# Working together: ICT Infrastructures to Support Collaboration

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## Summary
The paper summarizes a part of research carried out in ICCI project and provides a current review of ICT infrastructures supporting collaboration. It covers taxonomies, protocols, standards, components, typical subsystems as well as future trends and recommendation for two most important technologies with applications in AEC: (1) EIP (Enterprise information portal) – a single gateway to a company's information, knowledge base, and applications for all actors; (2) RTC (Real-Time Communication and Collaboration technologies) that provide means for asynchronous communication between geographically dislocated people using ICT. Proposed future developments are: orientation towards web services - with building information models, business intelligence, personalization, AEC information retrieval, p2p workspaces and grids.

## 1 Introduction
One of the most important goals of CIC (Computer Integrated Construction) is to improve communication, coordination and collaboration using ICT (Information and Communication technologies) – in order to increase information sharing in AEC at all possible levels. The prime focus of this paper is the technology supporting the concurrent and collaborative work over the internet. The most important prerequisites for successful work – whether individual or in a team – is knowledge needed to do the work and especially the availability of information needed in the processes. Two important technologies as driving forces that increase the level of information exchange: (1) Portal technology that serves as a single gateway for asynchronous information exchange to a company's information and knowledge base for employees and possibly for customers, business partners, etc., and (2) RTC (Real-Time Collaboration Technology) that is defined as any synchronous interaction between people who are not physically in the same location. Information sharing is only the first step in towards higher levels of sharing:

- **Information sharing.** Information sharing includes different types of information that must be interpreted by human – building product information, model based information sharing. Information is simply something that reduces uncertainty – something crucial in the construction project or in any other.
- **Knowledge sharing.** Knowledge sharing is one of the processes in knowledge management framework apart from knowledge creation, knowledge organization/storage, and knowledge application.
- **Application sharing.** Application sharing in the real world would also imply sharing of code or making applications available: categories of sharing are: code, components, applications, services, computing.
- **Workspace sharing.** Shared workspace is a virtual space allocated for employees' work (as in an office) and may include the sharing of several all previous levels of sharing. If one operates in the ICT supported infrastructure may have a shared workspace.
- **Resource sharing.** Resource sharing includes all kinds of sharing listed above as well as the sharing of other resources such as computing resources, processor time, equipment etc. – simply in a way in which work gets done.

## 1.1 Overview of EIP

EIP portal software is a set of applications that allow creation of dedicated extranets - web sites. For more information about the term EIP see (Firestone 1999). The core of enterprise information portal may be considered as an engine that can serve highly secure, personalized information and/or applications of any type.. This information can range from email, documents and different files to information from different databases, live productivity reports, whether reports, stock-quotes, etc. This information is afterwards transformed into single access point – gateway that is usually called portal. The relation between different types of information – portal software and its engine – and web page that that is used for delivery of information to the end user is illustrated on Figure 1. left. The functionality of EIP software is illustrated with mechanism in the middle of the figure.

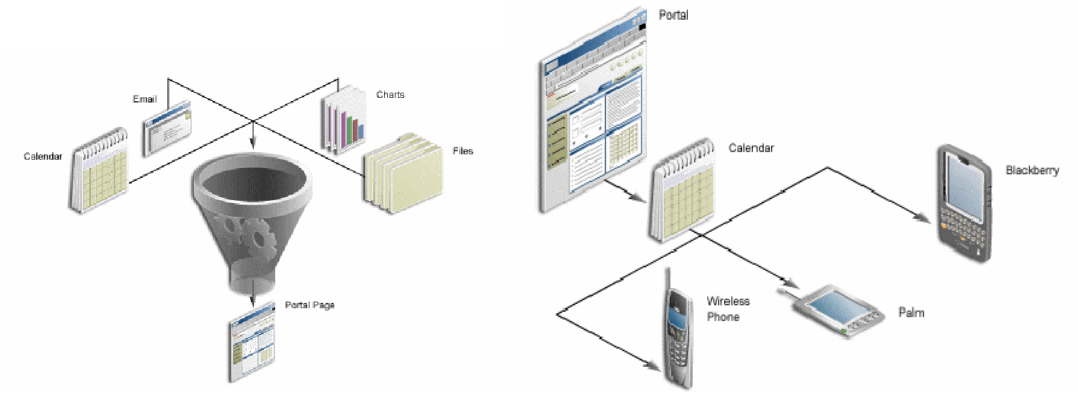


Figure 1: EIP software (Oracle.com)

