Groupware System in Construction Engineering

by

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Abstract

"Groupware" is one of those mysterious and undefinable terms that have the ability to affect all of our lives. This paper is an attempt to compile some of the knowledge and to categorize groupware systems into a more understandable term. This paper has been written with both the engineering and business-oriented reader in mind, but its goal is to enable construction engineers to understand the benefits, issues, and methodologies of groupware well enough to determine how to best use groupware in their construction firms. Therefore, focus in this paper will be how the construction industry can benefit from groupware technology and most of the examples will come from engineering or construction practice.

This paper is set up in several sections. The first section (Chapter 1) covers the definition of the groupware system and the importance of the groupware system on the construction industry. The second section (Chapter 2,3, &4) explores some areas of the groupware umbrella by categorizing groupware into more understanding terms. These include email and messaging, workflow and process management, group calendering and scheduling, collaborative document and image management, and electronic meeting system. This section lays out a functional framework that can serve as a guideline for construction firms and looks at the trend of all tools for the construction industry in the future. The Third section focuses is on the implementation (Chapter 5) of groupware systems by using the "Design studio of the future" as a case study for analyzing the efficiency of groupware. This section collects data and analyzes how groupware systems are implemented between engineering and architecture students on a real project. The last section of this paper (Appendices) provides all the groupware resources for those construction companies who are interested in groupware and want to update their current situation in the groupware market.

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Chapter I: Introduction

1.1 Traditional model for construction working process

Public works and building projects have existed since ancient times. The great civilization of Egypt, China, Greece and Rome attest to the imagination and hard work of these builders. But only in the late eighteenth century did engineering practitioners become self-aware of their profession. In 1782 an early builder of roads and canals in England by the name of John Smeaton signed himself as a "civil engineer" when presenting expert testimony in court.

Go to the end of world war II the practice of construction engineering was relatively simple. Design, expertise, and recommendations presented by construction engineers were routinely accepted. There was little private or public skepticism toward the profession. Non-peer review of designs and proposals was minimal. However, how the engineering profession interacts, relates, and works with both public and private sectors has changed over the last generation, starting from the early 1980s. Nowadays, project fall under close environmental, professional, regularities and political scrutiny.

Now, Construction is one of the nation's largest industries and a critical asset for enhancing the international competitiveness of US. Industry. In 1994, the combined value of new construction, renovation, maintenance and repair was about $847 billion, representing 13 percent of the gross domestic product, and the industry provided 10 million jobs. At this time that information technology are expanding into every industry, surprisingly, construction professionals is still

known as conservative, non-active, and repetitive job. The broad perception is that construction sector is technologically, inefficient, and expensive-and that developments in this sector are not as important or as deserving of support as in so-called "high-technology" sectors. Most construction company are still managed and organized in a traditional way. The usual practice is that an architect will be responsible for design of the building and constructability issues won't be dealt with until the design is finished, making changes to the design more difficult or forcing the contractor to the selection of an inefficient construction process. The traditional work loop is shown in Fig1.

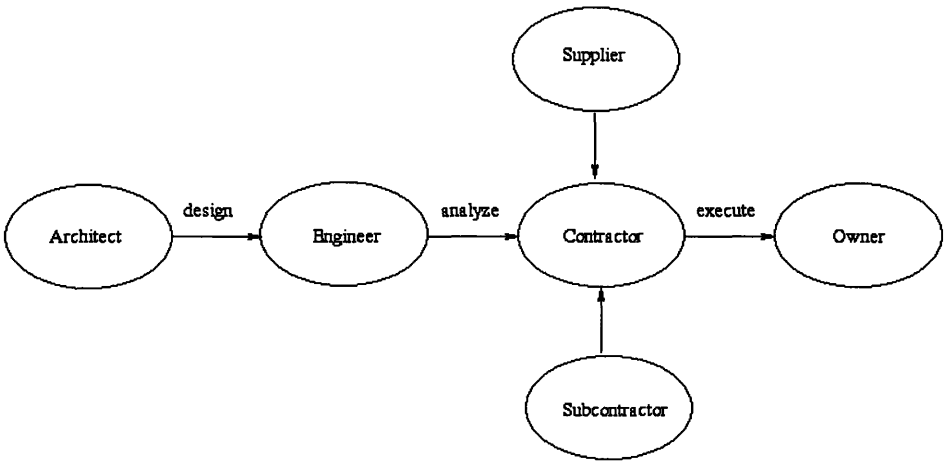


Fig 1 : Traditional Construction working process

One of the problem of the traditional construction project is "lacking of communication" between project participants. From the model, the work flow can be seen as "one-way direction process". No feedback or collaboration have been performed in this model. Every party have to wait for the precedence party to finish before starting their own work. They cannot intervene with other parties even they have different idea on the project. Contractor found the beam that engineer design out of the market stock. Engineer found architect's design structure unconstructability.

Even within party, "lack of communication" can cause inefficiency. Two site engineer have different idea on the same plan. Project manager do not know that estimator reduce cost by using different material. All of these problem not only can cause inefficiency but also increase unnecessary cost for the ongoing project.

Poor communication has long been known as a problem in the construction industry. In order to survive and be effective, construction firm need to adapt to rapidly changing condition, feeling, and philosophies and get rid of the idea of the traditional way of working. With increasing demands on quality, construction firms are also finding that they must adopt the best design, fabrication, and construction practices and technologies to remain competitive.

1.2 Proposed model for construction working process

With the potential of technologies today, communication term become broader and broader. We can communicate with the people around the world when and wherever we want to. In construction engineering, all or some of these technologies could come into construction firm for solving communication problem. Even construction firm get technology that they want, the "lack of the ability" of engineer on how to use the technologies could become another big problem for us. I propose the new way of working for construction process

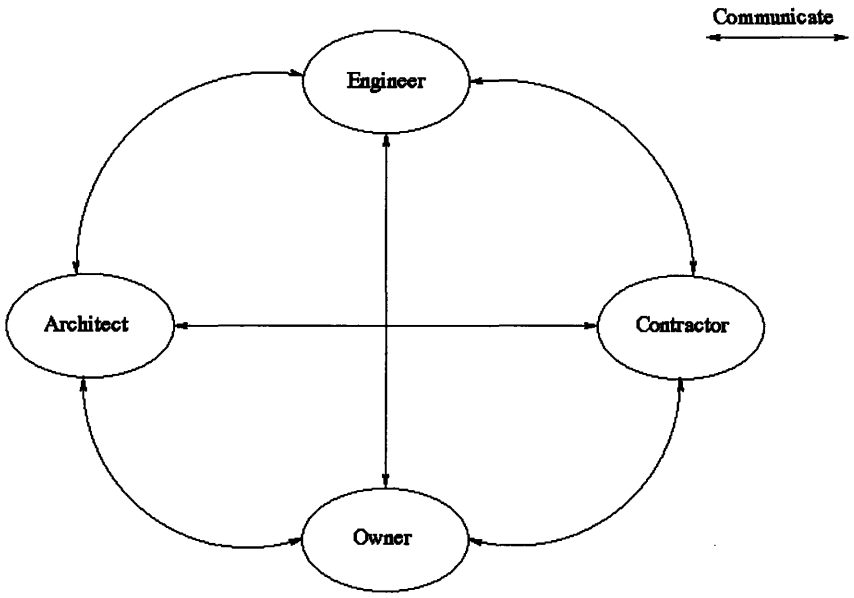


Fig 2 : Proposed Construction working process

From this model, the greatest competitive advantages is the ability to develop and share accurate information among all participants while a project is in progress. All parties are able to participate and collaborate at the beginning of the project and continue until the project end. The major party in that process (for example, architecture is a major party in design process) can get

the suggestion from engineer, contractor, or even owner of the project and make sure that everybody satisfy. If everybody can have and agree in the same idea from the beginning, conflict between parties will rarely happen when the projects goes on. We, as a civil engineer, must have, in addition to the classical technical backgrounds in structure, soil hydraulics, and transportation, a general idea of the rules and regulations in the construction industry. We must be able to evaluate alternatives from an economical standpoint, prepare a realistic work schedule, organize work on site, and conduct relationship with owners, colleagues and workers in a successful way.

In order to have success in this model, communication has to be in very clear and efficiency mode. In small project, face-to-face contact or small non-complex communication tools such as telephone seem to be enough. However, the size of today's projects has become so large that companies are forced to find the new and efficiency tools for communication process.

1.3 Definition of Groupware system

Groupware system has been introduced to business work for the last 10 years. But engineer still do not have the clear idea what it is. How construction industry can exploit this technology for increasing efficiency in our working process still be the mystique questions. This paper will try to understand the concept of groupware and find the way for using groupware technology from construction engineering point of view.

Groupware is an umbrella term for the technologies that support person-to-person collaboration. Groupware can be anything from email to electronic meeting system (EMS) to workflow. With the development of new groupware system and geographically-distributed computer network such as Internet, the collaboration between projects participants do not all have to gather in the same place and my model (Fig 2) become more and more realistic.

