22. WEB-BASED GENERIC SERVICES FOR THE CONSTRUCTION VIRTUAL ENTERPRISES IN THE OSMOS PROJECT

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Abstract

The paper gives a comprehensive description of the OSMOS[1] *project. OSMOS aims at providing an infrastructure that brings together, and promote co-operation between actors and companies on construction projects. In particular, an emphasis is put on developing an information infrastructure that enable SMEs to be more closely integrated on projects, and that will allow them to take a more active part in the design and delivery of the construction product. First, the paper gives a general overview of the construction industry process and organisational settings, and introduces the aims of the OSMOS project. Following this introduction, current as well as past research in the area tackled by the OSMOS project are presented. The OSMOS solution is then described via a generic framework addressing the information sharing and process control requirements of the project. Finally, the paper presents the OSMOS low entry level tools of the project along with the technical, process, and business ingredients for a successful implementation and take-up of the resulting internet-based service prototypes.*

Keywords: *Computer Integrated Construction, Virtual Enterprises, Internet.*

[1] OSMOS is a European R&D project within framework V: IST-1999-10491, *Open System for inter-enterprise information Management in dynamic virtual envirOnmentS.* The consortium includes construction IT service providers: *DERBi*, *JM Byggands*, *Olof Granlund*, and European leading research centres and academic: *CSTB*, *Information Systems Institute* of University of Salford, *VTT.*

INTRODUCTION

The challenge addressed by the OSMOS project is to provide construction participants with effective access to project information regardless of its form, format, and location, and on the other hand with increased flexibility to support smooth co-operation between non co-located teams, and the co-ordination of their work and activities in an environment that promotes trust and social cohesion. Moreover, distributed environments for the so-called Virtual Enterprise (VE) in construction must provide solutions for:

- IT support for the fragmentation imposed by the very nature of the construction industry in terms of communication and information exchange. Though still referred to as a traditional industry, the building industry in reality has adopted for decades the modus operandi of the VE, and buildings are designed and constructed by non co-located teams of separate firms who come together for a specific project and may never work together again.
- Better interactions between actors, that are still not well co-ordinated, especially because of the inherent dynamic business relationships taking place in the construction industry. It is worth noticing that the recent evolution of communication modes has generated even more needs for co-ordinated teamwork, due to increased number of geographically spread participants and at the same time the requirement for reducing design and construction schedules in order to improve time to market.

The paper gives a comprehensive overview of the OSMOS proposed solution. A generic framework is presented along with its technology constituents in terms of services, tools, and middleware supporting the construction virtual enterprise. This architecture is in the process of being deployed and interpreted within two of the three end-users involved in the project, to set up internet-based team work services. It is worth mentioning that the research is being conducted through three iterations. Each iteration has a duration of nine months, and will be used to assess and validate the OSMOS infrastructure, and address the potential risks in relation to the implementation of the proposed solutions. The important aspect is that change is anticipated at any stage of the software product lifecycle. In addition, potential risks are identified and prioritised early in the lifecycle, and are at the core of each iteration leading to the final OSMOS solution.

COMPUTER INTEGRATED CONSTRUCTION BACKGROUND AND STATE OF THE ART

State of the art research in the application of IT in construction reveals that integration has been achieved, mostly, on static models that define the structure of shared information in the form of files or databases. The OSMOS research team advocates that integration should be made through frameworks which define semantic relationships between the interfaces of separate distributed components. This is an area where Construction needs advances. Such frameworks are already under development, especially within the Object Management Group through business object facilities, based on the Common Object Request Broker Architecture [OMG 1996]. On the other hand, the World Wide Web has now emerged as a result of the growth of the Internet. It was, until the advent of HTML, mainly used in academia. However, HTML (which was derived from SGML), is mainly used to describe and exchange information contents as opposed to semantics.

The recent XML (eXtensible Markup Language), and the related DOM (Document Object Model) standards combined with semantic object models describing a building, e.g. STEP [STEP 1994] and IAI-IFCs [IAI 1997], offer a unique opportunity to promote effective information sharing in the VE.