EIP consists of following building blocks: (1) user management and security, (2) personalization, (3) document and content management, (4) collaboration and communication, (5) search, categorization, and classification, (6) knowledge management, (7) business intelligence, (8) customer and relationship management. EIP became extremely interesting in the AEC sector. The first systems were developed in-house and did not exceed the functionality of the FTP services. The growth of EIP was carefully recorded by on the www.extranets.cc. A growing interest and potential resulted in the growth of the solution for AEC market. Following figure shows the entrance of new solutions, which illustrates that after the "bubble-burst" there were actually no new solutions and the market become to be stable and consolidated.

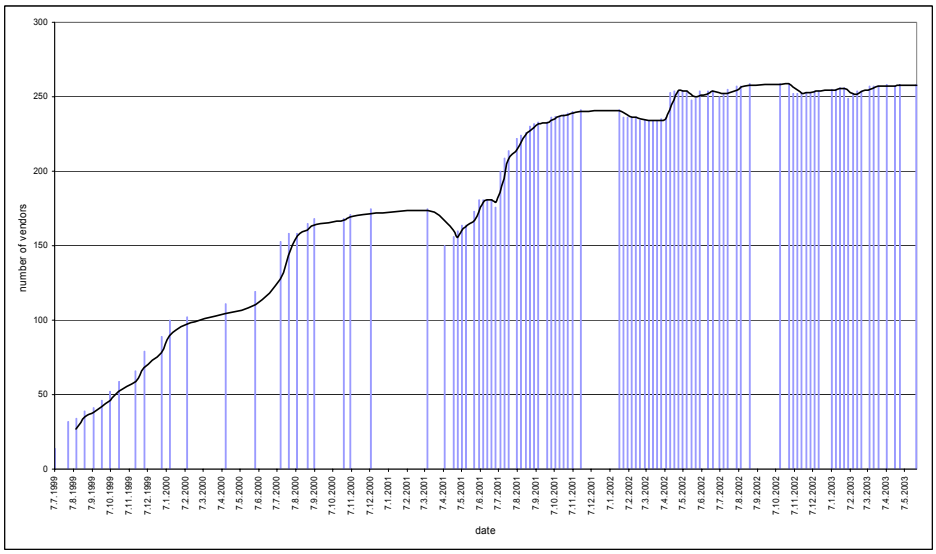


Figure 2: Chronological growth of the EIP number of vendors

## 2 Taxonomies for evaluation of collaborative technologies

Methodology for the evaluation analysis covers: type of networks, type of information, types and roles of users and types of access. The paper also addresses the collaboration, ownership and pricing model and describes a functional model of an EIP.

View points for evaluation are related to the following concepts: (1) Information flow over networks, (2) Interaction type (communication, collaboration, coordination), (3) Barriers associated with time and space under (4) Quantitative & qualitative set of criteria.

### 2.1 Types of networks

Networks have been developed to serve a particular purpose – particual type (quality) and quantity of information. According to the types of access, users and information, networks can be categorized into three categories: Internet, intranets and extranets (Baker, 1999). For details see table bellow. Main focus of EIP is in the category of intranets and especially extranets.

| | Internet | Intranet | Extranet |
|---|---|---|---|
| **Type of information** | General | Proprietary | Selective sharing |
| **Users** | Public | Organization members | Business partners |
| **Type of Access** | Open | Private | Controlled |

Table 1: Comparison of networks (Baker 1999)

From architectural perspective we can divide infrastructures for collaboration into two categories: (1) client-server and (2) peer-to-peer. An example of client-server tool is portal software, which is a type of software tool that is used to create a portal (starting point) for a company's intranet so that employees can find consolidated enterprise-related functions, such as e-mail, customer relationship management (CRM) tools, company information, workgroup systems, and other applications. The package may be customized to varying degrees of enterprise or individual specificity (searchcio.techtarget.com).

