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THE VIRTUAL CONSORTIUM: PROCESSES AND SYSTEMS IN THE CONSTRUCTION SECTOR

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ABSTRACT

Work in today's economic organisations is either performed through the execution of continuous operations or through the implementation of one-off projects; hence one can distinguish between "operation-centric" and "project-centric" business environments. New information and communication technologies facilitate the introduction of innovative organisational structures in both environments. Based on the term "virtual organisation", which is used for describing the new organisational structures in operation-centric environments, we introduce the term "virtual consortium" for project-centric ones and provide an analysis of the business processes of a virtual consortium. We concentrate in the construction sector, as one of the most suitable application domains to test the new concept and related systems. Focusing on one of the most critical processes of a virtual consortium, the bidding/tendering process, we review the existing information systems over the Internet that support this process for construction projects. Our results show that although there are a substantial number of systems that support searching for call for tenders, few of them provide support for other vital items of the bidding/tendering process, such as robust collaboration facilities for the virtual consortium formation and for the management of the bid. We then present the SupplyPoint system, which has been developed in order to electronically support and automate the whole tendering/bidding process of virtual consortia. Supplypoint provides - in addition to what existing systems already do - a collaboration platform that facilitates, in a virtual manner, the formation of consortia.

1. INTRODUCTION

Within business environments activities consist mainly either of operations or of projects. Although performing business by an organisation could combine operation execution and project implementation, in most cases core production processes are oriented towards one of the two models. Based on this orientation, we distinguish between operation centric and project centric business environments.

Operation centric business environments are characterized by ongoing and repetitive activities in the production phase. The client can only indirectly influence the features of the final product or the service provided, by combining or choosing from a variety of customised products or services the one that matches best his requirements. Typical examples are the automobile or the travel agency industry.

On the other hand project centric environments are characterised by unique and temporal activities in the implementation phase. The client predefines the main features of the final deliverable and monitors closely

the activities in the implementation phase of the project. Typical examples are the construction sector and the consulting sector.

In this paper we will examine new organisational structures derived from the rapid evolution of information and communication technologies in both the operation-centric and project-centric environments. The term virtual organisation is used in the literature for describing those structures in operation-centric environments. Starting from this term, we will define the virtual consortium for describing the new structure in project-centric environments. Thereinafter we will focus on the vital process for each virtual consortium, the bidding/tendering process, and we will review information systems over the Internet, which support this process.

The term tendering is used to describe all the actions performed by the awarding authority to produce, publish and manage tendering documents, while bidding incorporates the effort of interested organisations to win contracts by responding to tenders. The facilitating of the tendering/bidding process is especially important in project-centric environments, where timely opportunity identification and adequate consortium formation are key factors for winning a contract.

The goal of this paper is threefold:

- To suggest a new business model of the tendering/bidding process, which could constitute the basis for the development of systems that will automate the workflows of the tendering/bidding process and support the formation of virtual consortia;
- To analyse the characteristics of e-business for electronic tendering and bidding in the construction sector, by examining the chain of business processes and reviewing the pros and cons of existing systems;
- To present SupplyPoint, an innovative European-wide research and development effort that supports the whole bidding process electronically and, in addition to what existing systems provide, provides services for forming virtual consortia that bid for construction projects.

2. FROM VIRTUAL ORGANISATION TO VIRTUAL CONSORTIUM

2.1. Virtual Organizations: Review of the Literature

Virtual Organisations emerged when traditional organisations tried to maximize the benefits of the new information and communication technologies, forming flexible and dynamic networks to make best use of business opportunities. An accepted definition of the term is as follows:

> A Virtual Organisation is an organisation network, which is structured and managed in such a way that it operates vis a vis customers and other external stakeholders as an identifiable and complete organisation. Aken (1998) .

Many other authors have formulated definitions of VOs; see Jägers et al (1998), Fuehrer & Votalk (1997), Travica (1997), Have et al (1997) and Bultje & Wijk (1998).

Strader et al (1998) propose a representative model of a Virtual Organisation's life cycle. The proposed model divides the life cycle into four distinct phases: identification, formation, operation and termination phases. Each of the phases is made up of two or more major decision processes.

