# Computer Mediated Collaborative Methodologies for Schematic Design Process

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## ABSTRACT

In architectural design practice, a number of design participants are involved in the schematic design process. Participants of the schematic design process perform collaboratively or individually conducted activities at different stages of the design process. Research conducted on computer mediated architectural design systems suggests a variety of computerized methodologies to support participants in performing collaborative activities during schematic design process. Most of the suggested methodologies are designed and ready to be implemented in specific platforms, and others are implemented and anticipated to be evaluated against the requirements of specific architectural design domains. However, there is still no single model to date that satisfactorily meets the requirements of collaborating participants during schematic design process. Prospective users of the currently available models are obliged to choose among a vast variety of group design support solutions with little information about their potentials and pitfalls. This paper focuses on the identification of the fit between collaborating participants' requirements, prospects of design activities and the currently developed computer mediated design paradigms. In this paper, the author discusses the findings of two different researches conducted in two different professional design domains, and identifies the type of actions prevalent to schematic design process. The author introduces an analysis of a number of computer mediated methodologies that are developed to support participants during schematic design process. As a result of this analysis, this paper introduces a classification of computer-mediated methodologies according to their potential support to tasks and activities performed during the schematic architectural design practice.

## 1 INTRODUCTION

In architectural design process, a number of design participants work together in order to achieve design objectives which are to be satisfied with a final design proposal. This paper is concerned with the schematic architectural design process where design participants are involved in the development of design objectives and elaboration of preliminary design proposals. Section 2 introduces an empirical study conducted for the observation of the schematic architectural design process and for identifying actions and of their requirements. This study delineates when, who and what actions are performed to achieve the objectives of the schematic design process. The findings of this study are compared to the findings of another empirical study conducted in another professional design domain.

Research conducted in Computer-Aided Architectural Design (CAAD), Computer-Supported Collaborative Work (CSCW), Group Decision Support Systems (GDSS) and Distributed Artificial Intelligence (DAI) suggest methodologies which would have an impact on the nature of work conducted in schematic architectural design process. Literature consists of research conducted for developing computer-mediated collaborative tools that promises valuable contributions for schematic design process (Kalay 1997, Jabi 1995, Maher 1993, Bodker et al 1992, Fenves et al 1994). Suggested methodologies provide support to domain-dependent, domain-independent design activities or both. Computer mediated support systems for domain dependent activities are those that provide support to activities which are specific to a particular building design problem. On the contrary, a support system for domain-independent activities is freed from the implications of a design problem. There is a growing explosion in descriptive and prescriptive research on group support systems for mediating architectural design process at different stages. This observation indicate that there exists no single system to date that satisfactorily meets all possible requirements of domain-dependent or domain-independent collaborative design activities

In the implementation of currently available technologies to present architectural design practice, design participants (e.g. architects, clients, and engineers) are obliged to choose among a vast variety of techniques and methodologies. There are many factors involved in the selection of the most appropriate methodology that meets the requirements of the design participants. Prospective followers of these methodologies gain little information from literature about what is the most appropriate technology for a specific architectural design domain. Instead, most of the available literature on group support systems in architecture tends to focus on issues prevalent to the design and implementation of methodologies. They provide insights into the design and implementation issues of a vast variety of techniques available for schematic design practice. However, there is relatively little on general frameworks and empirically validated theories explaining (and predicting the outcomes of) why one design methodology should be preferred over another, and what should be the main considerations.

This paper focuses on telecommunication and computer technologies that are adapted for supporting collaborative design practice during schematic architectural design. The main purpose of this paper is to bring in an analysis of the fit between collaborative design activities and the proposed methodologies. In section 3, the author provides a comparative analysis and categorization of present methodologies in terms of the type of support they provide, their capabilities, advantages and pitfalls. In this analysis, a wide view of group support systems and technologies are taken so as to include those which enable individuals, groups and organizations work together on coordinated tasks during the early stages of the design process.