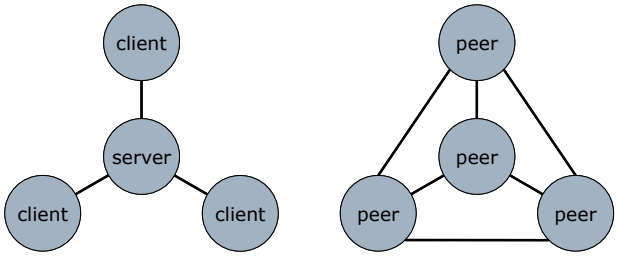


Figure 3: Client-Server and peer-to-peer architecture

Main advantages of Peer-to-Peer (P2P) architectures are direct communication and exchange that they enable cross organization infrastructure, go towards decentralized computing and provide network collaboration. Communication in P2P architectures fall into one of following three categories: (1) One-to-one, (2) One-to-many and (3) Many-to – many. Major characteristic of Peer-To-Peer technologies are: the ability to deal with issues of network capacity, Device diversity, mobility, intermittent connectivity, decentralized control, selective and controlled sharing as well as coordination and co-operation, Security and scalability (Endavor 2002).

## 2.2 Processes and information type

The most important activities in the AEC sector are related to the project activities, which maybe divided into following three stages: (1) pre-construction, (2) construction and (3) post-construction phase. Type of information depends on several factors (project phase, actor type, etc). EIP should allow AEC users to store, manage, search, retrieve and especially reuse all project information. As shown on the Figure below, specific project design data depends on different type of knowledge for which the information should be available.

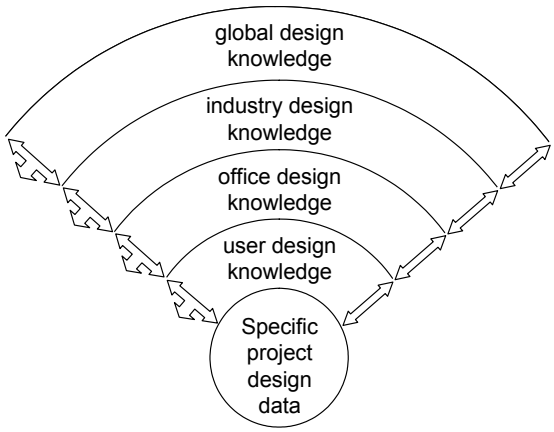


Figure 4: Design knowledge universe (Gero 1997)

For the selection of EIP it is also extremely important whether information is structured or unstructured. Not only the fact that information is not stored in different forms, it may not be available due to copyright or business advantage issues. Although collaboration portals primarily focus on teamwork, a modern enterprise information portal does not cover only information that is exchanged in the teamwork activities, but enables access to all important activities.

## 2.3 Actors and tpyes of interaction

Polotrock (2002) defines following four different types of typical group sizes:

- Individuals.
- Team. A group organized to work together.
- Organization. A number of persons or groups having specific responsibilities and united for a specific purpose
- Community. A group or class having common interests

Different individuals may play different generic roles that are business independent. (P- Person or a member of general public (not directly involved in the business), B – business representative, C – Customer of the services or goods produced in the business). Examples of generic interaction types are: B2P – Web representation, B2B (Business to Business) - SCM (Supply Chain Mng.) B2E (Business to Employee)- KM (Knowledge Mng.) B2C (Business to Custumer)- Customer Rel. Mng. (CRM). Most of the collaboration portals fall into the category of B2B exchange, but individual may need information as community member, memer of organization or in teamwork activites. A complete overview of requirements for tools for collaborative teamwork is available in (Varheij & Augenbroe 2001).

### 2.3.1 Technolgies for different interaction types

Following two figures give and overview of technologies that can bi used based on interaction types – time dependency and group sizes.

| | Synchronous | Asynchronous |
|---|---|---|
| **Communication** | AV conferencing<br>Telephone<br>Textual Chat<br>Instant messaging<br>Broadcast video | E-mail<br>Voice mail<br>FAX |
| **Collaboration** | Whiteboards<br>Application sharing<br>Meeting facilitation<br>MUDs and CVEs | Document management<br>Threaded discussions<br>Hypertext<br>Team workspaces |
| **Coordination** | Floor Control<br>Session Management | Workflow Management<br>Case tools<br>Project Management<br>Calendar & scheduling |

Figure 5: "Time-Interaction type" Collaboration technologies (Poltrock 2002)

Each of those tools have different distribution channels and maybe distributed independently or are made useful in combination with other applications. RTC tools are either pure browser based or maybe used fat or thin specialized clients. Technical implementation of RTC technologies may be: (1) On top of application, (2) On top of application type, or (3) Standalone application. Different types of tool distribtuions are suitable for different group sizes (Figure 6).