This life cycle fits into the operation centric environments where the organisation, virtual or not, designs, promotes, manufactures and distributes the final product or service. The main idea is the production of products or services addressing the needs of a large number of potential clients. The idea of virtual organising introduces a new dimension in the traditional operation centric production process. Using advanced Information and Communication Technologies (ICT), the process becomes more dynamic and

flexible involving different physical entities (organisation and/or persons), each of which contributes its core competences. As a result investment cost decreases and customisation increases.

On the other hand, the model fails to describe the main activities performed in project centric environments. In order to address this issue we introduce in the next paragraph the term of Virtual Consortium.

2.2. Virtual Consortium : Definition and Life-Cycle

Close co-operation between different organisations with complementary skills has been a long tradition in project oriented business environments. Typical example is the construction sector, where due to the complexity and the scale of the projects, organisations are almost obliged to co-operate. The dominant term for describing those co-operations is the term Consortium. As in process-oriented environments, the rapid evolution of Internet and ICT resulted to the appearance of a new virtual form of organisation, which we call Virtual Consortium, and define as follows:

> A Virtual Consortium is a co-operation of different organisations with complementary core competencies, which come together using advanced information and communication technologies in order to contest for and, if awarded, to implement a project.

Virtual Consortia exist for as long as they pursue or implement a project. A typical life cycle of the generic model includes 7 phases. As shown in Figure 1 the life cycle consists of autonomous operation, opportunities identification, virtual consortium formation, project contest, project implementation, residual operation and dissolution of the virtual consortium.

- Autonomous Development: Each Organisation -potential future partner of the virtual consortium - plans its strategy, gathers the required resources (e.g. investing to knowledge, people and infrastructure) and develops core competencies in an autonomous, independent manner. In this phase organisations often implement alone small-scale projects.
- Opportunities Identification: Each Organisation monitors the business environment to timely identify opportunities matching its profile and strategy. In most cases opportunities have the form of calls for tender for a project.
- Virtual Consortium Formation: For each opportunity identified, organisations analyse the competencies required for the correspondent project and search for partners with supplementary core competencies to cooperate. The terms of cooperation are negotiated between the different partners and when agreed, the organisation is formed.

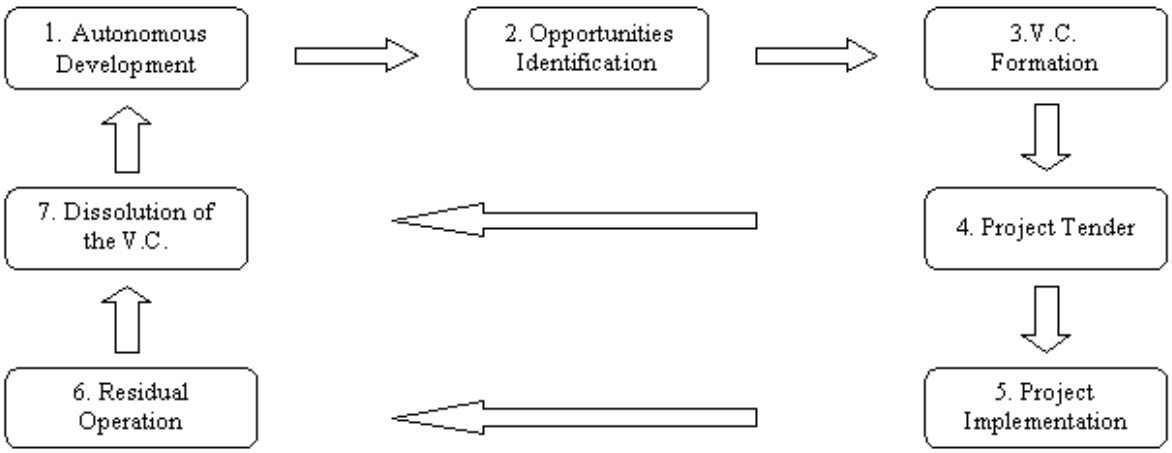

Figure 1: *Typical life cycle of virtual consortium*

- Project Tender: The Virtual Consortium elaborates the tendering documents and each partner is responsible for a part of the consortium's bidding document. The integrated bid is submitted to the tendering authority, which after evaluating the different bids, awards the contract for the project and signs the contract with the winner. Virtual Consortia that fail to win the contract are dissolved.
- Project Implementation: During this phase the organisation performs both the basic and supporting activities needed for the completion of the project. Activities are distributed and performed by the partners of the Virtual Consortium according to their expertise.
- Residual Operation: Very often, after the completion of the project, a small amount of resources are required for activities like management of final payments and maintenance. All those activities are performed during the residual phase.
- Dissolution of the Virtual Consortium: This is the final phase of the life cycle, where the assets of the virtual consortium are dispersed between the partners. The consortium ceases to exist and each partner returns to the autonomous development phase.