This chapter will look deeper into what the groupware system is and how I look at the groupware structure. Firstly, I look at groupware as a system. Groupware system consists of 2 layers that work together.

Application objects are the objects that people want to communicate with the others. It can be from simple text document to building file in AutoCAD.

Groupware tools are the tool that send the application objects to the others. It can be from email system to teleconferencing.

In the groupware system, both layers have to exist in order to make successful communication. I will look at each layer and categorize them for clearer picture of the groupware system in the next chapter.

Chapter II Application object

Objects is the task that people want to communicate between parties. In engineering fields, objects can be from simple text message or big file of AutoCAD drawing. In most cases, engineer collaborate on various objects to produce specific results. For example, various engineers might participate in specifying the design of a piece of equipment. Their goal might be to produce the final "blueprint" design specifications and diagrams for manufacturing. That diagrams or specification can be seen as an object for communication. For instance a group of engineers designing an office chair might take these steps:

1. Collaborate to identify the various components of the chair and then assign these components to various team members for design.

2. Collaborate to specify the various component interfaces to ensures that the pieces will fit.

3. Carry their specific tasks and monitor project progress and display the current status.

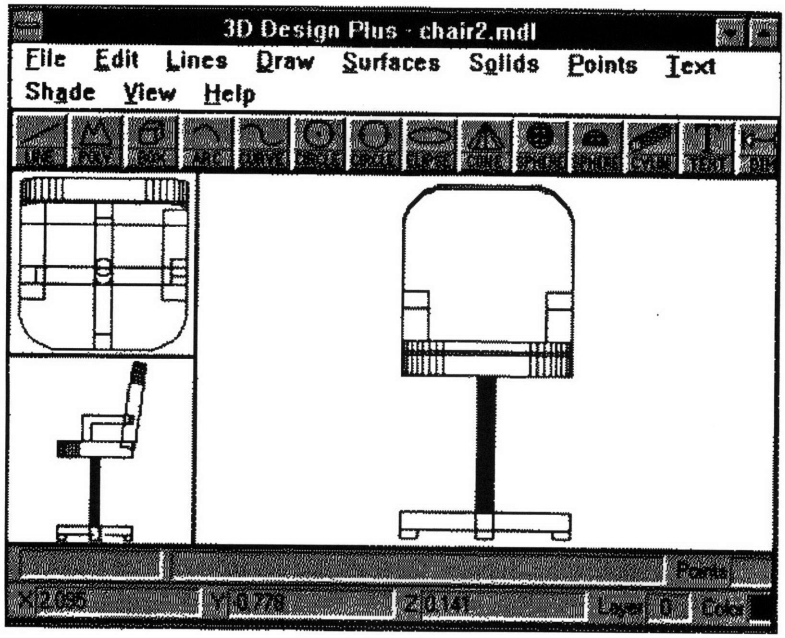


Fig 3: Example of chair design CAD user interface

Fig 3 shows an oversimplified example of a chair designed through a 3-D design application. Suppose the team decides to have three major component types for the chair: a seat, legs, and a back. The engineers could then work on the interfaces between the various pieces-the types of bolts and screws used to hold it together. Then each engineer could work on the details of the various components. The final design draft, together with a detailed description of each component, could then be submitted to manufacturing. In this case, chair drawing file is application objects that engineer would like to collaborate on designing.

2.1 Types of objects

In electronics environments, the objects shared by many engineers working collaboratively may be as diverse as the single-user applications used by different engineers. These objects created through collaborative efforts can be either:

1) **Simple elements**: Simple elements include a text document, a single graphics object (CAD), an image, a voice annotation, a table, a spreadsheet, a word processor file, and so on. Most applications provide some way for displaying and editing one or more of these simple element types. Some application have their own formats for storing these simple elements, and often include formats for text, images, video, or voice. The term "simple" elements is not mean to indicate that the element is not rich in information or that it is trivial to edit or display the element. With the exception of text, the viewing and editing of these "simple" elements could be quite complex.

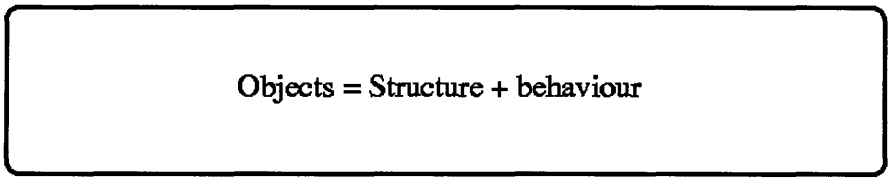
2) **Single application objects**: SIngle application objects include many word processor documents, many spreadsheets files, or many CAD files. Each of these element types has its own structure and editor behavior. For instance, a word processor can be used to write a memo or to compose a letter; a spreadsheet can be used to prepare a budget; a presentation tool can be used to

prepare a project road show, and so on. A single application might include several types or elements. For instance, a word processor can be used to edit text and tables.

3) **Compound objects**: Compound objects are aggregates of objects belonging to different applications. For example, a business plan can include text paragraphs describing the scope of the business, spreadsheets predicting the possible revenues of the business, piecharts and diagrams to describe market sectors all in the context of one "document".

2.2 Defining Objects

An object can be described as an equation:



Where structure contains the data portion of the objects. Typically, these are the files that the user open and edits. For instance, the CAD files may be all perimeters of the drawing, the number in the rows and columns of the spreadsheet, the various elements of the desk chair design in example that we just discussed.

Behavior corresponds to the operations that can be performed on the objects. For instance, the designer can change the viewpoint in a CAD file or zoom in or out to see the detail of the drawing file. These are all examples of various operations that can be performed on different types of structure.

2.3 Type of Collaboration on Objects

Looking at the purposes of sending the object in Construction industry, we can divide process of sending object into 4 areas;

1) **Simple**: Simple exchange of messages with attachment or enclosure is the most popular mechanism in all four types. The recipient of the message receives a copy of the enclosed files as well as the message. Message exchange through routing is a very important mechanism for sharing information.

2) **Commenting, approving, authoring**:An alternative method of collaboration on the creation and development of an object is to comment and approve the various components or paragraphs of the object being developed, without modifying the object itself. Civil engineer can give comment or suggestion on constructability of the structure to architect during architectural design process. Construction manager can give approvement to structure engineer on structure analysis plan.

3) **Coauthoring**: A sequence of text messages interchanged between collaborating co-workers could easily be coauthored. Something more complex, such as a design building. Two architect can design one model and coauthoring it. Note that the collaborative environment could span local and wide area networks, which mean that if coauthoring involves engineers in geographically distributed sites, then all of the participating site must have the same applications available. Here the application involves not only editors but the groupware tools to enable concurrent yet controlled editing of the same document.

4) **Information warehouses**: A less obvious but equally important area of collaboration is making information available within a small team, an organization, or even between organizations. Increasingly, most of the information stored and accessed concurrently in an organization is

in electronic documents rather than structured records stored and accessed through database management systems. The "object" could be a design document, a project schedule, a cost estimation bidding table, or any type of information. The information warehouse that contains the data can be accessed concurrently within a small team, a department, an entire organization, or even between organization.

2.4 Type of Application

Following is a list of typical engineering application types involving text, graphics, spreadsheet, CAD, and multimedia objects which might be used in a collaborative environment.

1) **Word Processors**: One of the most important and basic application types run on personal computers today is the word processor. Engineer can used this package to write letters, memo, project proposals and so on. Some of the most popular word processors for personal computer include Microsoft Word, WordPerfect, and AMI PRO.

2) **Spreadsheets**: Another of the most popular applications in business is the spreadsheet. Spreadsheets organize data in rows and columns and allow the user to introduce dependencies and formulae in evaluating the cells. Engineer can use spreadsheet for formula calculation, proposing budget or project cost estimation

3) **Presentation packages**: Presentation packages are used to prepare slide presentations that involve multimedia elements. Presentation software packages such as Microsoft's PowerPoint and Asymetrix's Compel allow the engineer to incorporate real site images, CAD graphic shapes of different sizes, scale, viewpoint; voice annotations that play during slide presentation; and video. Engineer can used this tool for present the project to the clients or customer.

4) **Personal Databases**: Personal database management tools allow users or small corporations to store and retrieve personal or business data(table) through customized forms and front

ends. Key characteristics of personal databases include search capability through criteria or predicates, the ability to easily construct form for tables, the ability to construct reports and generate reports from the tables of the database, and more.For example, construction manager want to hire architect who are familiar with bridge design, database tool can find group of people who qualified for that position and show all description and history of that candidates.

5) **Corporate Databases**: Often tools that work with personal databases also work with corporate database. Typically, corporate database for midsize and large corporations are managed by database servers. The same benefit as Personal databases for engineer. For instance, the same construction manager would like to talk to all material suppliers in site area. He can find all material suppliers by just input type of material, this tool will find all the supplier and show the price table and specification in one second.