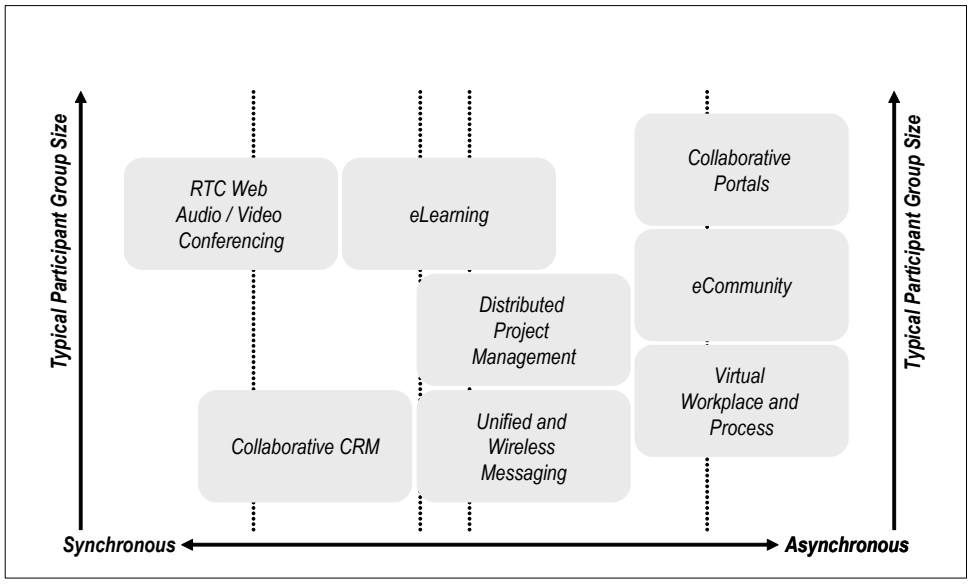


Figure 6: "Time - Group Size" collaboration ( CollaborativeStrategies.com, 2002)

## 2.4 Types of exchange

According to eMarketer.com we can brake down description of B2B exchanges into three ownership models:

- **Third party Exchange:** Exchange is owned and operated by a third party that is not considered to be a trading partner in B2B startup
- **Consortia Led Exchange:** Exchange ownership is shared between industry leaders and technology partners
- **Private/Proprietary Exchange:** Exchange is owned and operated by a single large firm

The same model can be used to structure EIPs. In the case of third party exchanges, pricing structure depends on following set of criteria divided into two related categories:

- **Pricing structure.** Most of the solution provide a demo version or a version with various quantitative limitations
    - **User limitations.** Most common are quantitative limitations (number of users allowed to concurrently use the portal or RTC facility).
    - **Project limitations.** Number of different project that can be run simultaneously, available space for the project.
    - **Time limitations.** Usage of the collaboration infrastructure may be limited to time of the whole service or part of the service(s).
    - **Technical limitations.** Software limitations, not fully functional – limited features, Hardware limitations, Infrastructure (bandwidth) limitations.
    - **Knowledge limitations**. An important aspect for adoption an EIP is the availability of support and training material for different types of users.
    - **Limited security services.** Security service may highly influence the pricing structure. They may be combined with one of the already mentioned limitations.
- **Security services.** Security services are a part of SLA (service level agreement) between portal users and provider. They include (Bort & Felix 1997):
    - **Authentication:** identifying and individual or computer to ensure that the party attempting to access a given area is a member of the appropriate group, or is listed in an access list.
    - **Confidentiality:** verifying that information is private and therefore seen and accessed only by intended recipients
    - **Non-repudiation:** ensuring that people cannot deny their electronic actions
    - **Integrity:** verifying that information received is the information that was put there by the originator
    - **Access control:** verifying that the resources are under the exclusive control of the authorized parties - ensuring that the person attempting to access has the authority to do so.
    - **Availability:** ensuring that data and server resources are up and running when needed, and that any downtime was not caused by a security – related incident. If goals one through five have been achieved, availability will be a natural result.

# 3 Important protocols and standards

## 3.1 Portal exchange standards

Following specific standards are important for the evolution of EIP:

- **Web Services** with its 3 core technologies, namely Simple Object Access Protocol (SOAP), Web Servoces Description Language (WSDL) and Universal Description and Discovery Interface (UDDI) form Basic Profile 1.0. Two types of web services are used in EIP: (1) Process oriented web services, and (2) Data oriented web services

- Java Specification Requests (**JSR**), JSR 168 is a standard to enable interoperability between Portlets and Portals, this specification defines a set of APIs for Portal computing addressing the areas of aggregation, personalization, presentation and security.