It is important to note that in virtual consortia, one of the participants is appointed as the leader of the consortium. The existence of the leader is usually required by the awarding authority in order to make more effective the interface between the authority and the consortium. The leader of the virtual consortium has the overall management of the project, and is responsible for the coordination of the partners. He is the one, who collects the payments from the authority and pays the partners according to their input to the project. Although all the partners of the consortium sign the contract with the Authority, the leader has the top-level responsibility for the successful completion of the project.

3. PROJECT TENDERING AND BIDDING IN THE CONSTRUCTION SECTOR

The suggested Virtual Consortium's life cycle indicates that the forth phase (project tender), where the project is awarded, is the more vital phase. Depending on the output of this phase the virtual organisation will either continue to the project implementation phase, or will cease to exist. A representative example for project-centric environments is the tendering/bidding process in the construction sector.

The tendering/bidding process in the construction sector is characterised by the involvement of a large number of actors, and requires a substantial investment of time and effort often with a limited success ratio. The set of actors involved includes the contracting authority, architectural and engineering firms, general contractors, specialised contractors, suppliers, manufacturers etc.

Those actors perform different roles during the tendering/bidding procedure. Based on the nature of the activities three roles have been identified:

- Client,
- Info Broker and
- Provider.

As shown in Figure 2, the main subject of the Client role is the successful completion of the tendering/bidding procedure.

The Client prepares tender documents, evaluates bids and assigns the contract to the winner of the tender. This role is performed by the contracting authority but also by any other actor who wishes to purchase services or products for the implementation of their work within a project. An example would be a general contractor searching for suppliers or subcontractors.

The role of Info Broker is to collect, organise, amalgamate and dispatch information about tenders in progress, potential partners, contract awarded and so on. As with as the typical Info Brokers, this role is also performed by the contracting authority and occasionally by any of the actors when for example passing information to partners or subcontractors.