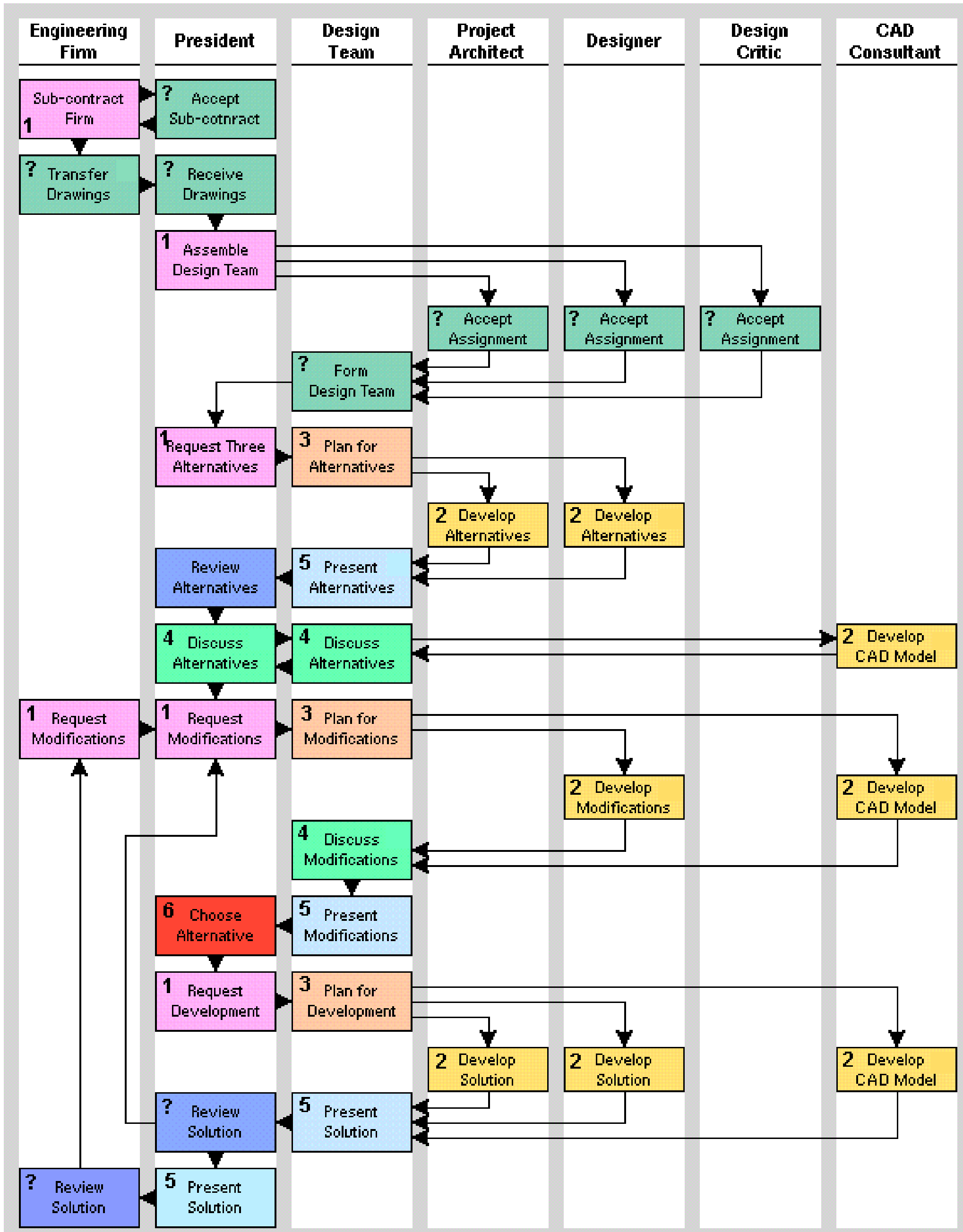
## 2 OBSERVATION OF COLLABORATIVE WORK DURING SCHEMATIC ARCHITECTURAL DESIGN PROCESS

In this section, the author describes a case study conducted to make an inquiry into collaboration during schematic architectural design process. This study (the author refers it as Case1) is conducted for the general categorization of domain-dependent and domain-independent tasks and activities of design participants during a typical schematic architectural design process. Observations have been made simply to answer the following questions: What are the type of activities and tasks that design participants are involved at different stages of a schematic design process? What are the main concerns of the participants in performing various tasks? The insights to the above questions are provided by observations made in Case1, and by comparing it with inferences made in a similar case study reported by Jabi (1996).