6) **Forms**: Form constitute a very important data type or structure. Numerous applications can, in different contexts, handle forms. Limited forms processing ability has been incorporated into some electronic mail systems, document imaging system, and database programming tools, to name a few. It is estimated that about one-third of all documents are some type of a form. Forms also play a very significant role in groupware systems. Often, in collaborative environments, it is forms that are routed, approved, signed off, and used as the main structure for collaboration. For big engineering firm, Forms play a big role for collaboration process. Engineer who design tools have to sign and author his work on form. Worker who set the specification of the product need to write all information into form. Form will standardize all the engineering collaboration process.

7) **Image Editors**: Image and other multimedia object editors are two fundamental types of software systems for creating and manipulating images in a multimedia workstation. The first

product category deals with editing and processing bit-mapped images. The second category deals with graphics object creation and manipulation tools. For example, 3Dstudio package provide architect with the capability of rendering CAD file with different of material or color.

8) **Graphics Packages**: Computer graphics packages allow the user to manipulate individual object elements; in other words, to describe the various attributes of the object. With graphic packages, the construction engineer is provided with a canvas or space on which objects picked from a list of available object elements (line, circle, or sphere) can be placed and used to construct a two-or three-dimensional compound graphics structure. The objects or elements in the resulting graphics tool are built from a basic or elementary units or blocks, where each elements has a size, shape, fill, position, orientation, and so on.

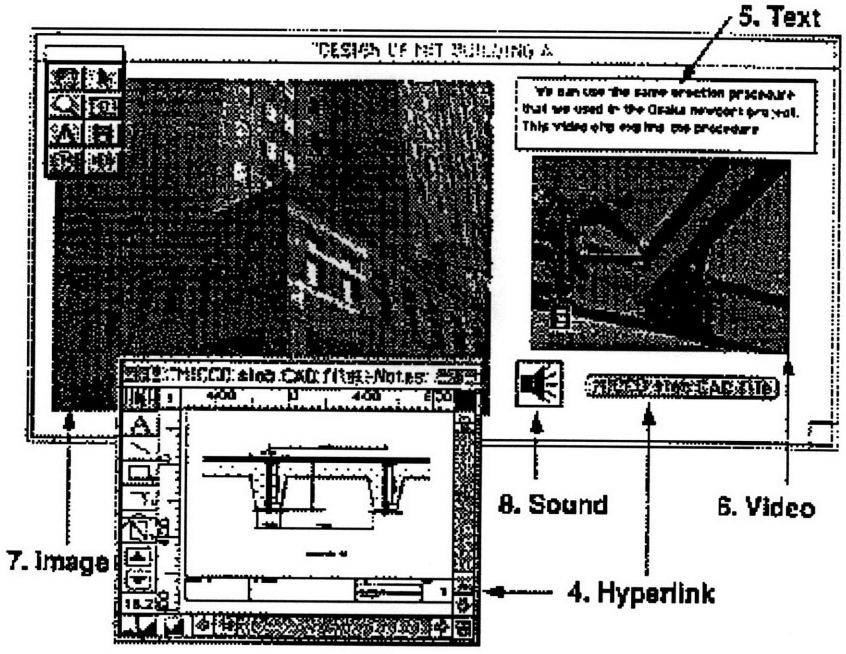


Fig 4 Example of Application object (beam cross section)

2.5 Application object in Construction industry

Over the past three decades, the problems of document production and management have increased markedly along with the growing complexity of construction projects. Software vendors propose numerous tools to support the production and maintenance of documents at a basic level (drawing editors, word processors, table-sheet editors, etc.). Although such tools provide many helpful facilities (save, restore, edit, etc.), they rarely handle any semantic aspects of the information being processed, and therefore remain limited in their support to the end-user. However, high quality documents are required to ensure the success of construction project activities.

We can see that construction engineer can easily afford to use a computer application and reap well known benefits such as higher productivity and the ability to work with state-of-the-art techniques of analysis and design. On the other hand, there are very dangerous pitfalls. Some of these dangers include the lack of;

- Software quality and reliability
- Education and training in the techniques of effectively integrating computer into engineering practice
- Proper and complete software user documentation
- Training in software use

Among these and other problem, by far the most potentially dangerous and the most difficult to identify, avoid or correct one are the problem of inadequate construction engineering groupware quality and reliability, and the gross misuse of computers for engineering analysis and design.

Chapter III: Groupware tools Criteria

The fundamental concept of groupware tool is *collaboration* between participants. Whether the interpersonal interaction is one of the many thousands of casual business transactions that constitute day-to-day life in the business world, or a high-intensity relationship that comes with coauthoring, groupware systems are being designed to support and enhance how we work together. Last chapter we look in groupware object and know *what* the workers can work with groupware. This chapter will try to focus on groupware tool that help people interact with the objects and find criteria to categorize the groupware tools.

Groupware can be anything from email to electronic meeting system (EMS) to work-flow. It is important to note that groupware is a relatively new term, describing a new market and a new set of technologies. Groupware provide tools to solve collaboration-oriented problems. Because of unclear definition of groupware tools, we need to find criteria to categorize all group-ware tool to have better understanding on groupware tool and find the opportunity for construc-tion engineering to exploit this technology.

Before we categorize groupware tool, we need to have some criteria on groupware tool to understand structure of groupware.

Criteria for categorizing Groupware tools :

3.1) Functionality (communication, collaboration, coordination)

Computer-based or computer-mediated communication, such as electronic mail, is not fully integrated with other forms of communication. The primarily asynchronous, text-based world of electronic mail and bulletin boards exists separately from the synchronous world of tele-phone and face-to-face conversations. While applications such as voice mail or talk programs blur the distinction somewhat, there are still gaps between the asynchronous and the synchronous

worlds.

Similar to communication, collaboration is a cornerstone of group activities. Effective collaboration demands that people share information. Unfortunately, current information system-database system in particular go to great lengths to insulate users from each other. As an example, consider two engineer working with a CAD database. Seldom are they able to simultaneously modify different parts of the same objects and be aware of each other's change: rather, they must check the object in and out and tell each other what they have done. Many tasks require an even finer granularity of sharing. What is need are shared environments that unobtrusively offer up-to-date group context and explicit notification of each user's action when appropriate.

The effectiveness of communication and collaborations can be enhanced if a group's activities are coordinations, for examples, a team of construction engineer and architects will often engage in conflicting or repetitive actions. Coordination can be viewed as an activity in itself, as necessary overhead when several parties are performing a task. While current database application contribute somewhat to the coordination of groups-by providing multiple access to shared objects-most software offer only a single-user perspective and thus do little to assist this important function.

Fig 5 show how these three function play a role in organization. We cannot totally separate them from each other. There is grey area between them and all groupware tool are trying to cover all these functions.

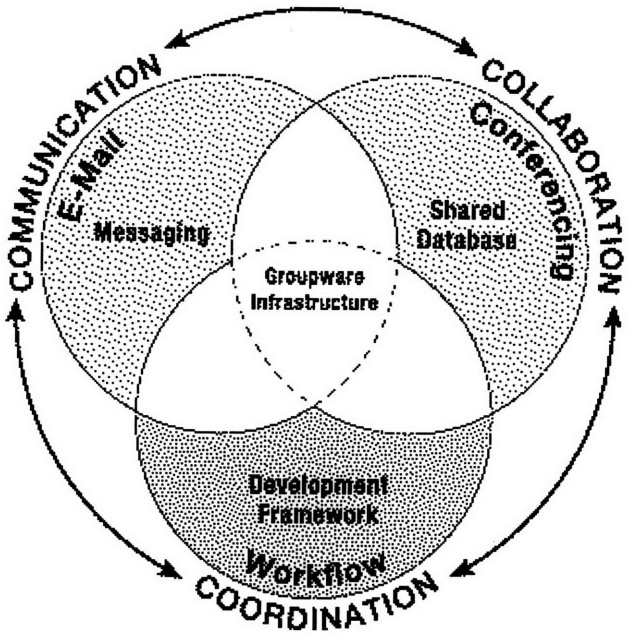


Fig 5: Relationship of 3 functionalities

3.2) Time Space (sametime-sameplace, sametime-differentplace, differenttime-sameplace, differenttime-differentplace)

Groupware can be conceived to help a face-to-face group, or a group that is distributed over many location. A groupware system can be conceived to enhance communication and collaboration with in real-time interaction, or a asychronous, non real-time interaction. These time and space consideration suggest the four categories of groupware represented by the 2x2 matrix shown in Table 1. Meeting room technology would be with in the upper left cell; a real-time document editor within the lower left cell; a physical bulletin board within the upper right cell; and an electronic mail system within the lower right cell. A comprehensive groupware system might best serve the need of all of the quadrants.

	Same place	Different place
Same time	Electronic Meeting Team Rooms Group Decision support systems Electronic Whiteboards	Videoconferencing Teleconferencing Screen sharing Document sharing Electronic Whiteboards
Different time	Shared Containers Mailboxes Electronic Bulletin Boards MUDs, Virtual Rooms, Kiosks Document Management Systems	Electronic mail Workflow Form Flow Messaging in general Routing & notification

Table 1 : Structure of Groupware from time–space criteria

3.3) Control Taxonomy (user, object, process)

This classification scheme focuses on the locus of control. In this framework, the locus of control can be user-centered, work-or-object centered, or process-centered,.