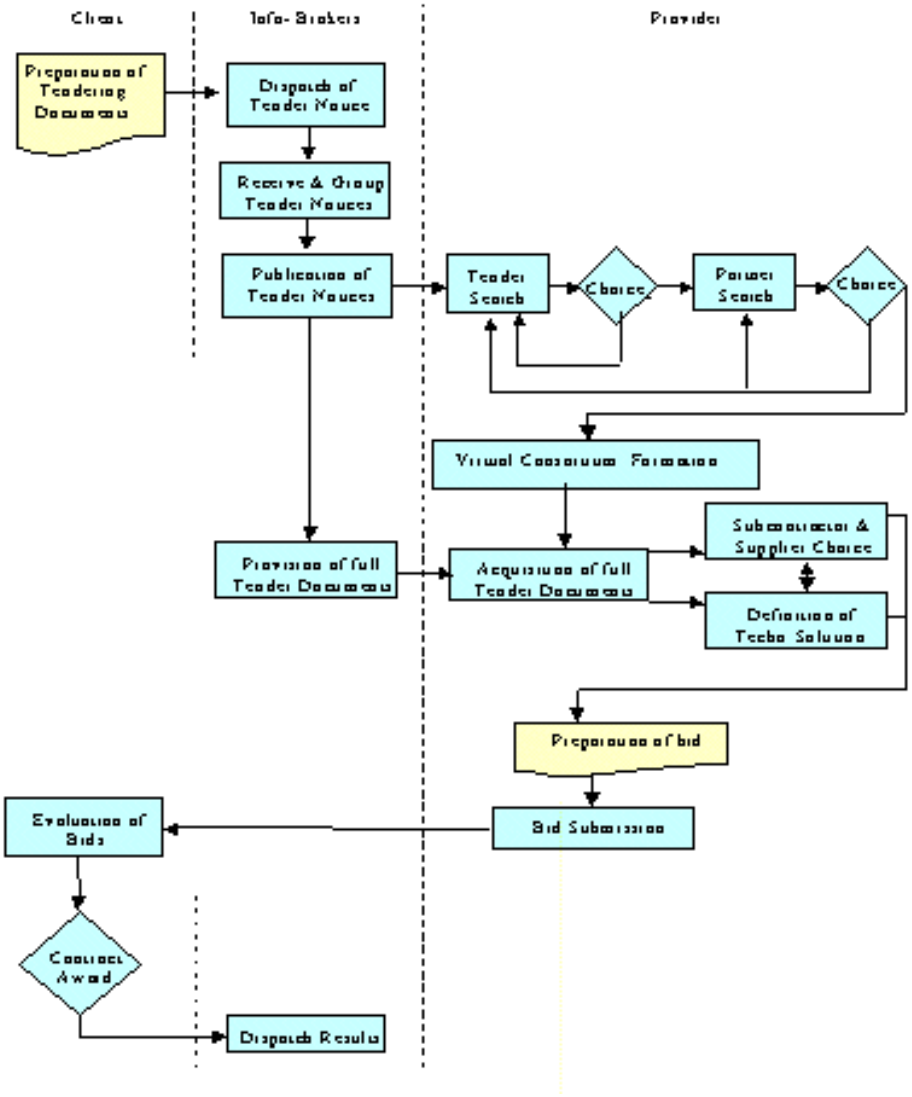

Figure 2: *Breakdown of tendering/bidding process by roles*

A typical provider could be a general contractor, who after searching for tenders and choosing one to bid, forms a Virtual Consortium with other contractors. The VC then prepares and submits a bid to the client. However, this is also the case when specialised contractors, suppliers or manufacturers send their bids to a general contractor that is preparing a bid for a tender.

4. VIRTUAL CONSORTIUM SYSTEMS IN THE CONSTRUCTION SECTOR

4.1. System Functionalities

Managing the tender/bidding process in a virtual manner consists of supporting electronically the execution, partially or in total, of the above activities. From the client point of view it is important to develop a module providing the ability to upload tender notices and tender documents making them directly available to interested parties and eliminating lead times. Often after the publication of the tender, clarifications are made, the module should in more advanced systems provide the ability to amend clarifications to tender documents after they are uploaded and to notify providers who have already downloaded the tender documents. This functionality is provided in some systems (for example ELPRO, see Slade (1998) for further details of the European environment).

Having made all the tender documents electronically accessible, focus is now on the way to access them. Thus a sophisticated search engine is required. This engine should enable quick multi-parameter search of tenders and flexible presentation of results. Additionally this module could automatically send e-mails informing the user of any new tenders that match a predefined profile(s). This profile is defined by the user and contains priorities and interests, which are the basis for the screening of new tenders. Another important issue is the ability to search for and gather information about potential partners, subcontractors and suppliers as well as to have a secure environment ensuring on-time and quick communication with them.

Virtual support has also to provide for the need for exchanging documents and messages within the VC after its formation, when the bid preparation process begins. An effective solution is the allocation of adequate space in a web server dedicated to the consortium, managed by the consortium leader and accessed by all partners (depending on rights). Towards the end of the tender/bid process, virtual management should support the electronic submission of the bid, the communication between client and provider and the electronic dispatching of the results. If this is accomplished in a way that does not endanger confidentiality of the bids, substantial advantages can be gained in the minimisation of the response times to tenders.

4.2. A Review of Systems

In this context many electronic tendering/bidding systems have already been developed and are currently in use, supporting the tender/bid process in the construction sector. Outside Europe most of the systems operate in the USA, in Canada, in Australia and in Hong-Hong.

In Europe a very important factor in the tendering process is the obligation of public bodies to publish calls for tender in the Official Journal of the European Union (Supplement S), when their values exceed the established thresholds. Thresholds vary, depending on the subject of the tender (e.g. services, procurement, works). In the case of public works the threshold is set at 5.000.000 Euro. In other words Europe has developed a database of medium and high value tenders fed daily by member states. This has resulted in the development of two categories of systems supporting the tendering/bidding process in the construction sector; pan European systems based on TED (Tenders Electronic Daily, the electronic version of Supplement S) and national systems fed by tenders published by national and local authorities.

