external, hence hindering collaboration. In order to overcome these situations, typically OEMs act as the system integrator for collecting data from individual stakeholders to create the final virtual product and to perform design assessment activities at the complete system level. However the access to such data is heavily restricted by OEMs, hence hindering ad-hoc collaboration and on demand collaboration between partners. In the CoSpaces approach, while it assumes that the OEMs or one of the appointed companies will continue to collect data from individual partners to create the final virtual representation of the product, it proposes a data architecture, which could be used to support on demand or ad-hoc collaboration between partners. Figure 2 below represents the CoSpaces approach for handling shared data among partners of business collaborations. It comprises of a *Secure Organizational Space*, *Shared Data Space* and a *Shared Data Access Manager.*

The Secure Organizational Space: This area represents the data spaces within each company which contains the relevant product information relevant for a specific project. Typically, such data are stored within their own PDM systems, data bases or

file systems. The data is protected by individual company firewalls using their own security mechanisms.

Shared Data Space: This conceptual space has two types of shared data spaces, one controlled within a De-Militarized Zone (DMZ) and one controlled by an external data sharing service agent.

The DMZ is a distributed data space, which combines the sub DMZ zones maintained by each stakeholder company. Each sub DMZ zone is maintained by the corresponding stakeholder to place the data that they wish to share with certain stakeholders. Within this Virtual Shared Data Space, every partner is able to upload data from the *Secure Organizational Space* and assign access right policies for the corresponding data sets and partners. Within CoSpaces, this Virtual Shared Data Space is being realized by providing dedicated data bases as well as a modified version of the BSCW server [6]. The Shibboleth approach [5] has been used within the CoSpaces project for user authentication and authorization tasks [8]. This approach ensures that the company has the authority to load, edit and delete their data within their own DMZ ensuring access to authorized users only.

The concept of an *External Data Sharing Service provider* has been introduced in the data architecture when the data from stakeholders has to be processed (i.e. translate to another data format or combine with data from another stakeholder). This external service provider could be appointed by the stakeholders to offer them with a secure data processing service necessary for data sharing. Some examples of services provided by this service provider are:

- Translation of CAD or simulation format to a CoSpaces specific format for visualization purposes.
- Creation of integrated views of a product from different stakeholders
- Geometric editing

This Shared Business Entity Server provides the same security, authentication and authorization infrastructure as the Virtual Shared Data Spaces and can be hosted by any external trusted third party. The access rights to the Shared Business Entity Server need to be agreed by the all collaborating partners a priori.

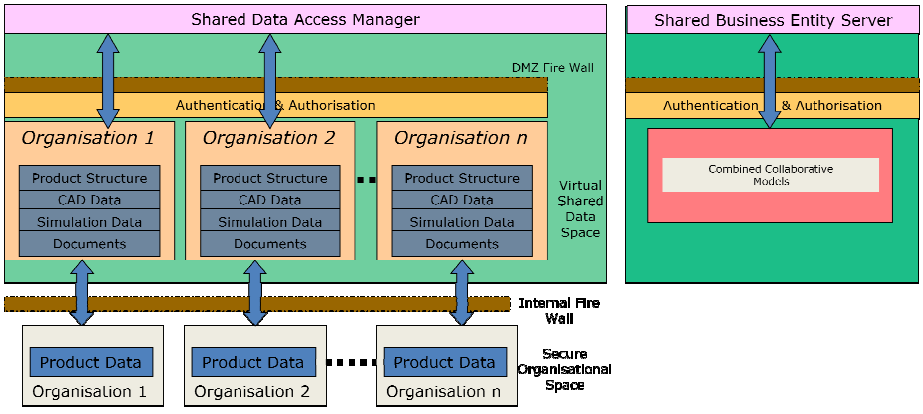

Figure 2 - CoSpaces Data Space

Conclusions

Dynamic collaboration within distributed business workflows is an exciting and promising field of interdisciplinary cooperation and will provide new and interesting working environments that facilitate cross-organizational data exchange and communication. The field has attracted world-wide attention and several international research projects have already designed and implemented first prototypes for appropriate infrastructures. Currently, projects have failed to resolve a significant shortcoming by not considering dynamism in collaborative environments favouring a static security infrastructure instead of looking for flexible solutions. This approach does not allow dynamic changes and/or adjustments, particularly during runtime [9].

In this paper, we have presented the vision of the European research project CoSpaces, which aims to create ad-hoc collaborative working environments that guarantee the utmost dynamic configuration for designers and engineers without neglecting important security issues. We have identified some key features and requirements, which make the mission of CoSpaces a promising, approach towards a wide user-oriented collaboration infrastructure.

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