Recent and continuous investigations on the use of advanced computer-based technologies, especially in ESPRIT funded European projects, including VEGA [Stephens et al. 1999], CONDOR [Rezgui et al. 1998], ELSEWISE [Elsewise 1999] and GENIAL [Radeke et al. 1999], have shown promising results. Today's difficulties lie in identifying the right reference marks and methodology to relate user requirements and needs to the adequate technology. However, the success of collaborative work relies not only on the ability to provide solutions to the problems of multi-criteria information representation, information sharing and exchange, information life-cycle support; but, also, the support of the various interactions taking place between individuals / groups / or corporations as well as the management of their authorities and rights over information in accordance with their precise roles in the VE. These important issues are tackled within the field of computer support for co-operative work (CSCW). CSCW is more generally concerned with the introduction and use of groupware systems to enable and support teamwork. Groupware solutions include traditionally a subset of the following system components: Workflow (task scheduling), Multimedia Document Management, E-mail, Conferencing, and shared schedule of appointments. A recent survey of groupware constituent technologies [Rezgui et al. 1999] reveal a lack of homogeneity, and a diversity of applicable de facto standards and APIs from the leading Groupware vendors. In fact, the last decade has seen a tremendous activity in new specifications and developments of standards and architectures for CSCW and enterprise application integration. While these developments seem to offer a challenging opportunity for the VE, they do hide complex architectural problems in relation to the selection of the right tools, toolboxes and infrastructures.

Therefore, a suitable team work IT-based solution requires a broad methodological approach, a deep understanding of the information / process requirements, and also the understanding of the dynamics and the specificity of the context in which the support for team work is required, namely the Construction industry.

THE CONSTRUCTION VIRTUAL ENTERPRISE REQUIREMENTS CAPTURE

The work involved in the requirement capture phase consists of, first, the analysis of intra-company business processes, and information management practices taking place within the project end-users (Derbi, Granlund and JM). In addition, the type and nature of inter-company interactions taking place on multi-disciplinary construction projects have been analysed along with the nature and semantics of the information being produced and exchanged, with a strong emphasis on contractual, legal and IPR (Intellectual Property Rights) aspects underlying this collaboration. Finally, the set of tools commonly used on projects are identified, with an emphasis on the understanding of their API (Application Programming Interfaces), communication mechanisms, and their information requirements. Based on this analysis, a Generic Virtual Enterprise Process Model (GVEPM), which forms the basis of the OSMOS requirements specification, has been developed. This model takes into account the concept of the three types of role companies (as illustrated in Figure 1) that are involved with construction virtual enterprises, namely:

Role A – *OSMOS VE Service Provider*. This role will be taken on by a company wishing to provide the complete OSMOS VE system and services.
Role B – *OSMOS Service Providers*. Companies taking this role will provide services that will plug in to the OSMOS system. (It must be noted here that Role B companies will not necessarily include only third parties between Role A and Role C companies. Some Third Party Services offered via the OSMOS platform might be provided by the Role A company).
Role C – *OSMOS Clients*. This role includes any company that will sign up to the OSMOS VE Service to run a project.

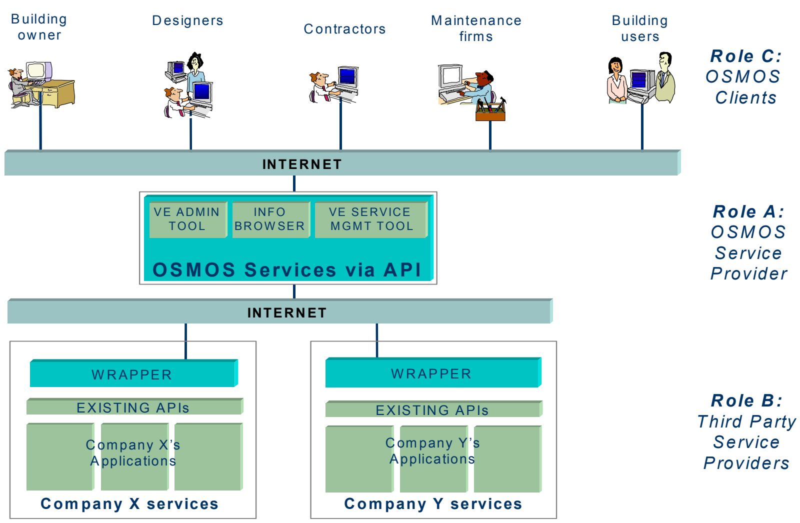

Figure 1. The Roles involved in a Construction Virtual Enterprise.