- Web Services for Remote Portlets (**WSRP**) is a cross-vendor protocol that defines a SOAP interface enabling portals and non-portal Web applications to incorporate remote portlets. WSRP uses customizes WSDL. WSRP defines: (1) a set of interfaces supporting an initial handshake between a portal and a portlet; (2) an interface allowing a portal to request a page fragment from a portlet; (3) an interface allowing a portal to marshal user interaction to the portlet; (4) a set of interfaces allowing portals and portlets to collaborate.

WSRP is a communication protocol between portal servers and portlet containers, while JSR 168 is a Java API for portlets to work with WSRP portals. Major advantage of separation of portlets from portal environment is that organizations can use third-party portlets to quickly assemble new portals. Portlets represent one of the most important mechanism for integration of geographically distributed applications and data in a way that is independent from platform and leverages distributed responsibility (between different business units or organizations) for creation and maintenance of applications. Developers cab use different development tools, methodologies, and architectures to create portlet functionality. Portlets achieve better control over the deployment environment in terms of load, performance, monitoring and security. There are two types of portlets:

- **Local Portlets.** Local portlets are portlets that execute inside a portal server. When a portal server generates a page and needs a page fragment, it calls the portlet code using a pre-defined API. JSR 168 defines a standard local portlet API for the J2EE environment.

- **Remote portlets.** Remote are portlets that execute outside a portal server, either in a local server inside an organization or at a remote location. When a portal needs a page fragment, it calls the remote portlet via a SOAP call. The WSRP protocol defines a standard SOAP interface for remote portlets.

Besides OpenLDAP that provides open source implementation of Lighweight directory Access Protocol (LDAP), following two standards contributed a lot to so-called single-sign on (SSO) feature:

- **Liberty** is an industry alliance to drive open, neutral standards for federated network identity management & services. Liberty builds a global set of attributes composed from a user's multiple accounts and includes identity information like username & password, preferences, identifications like license & credit card number, affinity programs, associates, history, etc.

- The Security Assertion Markup Language (**SAML**) is "an XML-based framework for exchanging security information. This security information is expressed in the form of assertions about subjects, where a subject is an entity (either human or computer) that has an identity in some security domain. SAML is being developed by the OASIS XML-Based Security Services Technical Committee (SSTC).

## 3.2 Real-Time-Communication protocol standards

Real time communication and/or collaboration (**RTC**) refers to any synchronous interaction between people using computers who are not physically in the same location and may include voice, video, messaging, application sharing and collaboration. RTC tools are used to facilitate live group interactions such as virtual meetings, Web-based seminars or "Webinars", distance education or e-training, or point-to-point multimedia communications. RTC tools are designed to mitigate the age-old difficulties and barriers associated with time and distance. Latest technologies that go along with recent developments in the area of RTC are: voice and video-conferencing (**VVC**), Instant Messaging **(IM**), presence indicators (**PI**), and workspaces (**WS**).

Major contribution to the advancement of RTC technologies was ensured by following protocols or standardization efforts:

- Internet Engineering Task Force (**IETF**),
- Session Initiation Protocol (**SIP**),
- SIP Instant Messaging and Presence Language Extensions (**SIMPLE**), and
- Real-time Transport Protocol (**RTP**)

Among most important standards for RTC VVC are Multimedia Teleconferencing standards (MTS) standards that comprise the core technologies for multimedia teleconferencing:

- **T.120 standards** address Real Time Data Conferencing (Audiographics) covering document conferencing and application sharing portion of a multimedia teleconference. The recommendations specify how to efficiently and reliably distribute files and graphical information in real-time during a multipoint multimedia meeting. The objective of the T.120 standards is to assure interoperability between terminals without either participant assuming prior knowledge of the other system; permit data sharing among participants in a multimedia teleconference, including white board image sharing, graphic display information, and image exchange, application sharing, and, specify infrastructure protocols for audio graphic or audiovisual applications.

- **H.32X standards** address Synchronous Communication: the H.320 addresses ISDN Videoconferencing, the H.323 addresses Video (Audiovisual) communication on Local Area Networks, and the H.324 addresses video and audio communications over low bitrate connections such as POTS modem connections.