- **User-centered**: User-centered groupware manages work locally. The user builds his own agent or client. The system is focused on the users, and they received data and enter commands from the outside. They may not know much about the data or the workflow. Their tools can include email macros, Lotus Agenda, Beyond's ability Mail tools, or a user-built view in Lotus Notes. Because the locus of control is centered on the users, they may route work flows themselves.

- **Work or object-centered**: Work or object-centered groupware manages work according to an object, such as document, that can mail itself, display itself, or update itself. The user writes instructions that follow the work. The problem here is closure. What happen if the

document is lost? This locus focuses on work steps, not transaction completed.

- **Process-centered**: Process-centered groupware ensures the work is completed, which may require a transaction or nested transaction model. It check the state of the transaction, unlike the work-centered approach, where the object knows its own state. This locus resembles a group agent rather than a user agent. It can be database-oriented and is a more global or enterprise-oriented system. This locus focuses on the work cycle rather than the object or the user.

Looking at criteria, I can categorize groupware tools into 6 categories:

- **Electronic Mail and Messaging**: Include messaging infrastructures, email system. (*cc:Mail--Lotus Development, Microsoft Mail/Exchange, MHS--Novell, Time and PLace/2--IBM*)

- **Group Calendering and Scheduling**: Automating meeting process, Scheduling checking (*Meeting Make--On Technologies, Network Scheduler--CE Software*)

- **Conferencing**: Collaborative and Discussion Databases, Electronic Conferencing, and Bulletin Board (*Showme 2.0--Sun Solutions, Aspects--Group Logic, Inc., Lotus Notes--Lotus Development*)

- **Group Decision Support Systems**: Electronic Meeting System, Audio and Video Conferencing (*Person to Person--IBM, Being There--Intelligence at large, Fujitsu Desktop Conferencing)*

- **Group Document Handling**: Group Editing, Shared Editing Work or Design, Group Document and Image Management, and Document Databases (*Face-to-Face--Crosswise, MarkUp--Mainstay Software*)

- **Workflow**: Workflow Process Diagramming Tools, WOrkflow Enactment Engines, Electronic Forms Routing Products (*Workflow Analyst--ATI, Staffware for windows--Staffware, ObjectsWorks--DEC, Flowmark--IBM*)

criteria / Groupware	Commu nication	Collabo ration	Cordi nation	STSP	STDP	DTSP	DTDP	User control	Object control	Process control
E-mail&meeting system	Major	Minor	Minor	No	yes	No	yes	yes	yes	No
Group calendering	Minor	——	Major	yes	No	yes	No	yes	yes	No
Conferencing	Minor	Major	——	yes	No	No	No	yes	No	No
Groupp decision support system	——	Major	——	No	yes	No	No	yes	No	No
Group document handling system	——	Major	Minor	yes	yes	yes	yes	yes	yes	No
Work flow	——	——	Major	No	No	yes	yes	No	yes	yes

Table 2 : Groupware tools by using specific criteria

Since system support common tasks and shared environments for engineering to varying degree, it is appropriate to think of a engineering collaboration tool spectrum with different systems at different points on the spectrum. Over time, systems can migrate to higher points on the groupware spectrum. This paper will try to focus on high spectrum tool because engineering field is technical intense field and can gain more form high-level collaboration tools.

Two dimensional are illustrated in Figure 6.

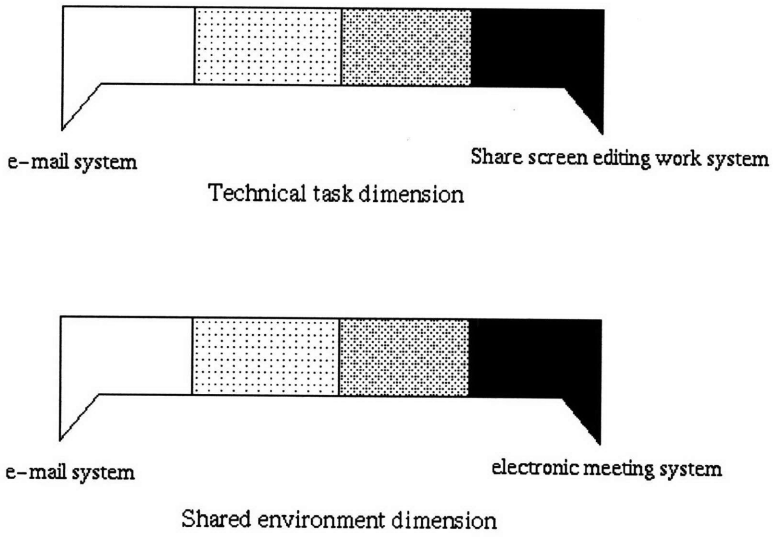


Fig 6 : Spectrum on Groupware system

- **Technical task dimension**: For engineer, electronic mail system can communicate general message such as memo or letter. This system is usually low on the collaboration groupware spectrum. In contrast, consider Share Screen Editing Work system that engineer can see the same drawing or model from different place. They can communicate with the same technical language (table or image). It is high on the engineering collaboration groupware.

- **Shared Environment dimension**: the typical electronic mail system transmits messages, but it provide few environment cues. Therefore it is rather low on the collaboration tool spectrum. In contrast, the electronic meeting system uses multiple windows to post information about the subject being discussed. Emulating a traditional construction site control. this system allows an site engineer to present an on-line presentation to construction engineer at remote headquater workstation. In addition to the site description control by the teacher, window display the attendance list, question and comments. This system is high on the collaboration tool spectrum.

Chapter IV: Groupware tools Categories

After categorize groupware tools, we will discuss on each tools in what it is, how it work, and how we as a construction engineer can use them.

4.1) Electronic Mail and Messaging system

Email and messaging technologies are among the most critical pieces of technology on which collaborative application are built, Almost every collaborative application requires that some information, be it a document, mail note, or routing form, be passed to another person. From engineering point of view, email is not a very powerful tool for collaboration but it is the tool that build as a foundation for other collaboration groupware to build a total solution. It will worth our time to understand the basics of electronic messaging and current issues as they apply to collaboration groupware.

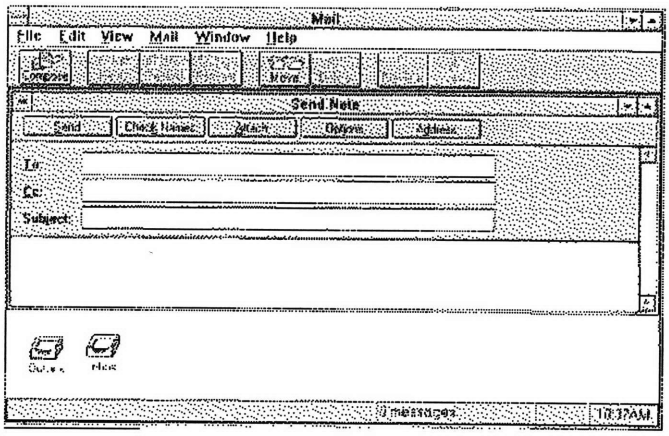


Fig 7 Sample user interface of e-mail system

Electronic mail can be defined as the transmission of text form one computer to another. The analogy of paper mail applies to electronic mail as well. Just as a paper mail message can be sent via the postal system to other users, and electronic mail message can be sent to one or more users. Once again, as with a paper mail message, the content of the mail message or envelope can

contain more than just simple text. While the majority of email messages are text only, electronic messages can also contain graphics, file attachments, faxed image, sound, and video. The characteristics of electronic mail are:

- E-mail is asynchronous
- E-mail is fast
- E-mail is text-based
- E-mail can be addressed to multiple receivers
- E-mail has a built-in external memory
- The external memory can be processed by computer

In construction industry, there are many kinds of message that always send. On site, engineer give feedback on costs, progress and other aspect of performance. At head office, manager may proceed a policy decision or change of procedure, or simple give an account of something happening in the organization.

Currently, we cannot clearly differentiated advantage of engineer over other professional on these technologies. However, in the future, email system can migrate to higher points on the spectrum such as ability to embed very complex object or animation. Email will move higher on spectrum and closer to the real collaboration tool. (as shown in Fig 8)

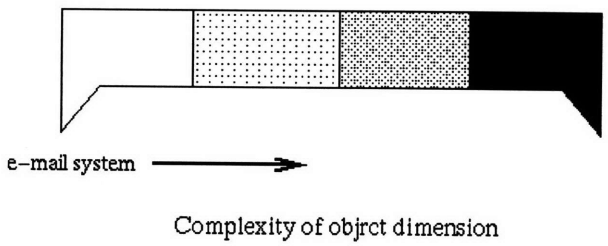


Fig 8 : Trend for e-mail system

The future of Electronic mail and messaging

Moving forward in 1996 and beyond, the future of the messaging market is at best described as "controlled chaos". The future of the market is pretty much dominated and determined by the three large players: Lotus Development, Microsoft, and Novell. While other players such as ON Technology and CE Software will continue to profit in the continuing email expansion, the "big three" software vendor will drive the market. Lotus continues to formulate a strategy of integration of its cc:Mail and Notes products. Microsoft needs to complete and ship its Exchange Server and provide the rich set of tools and applications already found within the Lotus Notes environment. Lastly, Novell, with its recent acquisition of WordPerfect, must migrate its remaining MHS installed base while continuing to develop upon and around the Groupware product line.