The case study (the author refers it as Case2) conducted by Jabi (1996) is one of the many studies conducted in this area, but one of the few studies that result with the classification of collaboration according to the type of activities and resulting artifacts. Observations in Case2 have resulted with a model that describes contributions of design participants. The model illustrates a chronological list of activities carried out during a schematic design process. In Case2, a conceptual model of collaborative design in schematic design process is developed due to observations made in the design of an exterior shell of a power plant. In this study, the client is an engineering firm that subcontracts an architecture firm in order to design the exterior shell of a power plant. The participants of the schematic design process consist of a client (engineering firm), the president of the architecture firm, a project architect, a designer, a design critic and a CAD consultant.

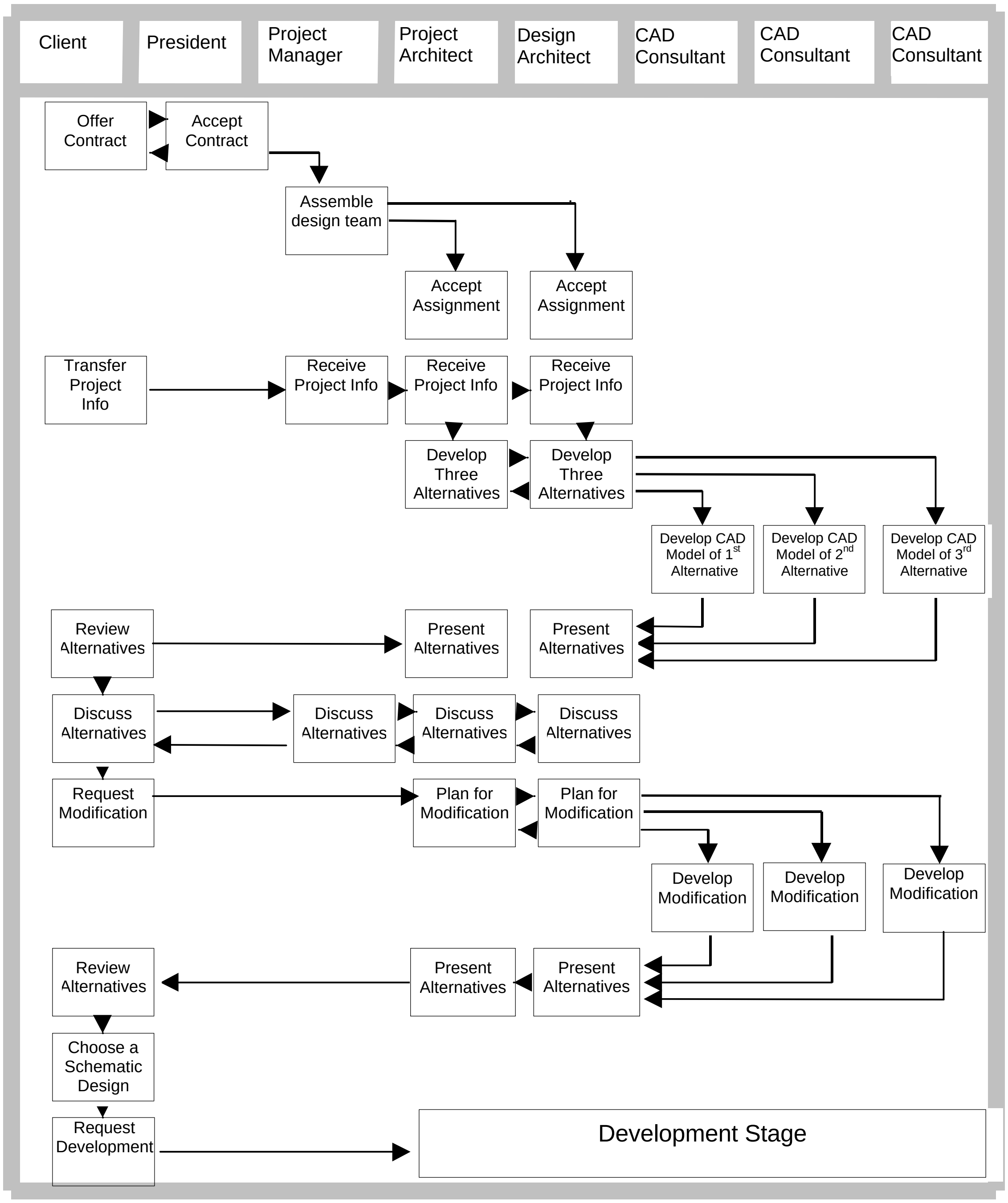
In Case1, observations are made during the design of an office building in Phoenix, Arizona. Insights about the schematic design process are gained due to the author’s informal interviews with designers working on the design of this office building. In this study, client is a private company located in Phoenix, Arizona. The participants of the design process consist of a client, the president of the architecture firm, a project manager, a project architect, a design architect, and three CAD consultants.