- **JXTA**: The JXTA protocols are a set of six protocols that have been specifically designed for P2P network computing. Interoperability - across different peer-to-peer systems and communities, Platform independence - multiple/diverse languages, systems, and networks, Ubiquity - every device with a digital heartbeat Using the JXTA protocols, peers can form peer groups, include another peer in that group, change peer groups, delete groups, communicate among themselves, exchange files and do many such activities. The 6 protocols of JXTA are: (1) Peer Discovery Protocol, (2) Peer Resolver Protocol, (3) Peer Information Protocol, (4) Peer Membership Protocol , (5) Pipe Binding Protocol , (6) Endpoint Routing Protocol

# 4 Highlights of the survey

From the extensive list of more than 300 solutions around 150 solutions were selected and analyzed in detail – for complete list of products see (Cerovsek & Turk 2004). Each solution is described in the form of record with basic information about the solution (ie. product name, vendor, suitability for the market, et.c). The most important information included in records is related to ICT support for collaboration – typical for AEC:

- Communication:
  - Asynchronous communication: Integrated E-mail and Discussion forums
  - Synchronous communication: Chat and Videoconferencing
  - Asynch – sychn. Communication: It is available through Document management facilities (Following abbreviations are used in figures bellow: DM – Basic Document Management functionalities, AT – Audit Trail, CU – Concurrent Use of documents, View – Ability to view files and documents without applications, Comment – Ability to make comments on documents and models, Redline – Ability to mark certain parts of document, for example it allows CAD models to be manipulated including viewing (switching on/off) layers, etc.
- Coordination:
  - Task. Mng – Task management (i.e. assigning, tracking, workflow etc.)
  - Calendar – Web enabled calendar
  - WebCam – Internet enabled site monitoring camera services are completely automated so that visual data as well as cams can be accessed and controlled from anywhere and help in monitoring construction site (Burchar 2002).
- Suitability for AEC project stage capabilities :
  - Pre construction,
  - Construction, and
  - Post construction

Summarized statistics is gathered on figures bellow.

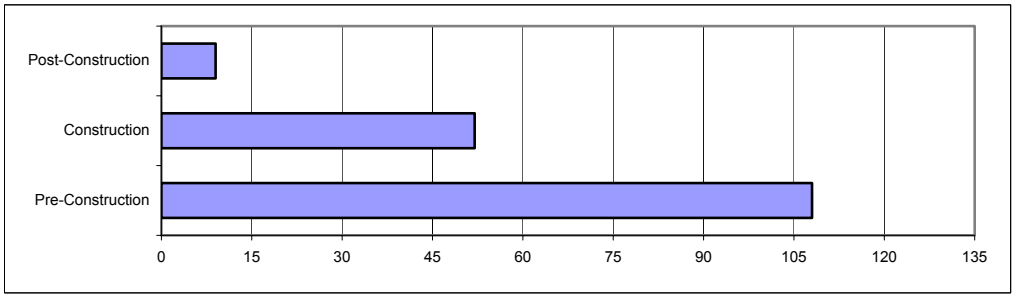


Figure 7: Suitability for AEC project stage

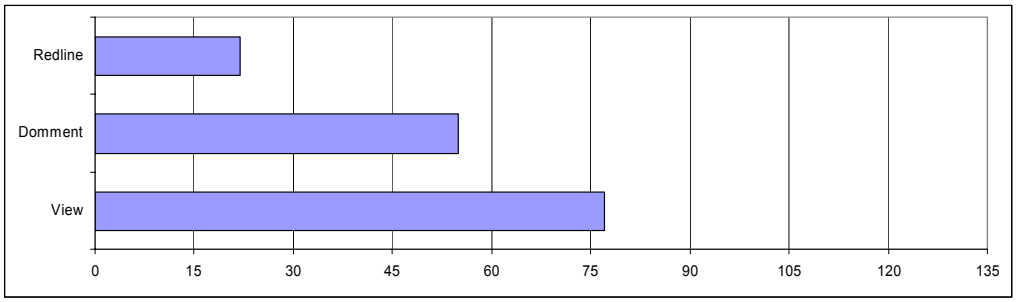


Figure 8: Availability to redline Comment and view documents without applications

For details, description and functionalities of building blocks of EIP described in 1.1 as well as specific AEC solutions consult full report (Cerovsek & Turk 2004).