For organizations planning or maintaining an electronic messaging system, the future remains bright. Increased competition and continued expansion of email will only enhance the amount of options and tools available for messaging environments and their administrators

4.2) Group Calendering And Scheduling

Calendering and scheduling, often referred to as group scheduling, are typically the first applications to be added to a messaging backbone. Because of the relatively low barriers and required customizations, user can employ electronic calender within their email to set appointments for themselves and others relatively fast. Group scheduling products are usually provided in one of two ways: as either a stand-alone scheduling product like that of Primavera CPU project control product, or one designed to be integrated within a unified messaging architecture like that of Novell's GroupWise product.

Imagine you as a construction engineer who want to form the meeting between all the project participants such as architect, site engineer, supplier, or clients. You tell the programs who you want to attend the meeting, date and time options, and the proposed agenda. The agents goes out onto the networks and check the schedules of the member specified. The agents send an email message which notify you and the other attendees of the room, date, time, and topic of the meeting. If there are time or resource conflicts, the agent will also notify you by email and ask you to choose another option for your meeting and begin the process again. Now, you get some idea how engineer can save untold hours of phone tag, email tag, and logistical time wasters. This system do not only save time and cost, but it can also increase efficiency of the project. If "Primavera project control program" can remind construction manger about time on schedule or give notice when the due time is approaching by email, engineer will be able to manage their time more precisely and efficiently.

Construction planning is more difficult than business planning in some ways since the building process is dynamic as the site and the physical facility change over time as construction proceeds. On the other hand, construction operations tend to be fairly standard from one project to another, whereas structural or foundation details might be differ considerably from one facility to another.

Forming a good construction plan is an exceptionally challenging problem. There are numerous possible plans available for any given project. While past experience is a good guide to construction planning, each project is likely to have special problems or opportunities that may require considerable ingenuity and creativity to overcome or exploit. Unfortunately, it is quite difficult to provide direct guidance concerning general procedures or strategies to form good plans in all circumstances.

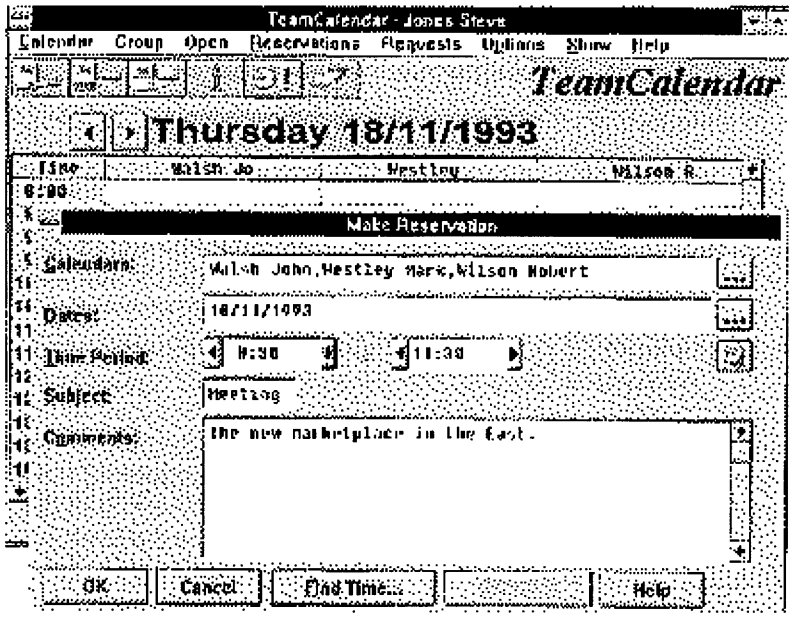


Fig 9 Sample user interface of Scheduling system

Currently, scheduling groupware company do not focus on construction field. The business is presented with a wide selection of products that offer similar front-end functionality with focus on general business purposes of providing "groupness". As the market mature, attention will be shifting toward how exactly these products work with specific industry. Therefore, we expect to see more construction scheduling system in the near future.

4.3) Conferencing

In construction industry, meeting take place all the time from intrafirm meeting (within company) and interfirm meeting (between different meeting). Table 2 show you the typical schedule meeting for big construction company. There are many reasons why construction company have many meetings when the project progress: to share information, to make decision, to avoid decisions, to socialize, and so on.

Many things can go wrong with a meeting. Everyone must get some experience that your

meeting did not work out or waste your time. Why? There are many reasons. During the meeting, participants may lack focus, or may be focus on hidden agendas. Some people may be afraid to speak up, while others may dominate the discussion. Misunderstanding occur as people use the same words for different ideas and different words for the same ideas. The wrong people may be at the meeting, and the right information may be unavailable. Besides being difficult, meeting are expensive. A meeting between construction managers may cost upwards of $1000 per hour just in salary costs.

NAME	FREQUENCY	SCOPE	PRIMARY TOPIC	ATTENDEES
Operation Report	monthly	project	status highlights; problems	Company president
Back Page Report	monthly	project	indirect project costs	Project through div. management
Blue Book Review	monthly	project	costs, risks, exposures	Owner (Client)
8–Quarter Report	monthly	territory through corporate	rolling forecost controllable margin & volume	Division & corp. management
Territory Meeting	monthly	territory	general activity project–specific issues raised by dept. heads & project executives	TGM, TOM, Department heads, & project execs
Group VP Meeting	monthly	territory	general activity (inc. financials, new business, personnel, risk & reserves)	Group VP, div. cost mgr., TOM & project execs
Executive Meeting	6 weeks	company	all co.–wide issues : policies, personnel, sales, earnings, risk	CFO, chief counsel, dept. heads, div. EVPs, & Grp VPs

Table 3 : Typical meeting schedule in construction company

For all their difficulty, meeting are still essential; for all their expense, they are not likely to go away. Meeting will remain absolutely essential and valuable. Organization use meeting to exchange information, generate ideas, discuss problems and make decisions. Construction site meeting are used to inform, co-ordinate, allocate tasks, update plans and check progress. Meeting

between contractors and designers for project discussion may require a good deal more bandwidth to support the subtle nuances of expression that most humans need to achieve a sense of experiencing the other person. On the other hand, many daily meeting between engineer for structure analysis require very little, if any, personal expression.

Modern technology has changed and continued to change the nature of real-time face-to-face meeting. Some of the devices and meeting support concepts that are currently popular include the following

- Electronic copyboards
- PC and a projector
- Team rooms
- Group decision support systems

Fig 10 A Portable Electronic Meeting System

4.4) Group decision support system

Synchronous and geographically displaced (same time/different place) meting are considered by many to be the most important form of meeting today. Modern communications technologies have changed the work world. In the past, restriction were imposed by geographical

limits. Telecommunication have shrunk the world. Perhaps it is not yet a global village, but more of an extended metropolis, yet it is possible now to transact business and perform work in collaboration across great distances.

The technologies that enable and support this form of human interaction include

- Teleconferencing
- Videoconferencing
- Data conferencing
- Virtual realty and cyberspace

Telecommunication technologies permit people to project those dimensions of ourselves that are most relevant for decision-making and information-sharing meeting purposes. They make it possible to transcend distances and time. In the current work atmosphere, the compression of space is of value, perhaps because the traversal of space usually translates into time. The greater the distance, the greater the time cost. The ability to reconcile time-critical issues in a relatively short amount of time is a clear business advantage.

Technologies that support same time/different place interaction include:

- Telephone conference calls
- Videoconferencing (one-to-one or many-to-many)
- Satellite downlinks (one-to-many)
- PC screen sharing/whiteboards.

Engineer have some task that can't solve by one person such as cost estimation. It can happen before project, during project, or after project (evaluation). Engineer from different sites can exchange their idea, experience, and suggestions. Most of the construction companies have regular meeting for:

- ensure that the contractor and other team members understand the project requirements and have an opportunity to check contractual, design and production details and ask for clarification or information

- ensure that proper records are kept and contractual obligation met

- compare progress with targets and agree on any corrective actions

- ensure that sub-contractors agree on action necessary to meet their obligations

- check that variations are confirmed in writing and that work is recorded and agreed

- ensure that the work of the main contractor and sub-contractors is properly coordinated.

- identify and discuss problems such as delays, material shortages and labor difficulties, and to take action to remedy them.

- identify any information needed; to check that proper records are being kept; to monitor the documentation and agreement of variation orders.

- give employees the opportunity to discuss problem relating to work methods, working condition, safety, incentives, etc.

Without conferencing system, all participants need to be in the same place in order to have efficiency meeting. In the future, we will see conferencing system more in the company like construction company that have different-place people and regular meeting. However, today many of these technologies are developing independent of one another. To date there is no single environment that combines individual and group support, remote and face-to-face collaboration, text, graphics, video, and voice links, and shared computer applications. Each working mode require electronic tools specifically tailored to the situation. As we moved toward the future, all group support technologies will be more and more integrated into the same working environment.