The GVEPM present the complete set of processes that may need to be undertaken in providing the OSMOS system platform. The highest level of the model represents the overall activities of a company wishing to act as an OSMOS VE Service provider (equivalent to Role A). The model therefore adopts two important concepts. The first is that the complete OSMOS VE service will be utilised by clients who wish to run projects. The company acting as the OSMOS VE Service Provider, therefore, will initially agree to a contract with that client depending on the client's specific VE requirements. Once the two parties have agreed to work together, a contractual agreement is made. The second concept is that of the VE Project itself, representing the set of generic processes required to operate a VE project. Figure 2 illustrates the process activities involved with providing and maintaining a VE Project:

- *Make Contractual Agreement* – this activity involves the actions required in the formation of a contractual agreement between a Client and the VE Service Provider relating to the operation of a VE Project. The input to the activity is the Client Requirements for the proposed VE Project, and it is controlled by the Legal Requirements. The outputs from the activity are the Contractual Agreement, which forms a control over the other five activities in this node, and the VE Project Specifications satisfied under the Contractual Agreement. The VE Service Provider performs the activity.
- *Set up VE Project Workspace* – this activity allows the VE Service Provider to allot the necessary servers, computer resources, logging facilities, required VE and Third Party Services etc., to a VE Project once a Contractual Agreement has been made. The activity takes the VE Project specifications as its input, and is controlled by both the Contractual Agreement and the Legal Requirements. Within the activity a VE Project Administrator will be registered and the VE Project will be initialised with the services selected for its operation. Output from the project therefore, includes the Registered VE Project Administrator (who performs the *Operate VE Project* activity), and the initialised VE Project with its selected services. The VE Service Provider, using the OSMOS Tools performs the activity.
- *Configure VE Project* – this activity includes all the actions required to configure the VE Project established under the terms of the Contractual Agreement from its initialisation to its actual launch. Inputs to the activity are the VE Project Requirements, the Initialised VE Project with Selected Services and also, potentially, already operational VE Projects. (This is because a VE Project that is already in operation will require re-configuring after certain events such as changes to access rights, actors, etc.). The activity is controlled by the terms of the Contractual Agreement, and the VE Project Management Committee. Output from the activity is the configured VE Project. The VE Project Administrator performs the activity using the OSMOS Tools.
- *Operate VE Project* - this activity represents all the actions required to operate a VE Project, in terms of Actors, Roles, Access Rights, and Services. Its input is the Configured VE Project, and the Contractual Agreement, Legal Requirements, and the VE Project Management Committee control it. Output from the activity is the VE Project (in its operational phase).
- *End VE Project and Dismantle Infrastructure* – this activity occurs at the end of the VE Project's lifecycle and represents the actions required to complete dissolution of the current VE Project. The VE Project is the input, and the Contractual Agreement and Legal Requirements control the activity. The outputs include the Product (or service) created by the VE Project and all of the information generated and created by the VE Project. The VE Service Provider is responsible for carrying out the activity.
- *Archive Project and End Contract* – at the end of the VE Project lifecycle the VE Project information is archived (and distributed, reused, disseminated, etc.) according to the Contractual Agreement, and the contract is ended. The input to the activity is information (to be archived). The terms of the Contractual Agreement control the activity, and the output is the information archive.