Figure 1: *Case2 – Client and Designer Activities Observed during Schematic Architectural Design Process (Adapted from Jabi 1996)*




where 1 = Request, 2 = Work, 3 = Plan, 4 = Discuss, 5 = Present, 6 = Choose

Figure 2: *Case1 – Client and Designer Activities Observed during Schematic Architectural Design Process*



## 2.1 **Observations**

The insights gained at Case2 are presented with a conceptual model as shown in figure 1 (adapted from Jabi 1996). The model describes the contributions of the design participants, and chronologically lists activities and transactions that took place during an architectural design process. In Case2, Jabi (1996) identifies six general categories of activities at the schematic architectural design process: (1) Request, (2) Work, (3) Plan, (4) Discuss, (5) Present, (6) Choose. Information on which activities fall into which category is provided in a colored version of figure 1 (http://libra.arc-pln.buffalo.edu/www/Flow). In figure 1, the author depicted the activity-category relation information provided in the colored version of figure 1, by identifying activities with their categorization number next to them. For example, the activities that fall into Request categorization are pointed out with number (1) as shown in figure 1. As shown in figure 1, not all of the observed activities, reported in Case1, fall into any one of the general categories of activities in schematic design process. Those activities which are not included in any category is pointed out by a question mark (?) next to them.

The insights gained in Case1 are presented in figure 2, by using a similar presentation technique as used in figure 1. Figure 2 shows which activities are conducted in which order, by which participants. The author categorizes the observed activities into four general categories of design activities: (1) Plan, (2) Design, (3) Share, (4) Review (figure 3). According to this categorization, assemble, formation of a design team, distribution of assignments to group members, and identification of future tasks and objectives reflect the *planning* concerns of the group. Work directed towards the creation or modification of design ideas fall under *design* category. Sharing of design ideas or information prevalent to the project among one or more design participants are the activities that are involved in the *sharing* of masses. *Review* type of activities are directed towards the analysis, evaluation, discussion of design ideas, and participants actions.

When compared the findings of both case studies, there are some similarities and variations between Case1 and Case2. The variations among the two case studies are the number of participants, the roles of the design participants at different stages of schematic design, the nature of the design problem, office setting, and communication technology. The observed similarities between two studies are the nature of activities and the requirements of these activities. Due to the comparison of both studies, the author concluded that both studies had identified activities and tasks similar in nature, but performed in different order by different design participants (figure 4 and figure 5).