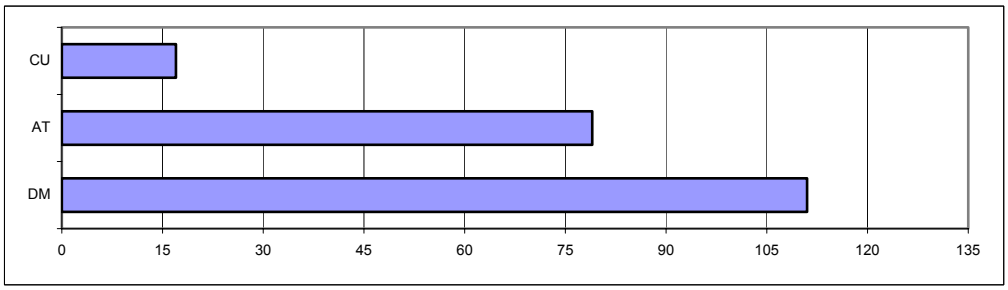


Figure 9: Support for CU - Concurrent Use, AT- Audit Trail, and DM – basic document management

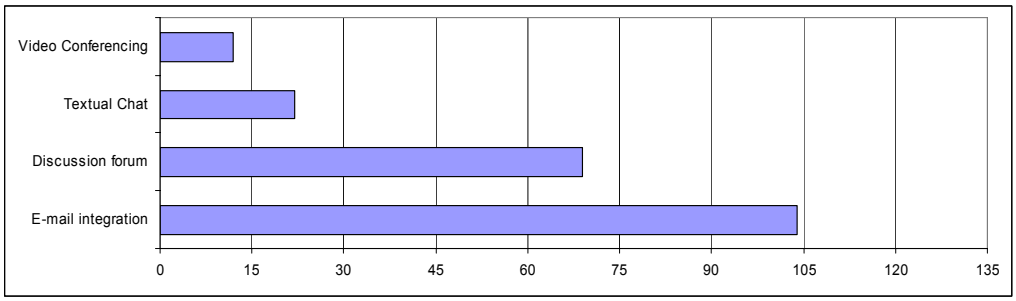


Figure 10: Availability of asynchronous and synchronous communication capabilities

# 5 Discussion and conclusions

## 5.1 Major players

As reported by "the inquirer" the enterprise portal market is increasingly dominated by major players like Orcale, Micorsoft, Sun, Bea, IBM and CA. Companies that used to dominate the market due to their' visionary and innovative technologies are nowadays facing serious competition because of the increasing interest of enumerated major player. For example  of such company is Plumtree Software that launched at the end of April a competitive product Enterprise Web Suite as a response to the developments on the market and probably the last attempt to stay in line with the developments on the market of Big players. For example Plumtree is bundling various new versions of existing software Corporate Portal and Content Server, version 3.0 of its Collaboration Server, and its Search capability. But it is also including an Enterprise Web Development Kit, which will enable customers to build applications out of web services running on different systems.

Table 2: Market shares of major Portal software vendors (www.plumtree.com)

| Vendor | Analysts Group | | |
|---|---|---|---|
| | IDC | Garnter | Delphi |
| **Plumtree** | 12 % | 7 % | 15 % |
| **IBM** | 9 % | 7 % | 8 % |
| **SAP** | 7 % | 7 % | 6 % |
| **Oracle** | 6 % | < 5 % | 9 % |
| **Microsoft** | < 1 % | < 5 % | 10 % |
| **CA** | 11 % | < 5 % | < 2 % |

ENR has found that, among design, engineering and construction firms that are currently using Internet-based project collaboration services, the service that is used more than any other is the Buzzsaw collaboration site from Autodesk, Inc. When asked, "which web-based applications are currently used by your firm?": (1) nearly 40 percent of the survey respondents named the Buzzsaw service, placing the Autodesk solution in front of competing offerings from (2) Meridian Project Systems, (3) Constructware and (4) Citadon.

## 5.2 Technological trends

Following technological trends in the field of

- Orientation towards web services. In contrast to great enthusiasm that was brought with the advent of web services. An interesting view to the future of web services was given by Gartner Group and exposes
- Increased importance of Workflow Management. High demand towards interoperability and multimodality – supporting availability of information to different mobile devices or point-to-point workspaces.
- Lower requirements for system management, ease of deployment and customization.
- SSO – Single Sign On solution. Among most innovative and user-friendly approaches to authentication is .NET Passport, SUN is also providing similar solution and others,…
- Alternative distribution channels for software, such as: distributed computing portals, grid computing, Tterminal servers and the use of thin client. There is also a significant shift towards multi-platform availability of software products (Linux).