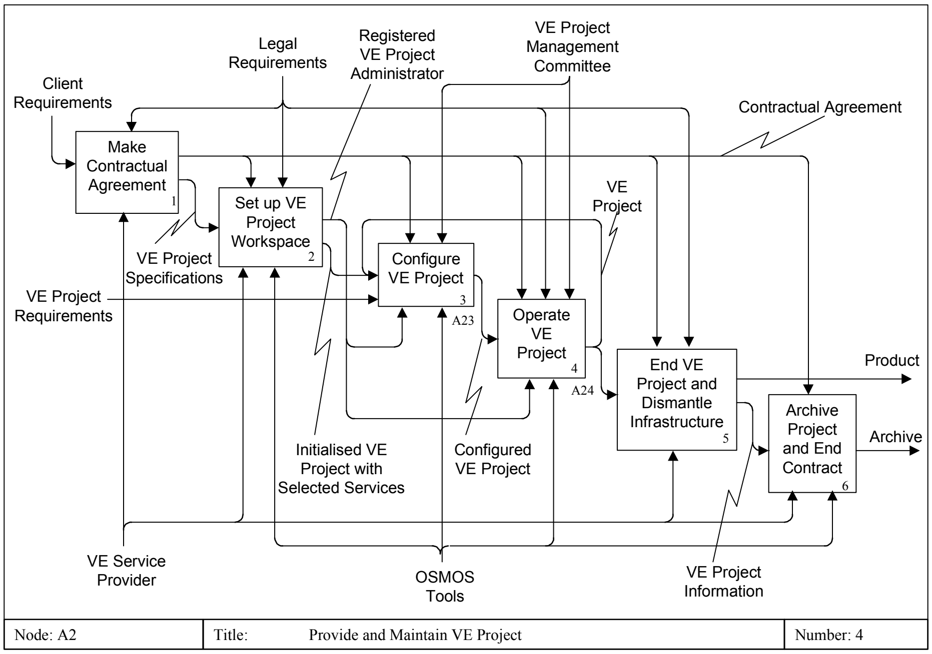

Figure 2. GVEPM: Provide and maintain a VE project.

THE OSMOS Framework

In order to implement the proposed OSMOS virtual enterprise a generic framework was designed. This is presented in Figure 3 in the form of a multi-tiered architecture. This architecture involves four main layers: application presentation layer, application logic layer, business object layer, and persistence layer. It is worth emphasizing that this architecture decouples the process logic and intelligence from the underlying business objects that vehicle the needed semantics. These business objects are, in turn, decoupled from data / information / knowledge storage technologies. This allows more flexibility regarding the structure of the underlying application schemas that are most of the time heterogeneous, proprietary and application specific, while allowing more freedom regarding the maintenance of the business object layer. On the other hand, the OSMOS architecture decouples the presentation layer from the process intelligence and logic. This enables a variety of front-end applications developed using various technologies (including web-based) to invoke and use the OSMOS logic. This architecture relies on three APIs: the OSMOS API (which is invoked through application front-ends in order to access implemented logic and intelligence related to Virtual Enterprise management, information management, communication within the VE, etc.), the Business Object Layer API (which includes an interface to the underlying business objects), and the OSMOS Registry API (which manipulates proprietary data structures). Figure 3 also illustrates how proprietary applications that have built-in logic fit within the proposed OSMOS architecture. Moreover, SGTi (developed by Derbi) and Granlund Web (developed by Granlund) will advertise a proprietary, OSMOS compliant, interface that can be transparently invoked through an OSMOS front-end (Web-browser and VE Management Tool) while relying on their own, proprietary logic and data storage technologies.