4.3. Comparative Analysis

Functionalities provided by the systems examined vary from system to system and include:

- electronic search of ongoing or assigned tenders;
- tender documents download;
- search for partners in the systems database;
- e-mail exchange between primes, subcontractors and suppliers;
- automatic search of new tenders based on defined user profile and user notification;
- electronic creation and submission of bids.

In Table 1 the existing systems are presented with regards to the functionalities provided.

From the systems' description and the above table we conclude that most of the non-European systems are initiated by, and focus on the support of tendering authorities, whereas systems in Europe more often aim to support companies, including the construction sector.

The main scope of most existing systems is to support the search for tenders and the acquisition of tender documents. Few of them also provide the ability to search for potential partners through a database containing companies validated by the authority, or members of local official construction companies'

records. Some systems also offer the ability to submit electronic documents after appropriate registration. The Canadian system MERX and the European system SupplyPoint are the strongest systems in terms of variety of functionalities.

With the exception of systems operated by tendering authorities, where services are provided for free, the most common pricing policy is to provide free tender search and require subscription to the service, before providing access to the full service package. However, many of the systems covering the national level in European countries require subscription before providing any service

	Search for tenders	Tender documents download	Search for partners	Bid preparation and submission	Automatic search for new tenders and user notification	Communication between involved parties
Trns•port Expedite	•		•	•		•
Bid Express	•			•		•
Bid Line	•	•			•	
Citadon MarketNet	•			•		
MERX	•	•	•	•	•	•
BIDDs	•	•			•	
DCIS System	•	•				
ETS	•	•		•		
TED	•				•	
Eu-Contracts	•			•		
BIP-Business Information Publications	•	•	•		•	
Tenders on the Web	•	•				
Visholm Media	•	•				
EPIN	•	•				
BI On Line	•	•				
Die Ausschreibungs	•	•				
Medien Pool	•	•		•	•	
Concursos Públicos	•	•				
Informatel	•	•			•	
Associação de Empresas de Construção e Obras Públicas	•					
Dario da republica:Concursos	•					
TATI	•					
AnbudsJournalen	•					
TEE Database	•					
SupplyPoint	•	•	•	•	•	•

Table 1: *Comparative review of existing systems*

One area, in which the systems we reviewed appear to be inadequate, refers to the existence of a solid collaboration platform that can support -in a virtual manner- the formation of a consortium.

Another important area refers to the integration and automation of the whole tendering/bidding process. Such an integration could be obtained by explicitly incorporating technologies like workflow management; see for example Laplante (1997), Mentzas & Halaris (1999), Van Dyke Panurak (1997) and Workflow Management Coalition (1998) within the virtual environment.

SupplyPoint attempts to support the integration and automation of the whole tendering/bidding process using the workflow technology and also to provide services for virtual consortia that bid for construction projects. In the following, the solution of the SupplyPoint system is shortly described.

5. SUPPLYPOINT: DESCRIPTION OF THE SYSTEM

SupplyPoint provides an environment, where small and medium-sized enterprises (SMEs) can readily create supply chains and be supported throughout the life cycle of a bid, from contract identification to contract award. The core principle of the system's functionality features in Figure 3.

Specifically, Company A wishes to search for tenders and connects to the system through the Internet. The search for tenders can take place either directly by connecting to TED, or by entering other systems that publish tenders, using a browser. Search results are stored in the databases of SupplyPoint. Company A can now search, using SupplyPoint, for partners (Company B), and establish communication with them, resulting in the formation of a virtual consortium. Consecutively, Companies A and B use the electronic space provided to them by SupplyPoint and prepare the bid to the selected tender. In this context, they locate Company C that will provide them with the necessary material, and invitations to bid and requests for quotations are made.