Figure 3: *General Categorization of Activities in Schematic Design Process*

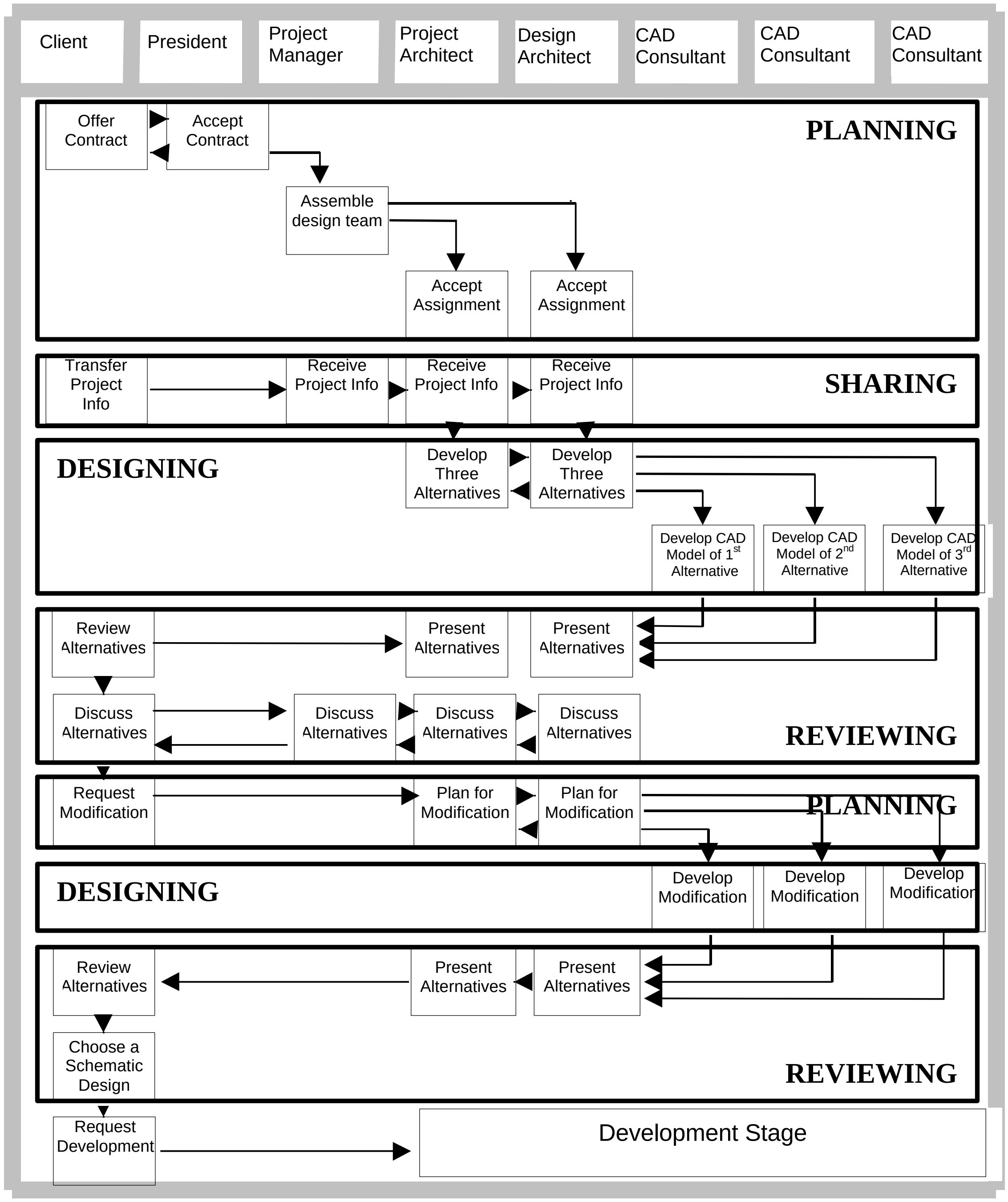


Figure 4. *Case Study 1: Member Participation at Early Stages of Design*

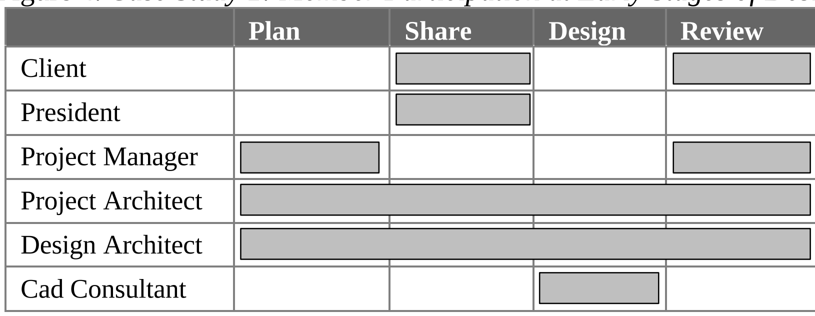
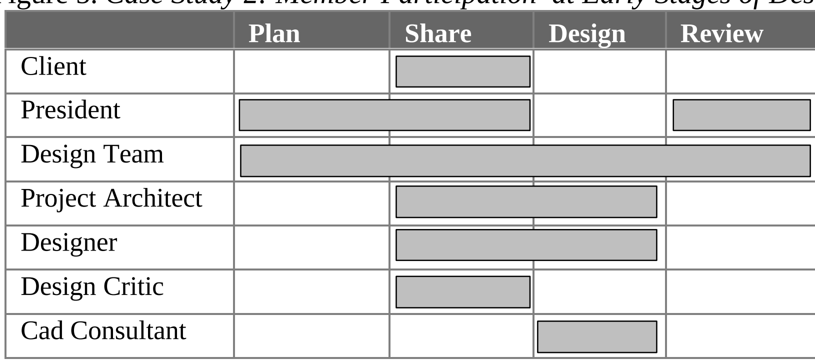



Figure 5. *Case Study 2: Member Participation at Early Stages of Design*




## 2.2 **Discussion**

The above case studies illustrate that schematic architectural design process is a collaborative process. Interaction occurs among different participants in performing different tasks and activities. Each design activity is a function that requires input from a design participant and generates an output when completed. In order to perform these activities, a design participant needs information and generates information. The input and the output of the design activities are presented and transformed in various formats (speech, written text, drawings). The collaborating design participants simply share information packages when performing certain activities. When more than two participants are involved in an activity, it is carried out synchronously in a shared virtual or physical environment or asynchronously in various locations.

The chronology of the design activities changes in different domains when different participants work on different design projects with different clients by using different design techniques. It is also concluded that the requirements of the design activities and of the chronology of performance is dependent on a number of factors such as the type of activity, number of participants, profile of participants, type of participant communication, the location of participants, the nature of work, and duration of work.