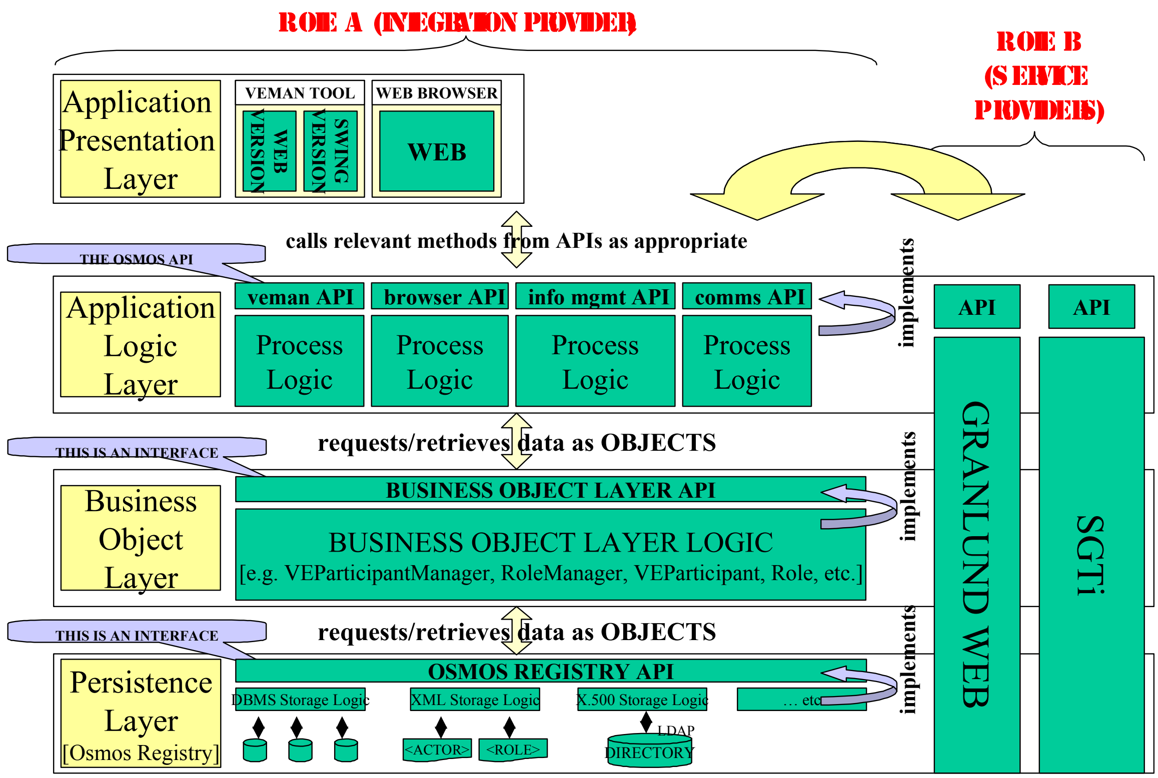

Figure 3. The OSMOS Framework.

One of the major goals OSMOS has to achieve is to have a minimal integration to allow existing services to be deployed into the framework. To resolve this issue, a layer will be developed that will give existing services distant access to the OSMOS API while ensuring the security of these connections. This layer will be developed using emerging technologies based on XML mapping of method calls, and a possible further "internal" use of CORBA (not visible to Third Party Services, but useful for the "core" interactions implementation). SOAP is one of the potential possibilities, but it doesn't answer all of our concerns, mainly because we also have the need to provide some user interface, for specific service interaction, to the Role C user (through Web pages in a Web-oriented environment as primarily targeted by OSMOS).

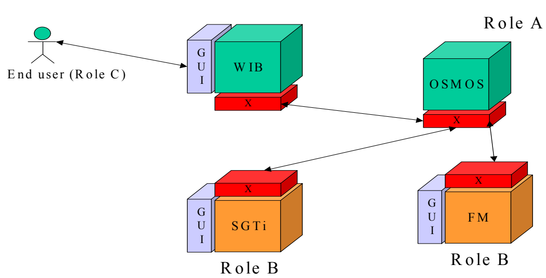

Figure 4. Interaction mechanisms within the OSMOS framework

Figure 4 shows how this layer will wrap existing services so they can be used as OSMOS services by Role C users. The Role B services will need to provide an API to their service via an XML description of their service (i.e. name of the service, methods, needed parameters, etc.). This description will configure the "X" layer as well as serve to register the service within the OSMOS framework. As well as enabling bi-directional communication by offering to services access to the OSMOS API and offering OSMOS access to the service's declared API, this "X" layer will provide means to transport (in the case of Web applications) their GUI (Web pages) to the user. This is an important feature since it will allow Role B Service provider to use part of their existing GUI logic without any changes, OSMOS and the "X" layer providing all the transport support. Moreover, OSMOS should handle HTTP requests and redirect them to the service, mapping it to a method call, so that the entire navigation is under OSMOS control (Access Rights Management).