4.5) Objects Management system

Objects management system are becoming popular as users increase their purchases by 30% to 40% per year. This is not merely because the infrastructure of networks, database, image processing, and interfaces in maturing. It is driven by the need to deal with the increasing number of digital objects (documents) from word processors to email and scanned images. As we discussed earlier, groupware consists of tools and objects. This tool will help manage the awesome increase in digital objects. We are producing digital objects at an enormous rate, from word processors to email text message. Not only is information increasingly originating in digital form, but paper documents are finding easier paths into the same document bases via image scanning, facsimile, and workflow.

In engineering firm, "blueprint" drawing, memo, reports, standard code, and the like, often end up in desktop pile. Most recently, email and drawing documents have become the majority of information store in engineering office. As with paper documents, most digital documents remain in author's office and are printed for delivery to others. There are many reason for this, but it is sharing digital documents (objects) that is the major purpose of Groupware objects management. Big gain from these system is that objects such as documents or other types of information can be shared and accessed concurrently by multiple participants in shared environment.

For engineering scenario, each design engineer and architecture will have a window at his or her computer workstation providing access to the same project under discussion -- a 3-D CAD model, let's say -- and windows for sound and picture communication with other participants. Since the entire process will unfold in an electronic environment, it will be easy to record it completely -- in effect providing an automated 'secretary' facility which closely correlates the video record of the discussion and interpersonal interaction with the evolving states of the model,

recording not only design decisions but also how they were reached and who influenced them.

Another example, Let's say the problem is one of site access a landslide has created difficulties in locating a bridge. The construction engineer instructs an interface agent to find some relevant satellite images so the conferees can assess the extent of the damage and consider new locations from database. As they speak, the agent searches the network, and soon reports back with what is needed. A course of action agreed upon, the architect in headquater see the same situation on her computer screen and sketches out the solution and sends it to an assistant at the site with detailed verbal instructions. The assistant modifies the model, and a few days later transmited change orders electronically to the contractor's office in another location.

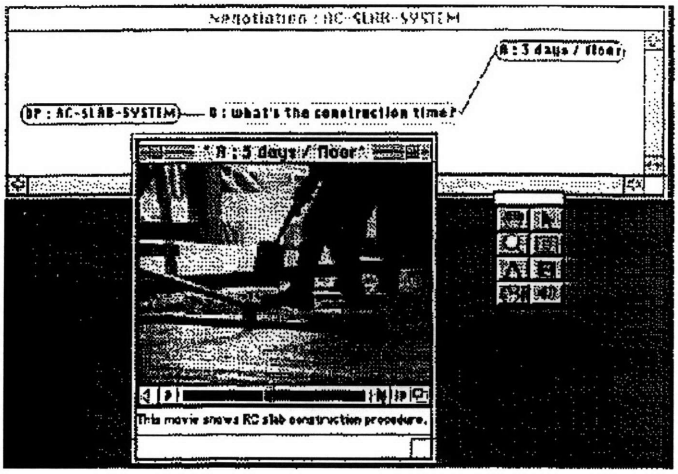


Fig 11 : A video clip is used to describe the construction procedure of a reinforced concrete slab

This is the nature of the engineering work that will be possible in the Future. And the use of Groupware object management system by engineers, who rely on digital databases to do their work, will allow them to carry much of their data with them to scholarly meetings and presentations rather than rely exclusively on summary printouts as they do today.

The future of Groupware object management system

We have discussed object management as if it were an isolated technology-- a place to put share information. In the future, we will see object management system as an integral part of networked operating system, different only in the specialized functionality. We will see extensive sharing environment in groupware products. It is also probable that object management will eventually become extensions to operating system, building on the distributed file systems already in place.

Groupware objects should be part of business processes and flow through organizations, serving as tokens of collaborative action. However, the workflow and objects management vendors are just beginning to come together; each starting to embrace the other's treatment of "groupware objects" or "work-flow". The word "Groupware objects" as an end will be replaced by "Groupware objects" as a means to the communication and collaboration that is the modern organization. Sharing objects will evolve to denote a collection of relevant multimedia objects of information, created on the fly to suit the ever-increasing demand to capture, define, organize, and, above all, share what we know.

4.6) Workflow system

Workflow is one of the hottest areas in groupware today. At last count there were over 130 different workflow vendors, and it seems like everyone is jumping on the process automation bandwagon. Workflow is the automation and management of the processes. Process is a sequence of actions or tasks which must be done to achieve a desired goal. These tasks are performed in a specific order by specific people, or by automated agents taking the role of a person to complete a task.

Construction industry is one of the business that need to be organize and well-structured

in workflow system. In the planning of construction project, it is important to recognize the close relationship between design and construction and how the work flow from one party to the others. These processes can best be viewed as an integrated system. Broadly speaking, design is a process of creating the description of a new facility, usually represented by detailed plans and specifications; construction planning is a process of identifying activities and resources required to make the design a physical reality. Hence, construction is the implementation of a design envisioned by architects and engineers. In both design and construction, numerous operational tasks must be performed with a variety of precedence and other relationships among different tasks.

Without workflow system, engineer could get the building plan before architect finish designing and working on the wrong model. The workflow system tool can be used to help project manager design how that task flow to the right person at the right time.

The workflow market is a moving target; over a hundred companies claim to provide some workflow features in their products. One of the big player in the market is Lotus. Many people believe that Notes is, indeed, a workflow product. And the Notes platform does offer quite a few workflow features, such as serial routing, action buttons, and status-tracking. Companies such as Quality Decision Management Incorporated (North Andover, Massachusetts), with its quality *At Work* product, and API (Shrews bury, New Jersy), with its Workflow Engine, have built tools on top of Lotus Notes to automate and manage processes.

The current generation of workflow products on the market also provide excellent tools for laying out a graphical map of the routing of a process. Products such as AT&T GIS's ProcessIT, Sigma's OmniDesk, Reach's WorkMAN, and Digital's LinkWorks provide graphical mapping tools that let business users--project managers, knowledge workers, etc.-draw the flow of information and steps of the process using drag-and-drop icons and connectors.

Despite almost universal agreement that the automation of business process is necessary and valuable, workflow is not selling well. Part of this because of confusion of the market. Implementing workflow is unknown territory which often require large investments of time, money, and change.

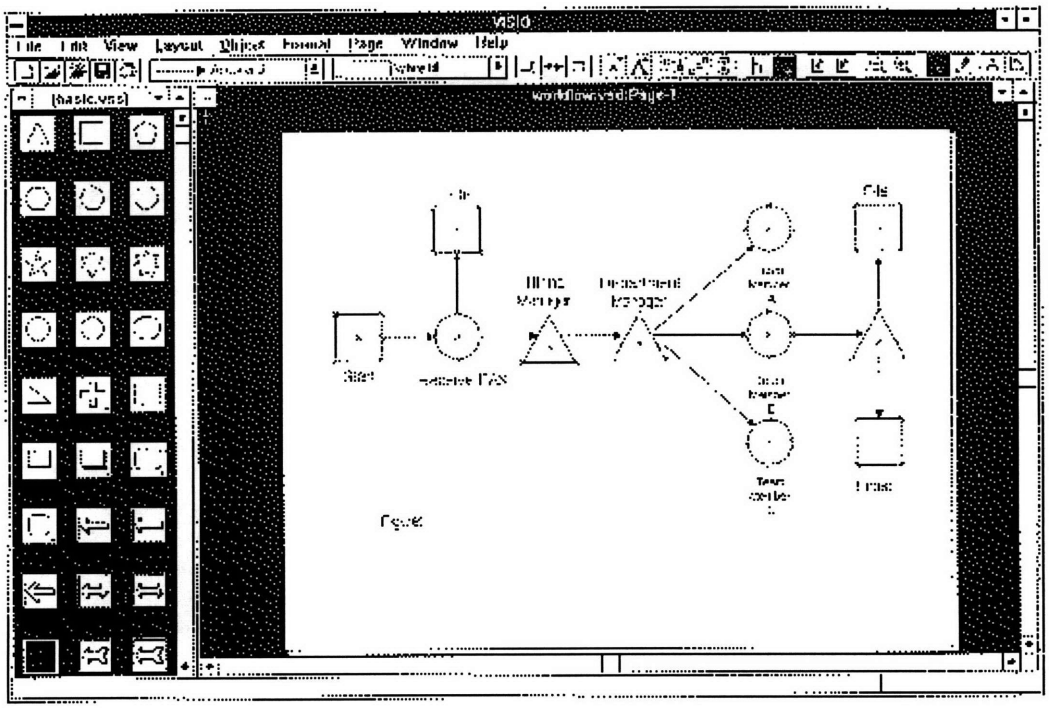


Fig 12 : Sample user interface of Workflow system

Chapter V: Implementation (Design studio of the future class)

5.1) Introduction

The school of Architecture and the department of Civil Engineering at MIT has begun the construction of a new collaboration design studio space which will serve as a laboratory for the design studio of the future. The Design Studio of the future is a research and development effort to evaluate and promote the use of advanced computing methods and groupware tools in engineering design. The projects provides a facility for advanced research in design methodology and support environments, as well as classroom facility for applying these advances directly in design education curricula.