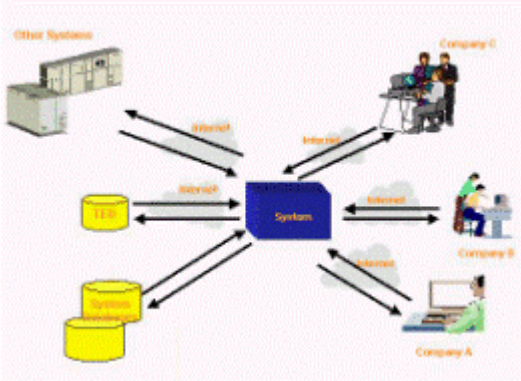

Figure 3: *System functionality*

5.1. Rooms

A basic concept of SupplyPoint is the concept of Rooms (e.g. BSCW, see Bultje & Wijk (1998)). It provides the users with a readily comprehensive metaphor for their "location" within the SupplyPoint system.

A Room is a place in the system, where information (documents) and users that have access to that information are stored. Rooms can contain other rooms and documents in a hierarchical manner analogous to most computer directory tree structures. Similarly each room has rights for visibility and access. Again, documents have rights for view, edit and delete. A top level Room is automatically created when an organisation is registered to SupplyPoint. This is the "Home Room" of the organisation. Users can create (and subsequently edit and delete) new Rooms and store information (e.g. contracts and potential partners) concerning the formation of Virtual Consortia. They can also add, edit, view and remove both documents and user access from the Rooms. The GUI representing the notion of rooms is currently implemented as a tree structure in much the same way as for example windows explorer.

Each entity (a subscribing organisation or a virtual consortium) in the system owns a top level „Home Room“, which by default contains two sub rooms: “Bookmarked Organisations” and “Bookmarked Contracts”. These Rooms help to organise information that concerns contracts and organisations and will be used for the formation of a Virtual Consortium.

5.2. SupplyPoint Functional Structure

The SupplyPoint system consists of nine concrete, autonomous subsystems (see Figure 4).

- the document management subsystem, which provides a flexible environment for creation, editing, exchanging and deleting of documents;
- the workflow management subsystem, supporting the automation of workflows for the formation of the virtual consortium and the preparation of the bid;
- the subsystem for the management of the electronic payments of the users’ fees;
- the subsystem for the management of searches, including the criteria-based search for tenders as well as the search for potential partners using the profiles of the companies registered to SupplyPoint;
- the administration subsystem, which gives users the possibility to add other users and change the company’s working and interest profile;
- the graphical user interface (GUI) that connects the user to the system;
- the help subsystem, providing technical and functional help to the users;
- the communication subsystem, which on the one hand connects with databases and systems containing information useful to the users (TED, ELPRO) and on the other hand supports the communication between users and companies-members of the virtual consortia;
- the access control subsystem, concerning the registration to the system and the user authentication prior to having the desirable information available

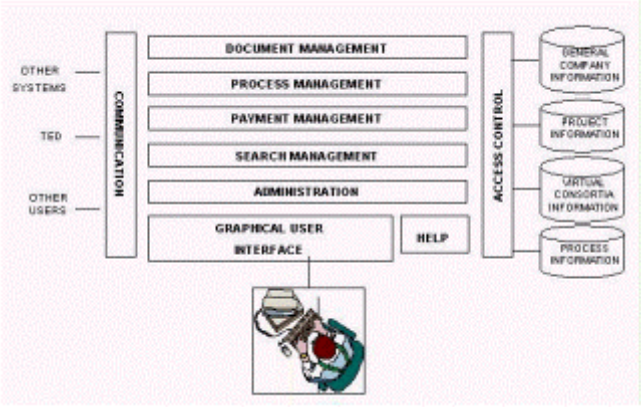

Figure 4: *Functional structure*

5.3. SupplyPoint Architecture

Figure 5 shows the main components of the SupplyPoint (SPP) architecture. The system consists of two main parts, the SPPClient and the SPPServer. It also allows for integration with external systems (ELPRO is shown as an example).

It should be noted that the Common Object Request Broker Architecture (CORBA) is used to provide a communications protocol. The SPPClient establishes a connection with the SPPServer via IIOP. The Lotus Notes Domino Server is used to provide the basic workflow components and infrastructure. The visual element is mirrored in the client using a Java GUI, thus providing a high degree of integration.