The OSMOS Services and Tools

In order to achieve the objectives of the proposed OSMOS Framework (described in the previous section), it is not only important to specify the right business objects that participate in a VE solution, but also to specify the right functionality as well as user interfaces (both packaged in the form of low entry level tools) that will allow team work to take place effectively on projects. In that respect, a set of models have been developed that form the business object layer logic. These models include a Distributed Information Management Model, and a Semantic Multimedia Document Model. The range of services that OSMOS will provide include: Information Management Services; Message Based Communication Services; Building and Construction Workflow Service; Application Inter-Working Services; Scheduling Service; Conferencing Service. These services are used as a basis for providing two OSMOS generic Integration services: the VE Management Tool and Web Information Browser.

The OSMOS VE Management Tool (VEM) is the tool used by the administrator of the VE system. It provides a set of functions, implementing a subset of the OSMOS Integration Services, enabling the setting-up and management of a VE. The basic functionalities of the VEM include:

- ability to create, modify, update (register) VE participants (actors);
- ability to create roles and assign these roles to actors;
- ability to create objects and object classification;
- Ability to define actors' right over the invocation of methods on objects.

The OSMOS Web-based information browser (WIB) is the main entry point into the OSMOS system. The role of this service is to provide users with mechanisms to relate any particular nugget of information with other information to which it relates based on its semantics (meaning), regardless of its actual form and storage format. In addition, the Information Management Services allow the users to classify their information elements into various "views", to allow versioning of information to take place, supply metadata about the information stored (both for all versions of a nugget of information, and for a specific version), and also to store and retrieve information to and from the OSMOS-based Virtual Enterprise using his OSMOS-extended application (which is transparently invoking through the OSMOS API). The functionality of this service include the following features:

- The ability to upload and download Information Elements from the OSMOS architecture;
- The ability to semantically classify Information Elements into whatever groups the Virtual Enterprise desires (this would be used for defining default access rights, etc);
- The ability to locate which server a given Information Element can be downloaded from;
- The ability to add a reference from a nugget of information to a part of an Information Element, regardless of whether it is within the same or within a different Information Element;
- The ability to list all the parts that a Information Element references, or is referenced by;
- The ability to query the status of a referenced Information Element (e.g. does it exist, is it available on-line, etc.);
- The ability to maintain (or propagate) changes to referenced Information Elements in a consistent manner (for example, when a new version of a document is produced, the end user should be able to specify whether existing references point to the previous or the new version of that document);
- Document management services in general, such as versioning, backups, maintaining metadata about that Information Element, etc.

THE OSMOS Internet-based Prototype Services

Two OSMOS team work service providers will be set up in Finland and France. Olof Granlund and VTT in Finland, and DERBI in France will set these up. The aim will be to provide OSMOS platforms in these respective countries for OSMOS clients to use for the set-up, management, and dissolution of virtual enterprises. Each platform (i.e. in Finland, France, etc.) will contain the OSMOS core (identified as "Role A: OSMOS Integration Provider" and dealing with the OSMOS Tools and Integration Services) in addition to OSMOS compliant services. The platform in Finland will contain Granlund services and that in France, the services of DERBi. Being OSMOS compliant services (identified as "Role B: OSMOS service providers"), these services have a plug-and-play capability with any OSMOS core. A typical scenario is illustrated in 5 below.

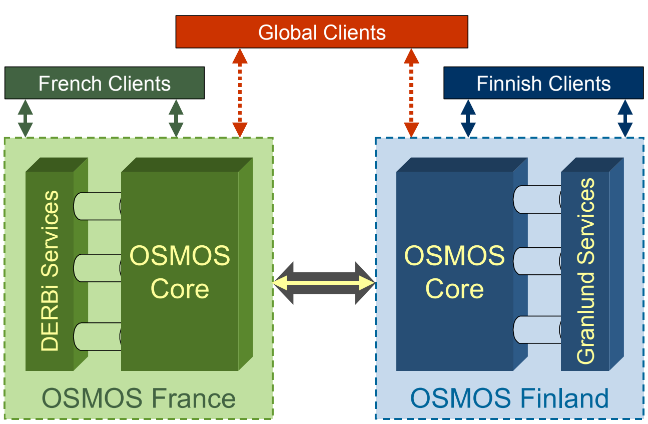

Figure 5. OSMOS teamwork service providers

It is necessary at this point to draw a line that differentiates between "OSMOS Finland" and "OSMOS France". From the figure above, the only distinguishing factors are that one is hosted in France with an interface to DERBi services and the other in Finland with an interface to Granlund services. The very nature of the services enveloped under "DERBi services" and "Granlund services" is different. While the focus of the DERBi services is around their SGT*i* document management system, that of Granlund is around their Ryhti (Granlund FM) facilities management tool. As such, in a distributed environment, these services complement each other. This is illustrated in Figure 6, where both services being OSMOS compliant could be "plugged" into a common OSMOS core and as such made available to certain OSMOS clients requiring these services in parallel.