The project integrates advanced groupware support and information superhighway technology to allow experimentation with new ways of providing access to knowledge, new ways of structuring collaborative processes and new approaches to teaching. Of particular interest are joint projects to develop support systems and to test them on practical studio work, and to explore the educational uses of digital imaging and video teleconferencing. Results of such work are likely to be of wide interest in the design community, and to point the way to important applications in other domains.

By taking the class in Design studio of the future at MIT, The author have a chance to understand the role of groupware in construction project and the efficiency of the system. This paper will try to collect the role and efficiency of the groupware system in the project and weigh the benefit and cost of using groupware system compare to traditional way of working.

This class are offered for 3 department: Civil engineering, architecture and mechanical

engineering. Objective is to see how they can collaborate as a team by using all groupware technologies. The first part of the studio is a 4 week "chair design" project and the second part of the studio is a 10 week "pavilion design" project.

5.2) Chair Project

In the first project, student are assigned into group. One group consisted of architect, civil engineer, and mechanical engineer student for variety of proficiency. The purpose of this project is to explore and develop a common understand of design and qualitative characteristics among the interdisciplinary design team members. They are asked to conceptualize, design, test, prototype, and fabricate a design for a chair. the 'chair' represent a constant challenge to designers and architects alike-a refection of architecture in miniature at the level of sculpture, fabrication and production, ergonomics and comfort. This project is also an exercise to test and explore the advances technologies associated with small scale prototyping and fabrication and CNC machine.

Team discussion, designation of task, and research were performed in the first week. All the collaboration and communication process were done by face-to-face meeting because of no place and group size constraint. In the second and third week, all group worked on design concept development, testing an idea, prototyping and testing of parts. In this stage, students were able to digitize the body mold for contour of the real human body and then use digital shape for referencing in design the shape of the chair by using CAD tools. In this stage, student can document all their CAD model and related file such as animation or rendered image in to Lotus Notes system. Each member can work in different time, same place mode. And fourth week is the time for fabrication by using CNC machine.

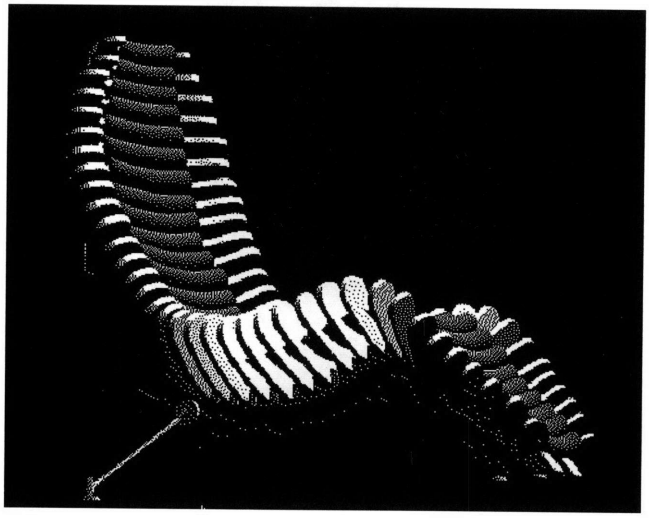


Fig 13 Our group's chair on Design studio class

To complete this project, we found many problem not from technology or hardware factor, but from human factor. We found that interdisciplinary collaboration process need very well-organized structure in order to meet the goal. Face-to-face meeting schedule cause many problems. We cannot set the time during the week for working together. The meeting time was set to be during the weekend. At the meeting, some participants did not know their role, did not have the same goal or objectives, and did not have the same or clear picture of the project. The reason that we did not use much of the groupware system is that we did not know how to use it efficiently. We try to learn how to use them at the same time project was running. Time constraint made us decide not to use groupware system for collaboration. We expect to exploit groupware system more on the next project (Pavilion project)

5.3 Pavilion project

Second project is Pavilion design project. The students will focusing upon the design, development and part construction of a Pavilion. In so doing we will be exploring the design pro-

cess engaging the issues of an integrated digital environment together with physical modeling as particularly expressed through CAD CAM prototyping and fabrication. The other agenda that we explored is that of an integrated approach to environmental design. We will be looking at the integration of passive based photovoltaic energy technologies and environmental strategies-with concepts of space, assembly technology and structure. The interdisciplinary of the studio will enable us to explore the integration of such 'sustainable' concepts, leading to the simulation and testing of these using some of the computational 'tools' that are available.

The time frame will be subdivided into 3 parts of about 3 weeks. First 3 weeks will be preliminary design and conceptual studies. This stage will assign students for developing initial ideas and establishing objectives and information flow within design team. Second part (next three weeks) will be design development, testing, and prototyping. This stage will simulate and test structural system, environmental system (light, air, and climate control), and energy performance. Last stage (last three weeks) will work on fabrication, build, and presentation. Students will use CNC machine for fabrication. Review and conclusion will be done in this stage for the potential for next research.

At the beginning of the project, we decide to document the progression of the project by using World Wide Web. The reason that we did not use Lotus Notes is the insufficient access of the application. Some member of our group do not have connection to Notes at the studio. Some member prefer working at home. Compatibility of World Wide Web gave us more flexibility on working place. All the schedule of the meeting were set through the Athena e-mail system. We didn't use scheduling and workflow system on this project because of unavailable resources.

We had a chance to do teleconferencing with the engineering office in LA for collaborate on the concept of the project at the first stage. The performance of the system are considered to be in

dissatisfaction level. We still don't know much on how to use the tool. We spent most of the teleconferencing time fixing the problem and learning these new tools. The tool by itself seem to be not fast enough in picture refreshing rate. Picture still look awkward and collaborator seem not to have the same idea on the projects.

CAD tools had been used most of the time for Project representation. However, we found that, in some level, Picture on the screen cannot replace the traditional real 3D model. Sometime we discuss the structure problem by using on-screen CAD model and found out that we have different picture in mind. At the second stage, all members in class decide to build real small scale model for the Pavilion representation.

Evaluation of Groupware system on Pavilion project

After taking this class, we have the clear idea about the problem of groupware system in the real construction project. We believe that the greatest challenge facing the groupware market today is "education"-educating construction participants about the need and ability to collaborate, and how collaboration can improve the efficiency of the project. Currently, it is very difficult to convince all engineer to change their traditional working style by applying the groupware system into working environment while the new system still did not work in the promising way. For example, the incompatibility of Lotus Notes running across internet still be the problem in the real collaboration process. Another barrier for groupware system is the individual preference of the project participants. One guy in our group do not check his e-mail regularly, the best way to communicate with him is leaving the small memo on his desk. Another guy prefer working at home, all his work came in from of AutoCAD on PC file and we got problem on transfer the file and consequently miscommunicated some of his idea.

Chapter VI: Evaluation and Conclusion

After looking at all groupware system in the current market, we are able to categorize groupware system into several categories. We look at the application object and differentiate them by using type of collaboration on objects and type of application. We categorize groupware tools by using Functionality, TIme Space, and Control Taxonomy criterias. All of the groupware systems can affect Construction industry in some level (depend on the degree of technical spectrum of that system).

The two major challenges to groupware are technical and organizational. Of the two, the organizational challenges are more difficult. For the technical challenges, a technical solution must be found. However, even if the technology solves problem, work well, and is rolled out efficiently, if the corporate culture does not support it, the groupware implementation may not be successful. Even if culture support it, but there is no economic justification for a groupware solution, it will fail.

Current groupware product categories are going through a cycle of expansion as many new products become available in the next few years. For construction company, it is clear that clients will be demanding greater quality, at lower cost in a shorter time frame as the year 2000 approaches. In order to maintain its competitiveness, the construction industry must change its mindset to respond to these requirements. Owner organization are looking to the engineering and construction community for new and innovative methods to meet these more demanding needs. New approach to the development and implementation of collaboration technology (in form of groupware system) could be critical if the construction engineer want to avoid being overwhelming by other occupation challenge.

Appendices

The goal of this section is to provide reference information for those interested in groupware. This section covers vendors, events, paper and electronic news sources, user groups, and extensive reading list. Every effort has been made to ensure accurate information; however, given the dynamic nature of the groupware market, maintaining up to date information is difficult at best. This listing is accurate as of early 1996.