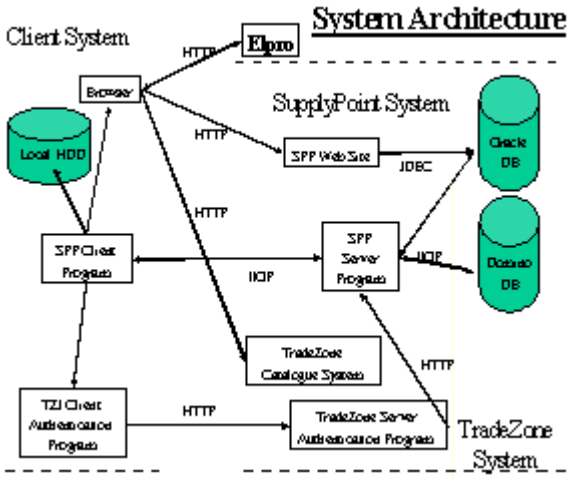

Figure 5: *SPP architecture*

5.4 Forming Virtual Consortia Using SupplyPoint

The formation of virtual consortia within the SupplyPoint system involves the direct interaction and communication between potential partners, who enter into discussions, through the system, to form a collaboration to deal with a specific tender/project. The concepts behind this process are described in Tsakopoulos et al (1999).

An organisation can identify potential partners using various searches or through suppliers/partners already known to them (bookmarked). Discussions with these potential partners can be carried out and agreements made, to form a virtual consortium by creating a shared work area containing various collaboration sections.

Within this on-line business area, or virtual company building, the partners are given access to discussion rooms, data storage rooms and workflow procedures, to facilitate the collaborative processes to prepare and submit a bid for tender.

Before actually forming a VC, the interested party should have selected partners and documents needed for the bid, and collected all that information in a Room (using the "Drag and Drop" functionality of SupplyPoint). This initial Room represents the first stage of the setting up of the VC. The agreements with the partners are not yet finalized and it is possible that some partnerships will fall apart, while new ones will be created.

The communication with the potential partners is supported by the Workflow subsystem of SupplyPoint. Initially, a message serving as an invitation to partnership can be composed. The actual partnership invitation, as well as all the necessary information concerning the desired contract can come as an attachment to the message. The potential partner will receive notification in his mail. After evaluating the invitation, he will communicate a positive or negative response to it. Lack of answer, is also a possible outcome. This process may need to be repeated several times, to communicate with all potential partners. Once the contact phase with all prospective partners is over, the virtual consortium can actually be formed.

The Setup VC component of SupplyPoint represents the final stage of the VC formation. All the system Rooms can be browsed and the one that contains all the relevant information (documents and users) for the VC is selected. The Room name appears in the Setup VC component, as well as its documents and users.

The documents and users that will, from now on, belong to the VC are selected and transferred to the Room of the VC.

Once formed, the VC can do anything that a single company can do within the SupplyPoint system. However, internal workflow will be required to ensure that all relevant parties have agreed on a particular action. For example, the partners must electronically approve any tender documents before they can be submitted as a bid. To prepare a bid, a workflow procedure is used allowing all partners to contribute and agree to the bid before it is sent to the awarding body.

A tender/bid document is created and circulated to all partners in turn. Tender details are entered into the document by each partner and after each partner's contribution, the final document is prepared for submission. Each partner must access the final document and approve or modify it. If a document is modified, the approver list is reset and all partners must re-approve. A manager must ensure that a document is fully approved before submission.

6. CONCLUSIONS AND FURTHER RESEARCH

The review of the systems providing electronic tendering/bidding facilities revealed weaknesses and hence areas for improvement and further research. Besides SupplyPoint, none of the examined systems provides services for virtually supporting the formation of a consortium and for automating the tendering/bidding process. Although SupplyPoint has started some initial attempts to provide solutions to these issues, their full integrated coverage remains open for additional research.

Furthermore, the virtual support for the "Project Implementation" and "Residual Operation" stages of the VC life-cycle is a major issue which has not been thoroughly examined up to now. Specifically, for the SupplyPoint system, a virtual environment that would support the actual implementation of projects could include the connection of worksites to the Room of the VC, the remote use of project management software, the electronic submission of progress reports to the contracting authority, the electronic payment of the VC, etc. Also, providing online auctions could enhance the existing procurement processes.

Although SupplyPoint has been developed within the construction sector environment, it can easily be transferred to other project-centric environments with minor adjustments. For a precise estimation of the advantages of applying SupplyPoint the monitoring of the system utilization by a broad range of construction companies is judged to be purposeful.

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