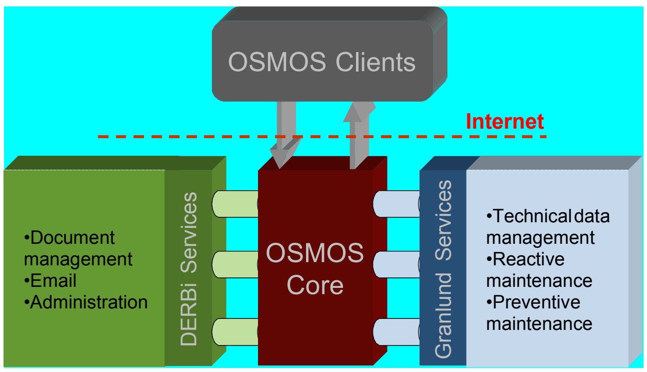

Figure 6. OSMOS prototype services

The prototype set-up in Finland by Granlund contains services targeted for building users and maintenance companies to be used in a facility management (FM) scenario. Concentration is on those FM services that clearly have a need for location independent functionality and thus are suitable for a Web based solution. Such services are in the field of technical data management and reactive and preventive maintenance. The main functionalities of the services include: Technical data management services (Add/Edit/Delete object, Edit object attributes, Edit object instructions), Reactive maintenance services (Add a service request, Get service requests, Confirm a service request) and Preventive maintenance services (Print weekly work order).

The prototype set-up in France by DERBi contains electronic document management and email based communication services targeted for the construction industry. Their aim is to facilitate the management of documents during a construction project's life cycle. The document management service allows documents to be stored on the basis of a defined codification mechanism that can be later used for easy document retrieval, while the email based communication service provides an interface for clients to communicate and share documents. The main functionalities of the services include: Electronic document management service (Store documents on a server, Search for documents using simple criteria, Access document meta-information, Retrieve documents, Create document folders, Manage document versions), Email based communication service (Check emails, Send emails, Retrieve emails).

All services mentioned will be refined and extended during the course of OSMOS and in particular during the project 3rd iterations.

CONCLUSION

The paper presented the European OSMOS project. The latter involves leading research and academic institutions, along with key industrial players, in the building and construction domain. The OSMOS framework was described along with a set of base technology that are potential candidates for OSMOS. The services that OSMOS will provide are expected to enable construction industry software to be integrated with traditional Groupware software components, and, on the other hand, to accommodate intra-company and inter-company communication. It is expected that the project will advance the state of the art in the application of CSCW in the construction domain by:

- Providing construction specific, and scalable solutions, that take into account the particular organisational settings of each construction enterprise participating in the VE, including SMEs.
- Providing IT and organisational solutions that promote trust and social cohesion among the partners of a construction VE.
- Providing effective, model-based solutions, to support Communication, Co-operation, and Co-ordination between individuals and groups collaborating in a construction VE, based on the specificity and information / process requirements of the Construction domain.
- Providing models for business processes, working methods, organisation, contracts, and legal responsibilities related to CSCW in a VE.
- One of the fundamental tangible objective of the OSMOS project is the ability to deploy a flexible adapted team work solution in a limited amount of time, e.g. in days or few weeks as opposed to months, as it is the case today for the deployment of Electronic Document Management (EDM) and Product Data Management (PDM) systems in construction companies. The project end-users are presently involved with the deployment and interpretation of the proposed system architecture within their organisation, to set up internet-based team work services. The OSMOS consortium is in the process of setting up four user interest groups in Finland, France, Sweden and the UK. These groups are expected to provide ways of translating the results to other industrial sectors across Europe.

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