Appendix A : Vendors

Calendering and Schedulimg

1Soft Corp.
Gregory Throne
707 987 0256

Arabesque Software Inc.
Frank Coyle
206 867 3757

CE Software
Curtis Lee
515 221 1801

Campbell Services, Inc
Ray Peabody
810 559 5955

Corporate Software, Inc.
David Gonzales
703 522 1310

Cross Wind Technologies, Inc.
Kevin Colgate
408 335 5450

Experience in Software, Inc.
Carolyn Burd
510 644 0694

IBM, Software Solution Division
800 IBM-CALL

International Project Management, Inc.
George Blackburn
508 529 4845

Microsystems Software, Inc
Glenn Martyn
508 879 9000

Milum Corporation
Scott Hayes
512 469 2966

Now Software
Mike Sherwood
503 274 2800

Electronic Mail

Alisa System Inc.
Don Cole
818 792 9474

Apple Computer, Inc.
800 SOS APPL

Artisoft, Inc.
Joe Stunkard
602 670 7100

Attachmate Canada Limited
Elaine Brill
416 979 1380

CE Software
Curtis Lee
515 221 1801

Clarify Software
Gwen Peterson
415 691 0320

Clark Development Co., Inc.
Steve Clark
801 261 1686

Compuserve
Michael Finney
614 457 8600

Datamedia Corporation
Fredic B. Gluck
603 886 1570

Da Vinci System Support
919 881 4320

Daxtron Laboratories
Kino H. Coursey
817 924 6707

Digital Equipment Corp.
Stephen F. Martin
603 881 6150

MCI
Mike Sutter
800 999 2096

Microsoft
Dave Perry
503 245 0905

Novell Inc.
Mark Ryan
408 577 7190

Oracle
David Michaud
415 506 3228

Radio Mail Corporation
Mark Elderkin
415 286 7839

Sarrus Software, Inc.
Liz Statmore
800 995 1963 or 415 345 8950

Group Decision Support System

Corporate Memory Systems
Donna Jarrett
512 795 9999

Desktop Data
Brad Singer
800 255 3343

Don Borth Consulting
Don Borth
414 235 0294

Eden Systems Corporation
Richard P. Nashleanas
800 779 6338

Experience in Software, Inc.
Carolyn Burd
510 644 0694

Expert Choice Inc.
William L. Peace
412 682 3844

Global Consensus Inc.
Wade Whitmer
214 446 1952

IBM, Software Solution Division
800 IBM-CALL

Idea Fisher Systems, Inc.
Matt Engen
714 474 8111

McCall, Szerdy & Associates
Mike McCall
800 423 8890

Option Technologies, Inc.
Barbara Clark
612 450 1700

Pacer Software, Inc.
Peter Coppola
508 898 3300

Pangea Corporation
Marty Martel
703 256 6871

QSoft Solutions Corp.
Anita Pomerantz
716 264 9700

SMART Technologies Inc.
Natalie Young
403 245 0333

Show Business Software
Rachel Riley/Louise Darcy
1144 71 833 8041

Teamworker L.C.
Andrew Gear
801 943 0160

Trinzic Corp.
Lee Warner
603 325 8228

Workflow

At&T Global Information Solutions
Jim Davis
513 445 7257

Action Technologies
Mark Thorp
510 521 6190

Bull Worldwide Information Systems
Gary E. Olin
508 294 4911

D&B Software
Lorretta Gasper
404 239 3658

Delrina Corporation
Randy Busch
416 441 3676 x 2191

Digital Tools
Ritta Merilainen
408 366 6920

Edge Software, Inc.
Sales
510 462 0543

Edge Systems Inc.
Ken Concon
703 525 EDGE

Edify Corporation
William Matlock
408 982 2920

FileNet Corp.
Cathy M. Subatch
714 966 3496

G.E. Information Services
Egan Skinner
301 340 4536

Hewlett-Packard
Andrew Ransom
408 447 6214

IBM
Don Demark
301 803 3169

IBM, Software Solutins Division
800 IBM-CALL

IMARA Research Corp.
Linda Gradner
416 581 1740

Intelligent Systems Group
Phillip A. Mongelluzo
203 876 6199

Jet Form Corp.
Fred Lucici
617 647 7700

Keyfile Corporation
Patricia Hopper
603 883 3800 x 390

The following section contain non-vendor information including a reading list covering groupware books, technical articles, academic journals, computer trade magazine, and the business press. It also includes information on: events, news-letters, and other groupware services.

Appendix B : Books

Eventhough there is intense interest in groupware, not many books are on the market yet. the listing below covers many of the better volumes.

Currid, Cheryl. *Re-engineering Toolkit: 15 Tools and Technologies for Re-engineering Your organization*, Prima Publishing, 1994

Davidow, William H. and Malone, Micheal S. *The virtual Corporation: Structuring and Revitalizing the Corporation for the 21st Century*, Harper Business, 1992

Dekoven, Bernard. *The Connected Executive*, Institute for Better Meeting, 1990

Gewirtz, David. Lotus Notes 3 Revealed, *Your Guide to Managing Information and Improving Communication Throughput Your organization*, Prima Publishing, 1994

Johansen, Robert, Sibbet, David, Benson, Suzyn, Martin, Alexia, Mittman, Robert, Saffo, Paul. Leading Business Teams; *How Teams Can use Technology and Group Process Tools to Enhance Performance*, Addison Wesley, 1991

Lloyed, Peter. *Groupware in the 21st Century, Computer Supported Cooperative Workinh Toward the Millennium*, Admantive Press Ltd., 1994

Marca, David and Bock, Geoffrey. *Groupware: Software for computer Supported Cooperative Work*, IEEE Computer Press, 1992

White, Thomas and Fisher, Layna. *The Workflow Paradigm: The Impact of Information Technology on Business Process Re-engineering*, Future Strategies Inc., 1994

Wilson, Paul. *Computer Supported Cooperative Work*, Intellect Books, 1991

Mallash, Efrem G. *Understanding Decision Support Systems and Expert System*, Dow/Irwin, 1993

Olson, M. H. *Technological Support for Work Group Collaboration*, Lawrence Erlbaum Associates, 1989

Turban, E. *Decision Support Systems and Expert Systems* (3rd Ed.), Macmillan, 1993

Appendix C : Journals

Academy of Management Journal

Accounting, Management and Information Technologies

ACM Transactions on Computer-Human Interaction

ACM Transactions on Office Informations Systems

Behaviour and Information technology

British Journal of Management

Collaborative Computing

Communications of the ACM

Concurrent Engineering: Research & Applications

Decision Support in Public Admin.

Group Decision and Negotiation

Harvard Business Review

IEEE Transactions on Systems, Man, and Cybernetics

Information Systems

Interacting with computers

International Journal on Intelligent and Cooperative Information Systems

journal of Applied Psychology

Journals of MIS

Management science

MIS Quarterly

PRESENCE

Technical/Trade Publications

Byte

Communication week

Computer world

PC week

Appendix D : Electronic Resources/Sites

The internet newsgroup "comp.groupware" is the best place for information and discussions on groupware, and is erad by about 28,000 people monthly from all over the world

Other internet newsgroup that also have groupware information include:

biz.comp.services

biz.comp.software

ca.seminars

comp.client_server

comp.infosystems

comp.mail.misc

comp.newprod

comp.org.eff.news

comp.org.ieee

ieee.announce

Lotus Notes discussions (miscellaneous)

Other Information Resources on Groupware

GroupTalk (The Newsletter of Workgroup Computing)

David Coleman, Editor

Collaborative Strategies

1470 DeHaro Street, Snafrancisco, CA 94107

For subscription information, contact Abby Kutner

Phone (415) 282-9197, FAX (415)550-8556 or E-mail ; grouptalk@collaborate.com

Possible electronic publication in late 1996. $395 annually, $449 overseas

Groupware News

Roger Whitehead, Editor; Office Futures

14 Amy Road

SURREY RH8OPX UK

Phone 44 (88) 371-3074, FAX 883-716793, E-mail; rwhitehead@cix.compulink.co.uk.

$400/year, $500 outside Europe

Workgroup Computing Report

Ronni Marshak, Editor

The Patricia Seybold Group

148 State Street, 7th Floor

Boston, MA 02109

Phone (617) 742-5200, E-mail; Rmarshak@mcimail.Com

Ferris Newsletter

David Ferris, Editor

Ferris Networks

353 Sacramento St.

Sanfrancisco, CA 94111

Phone (415) 986-1414, FAX (617) 742-1028

MacGroupware Yellow Pages

ftp://netcom.com/pub/consensus/groupware

LNOTES-L A mailing list created to exchange information between Lotus Notes users. This list will supplement comp.groupware (a Usenet news group) in aiding Lotus Notes users and properspective users in many issues including, but not limites to, technical support, bug reports and workrounds, configuration information, recommendations for future versions of Notes, and general talk about Lotus Notes development, implementation, administration, and so forth. Please note that this list is in no way connected with lotus Corporation or any of its subsidiaries. To ensure to this list, send message to lnotes-l-request@wums.wustl.edu. In the body of the letter, enter SUBSCRIBE LNOTES-L. You will then be automatically added to the list.

Business Process Redesign List The name of the list is BPR, and to join it send the following one-line message to mailbase@mailbase.ac.uk: join BPR <your first name><your last name>. If you require any further information on the BPR discussion list, contact the list owner; Gerald Burke (a.g. burk@cranfield.ac.uk)

Business Process Redesign Mailing List The newsgroup BPR-L has been created on Internet, accessible through regular mail from any platform. To subscribe, send an email message to listserv@is.twi.tudelft.nl or to listserv@zxduticai.twi.tudelft.nl with one line of text.

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