## 5.3 Success factors

IDC group has determined 4 simple rules for a dream collaboration tool as they call it. These 4 four rules perfectly match the requirements for the profile of AEC users of collaboration tools: (1) Easy to use; (2) Reliable; (3) Secure and (4) Integrated with email. Following list is

- Human – computer interaction. The familiarity with GUI plays one of the most important factors for the adoption of ITC collaboration tools. Support and help desk are desired.
- Support for multi-project activities with single interface and seamless integration of different information soruces. Features like audit trail are driving forces.
- Level of digitization. Availability of the companies' digital documents project and related information strongly influence the adoption of AEC EIP collaboration support.
- Security services. Besides well defined security services (Bort and Felix 1997).. Message privacy and anonymity are of the most importance (especially for tendering).
- Diversity of communication channels. Communication type depends on project phase. There is a need for differentiation of applications supporting collaboration by the stage of the building life cycle as well as by type of applications used for professional work.
- Integration of communication channels. Take into account communication channels and changes in those communication channels with the adoption of new technologies. Teaming characteristics – group size, participants' knowledge.
- Support for engineering data structures. Support for manipulation of CAD models, schedules and other engineering data is of extreme importance. There is a need for OnLine as well as offline information processing and viewing

## 5.4 Recommendations

Following list contains recommended priorities for AEC EIP:

- **Suitability for AEC project phases.** Available tools and services cover well pre-construction and project – design phase. Project phases that are not covered adequately are: Post-construction Phase (ie. facility management) as well as construction phase.
- **Evolution of Web Services for AEC.** Various types of applications used for professional work could be easily transformed into web services by moving processing of input data from local machines to web services. Web services for building life-cycle management based on building information models should be accessible through EIP.
- **EIP components for AEC.** There is growing interest in following EIP components: EIP: business intelligence, content management, personalization and business to customer relationship management. These components could be distributed through specialized AEC portlets or Ms Web Part technology.
- **Improved AEC information retrieval.** Evolution of tools for data-mining and clustering for project information including textual files, schedules and financial data. These include the development of specialized technical search engines for AEC data.
- **Use of hybrid topologies.** Combined centralized as well as decentralized architectures that would automatically assure users that they will not loose any information. Users in the future will not only access information, but collaboratively work on models and run programs via standard browsers or specialized clients. Portals will provide a gateway to machines, data, applications, and other computing services, which can be located at different sites and managed by different entities – so that jobs can be automatically routed to independent cluster/resource management systems – accessible through grid.

# 6 Acknowledgements

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# 7 References

Baker, R. H. (1997). Extranets : the complete sourcebook / Richard H. Baker. - New York [etc.] : McGraw-Hill, cop. 1997. - XII, pg. 576.

Bort, J. & Felix, B. (1997). Building an Extranet : connect your Intranet with vendors and customers. New York [etc.] : J. Wiley & Sons, 1997. XXVI, pg. 326.

Burchar, B. (2002). *Monitor projects via the web Web-based cameras chart progress, provide security.*

Cerovsek, T. and Turk Z. (2004). D222: Market Watch in ICT infrastructures for construction projects. ICCI deliverable. <http://vtt.icci.com>

Carter, R. (2003). *Microsoft Real-Time Communications: Protocols and Technologies*, Microsoft Corporation, Februrary 2003.

Endavor Technologies (2002). Introducing P2P. <www.Endavor.com>

Firestone, J.M. (1999). Defining the enterprise information portal. <http://www.hpcwire.com/dsstar/00/0822/102054.html>

Pfaffenberger, B. (1998). Building a strategic Extranet. - Foster City [etc.] : IDG Books Worldwide, cop. 1998. - XXVIII, pg. 403.

Poltrock, S. (2002). Mapping Collaboration Technology Requirements to Human Social Structure. Mathematics & Computing Technology Phantom Works. The Boeing Company.

Varheij, H. and Augenbroe. G. (2001). A Survey and Ranking of Project Web Site Functionality. College of Architecture, Georgia Institute of Technology, Atlanta, GA 30332-0155 < http://eaec.arch.gatech.edu/issues/articles/hans_csi2002.pdf>