## 3 COMPUTER MEDIATED COLLABORATION METHODOLOGIES FOR SCHEMATIC ARCHITECTURAL DESIGN

Identification and classification of every task and activity that would take place during a typical schematic architectural design process is an essential task that needs to be done. Identification of the requirements of design activities in a typical schematic design process provides useful information to system analyzers and developers who develop group support systems for schematic design process. Developers of such systems have to comprehend what type of activities a system should manage and support, which user skills and capabilities the system should be tailored to, and when and how it should provide support to the schematic design process.

System and software developers comprehend the requirements of schematic architectural design practice in different ways, and thus suggest different methodologies for mediating schematic architectural design process. In the implementation of a specific collaborative design methodology, different vendors and system developers require varying system requirements, undertake varying implementation paradigms, and introduce different products. Different group support systems mediate similar or varying methodologies in different ways.

In section 2, it is shown that design participants typically perform four basic types of activities (Plan, Design, Share, Review). This section illustrates how currently developed computer-based methodologies provide support for each one of these activities. The author classifies the currently available methodologies for mediating collaborative work in schematic design process according to their support to different concerns and activities of the design participants.

### 3.1 **Support for Planning Activity**

Planning activity is the identification of the following future task(s) and activities(s) that needs to be undertaken by participating design members. In planning, members get prepared for the next step and bring together the resources (human or machine power) required for performing the future tasks. At schematic design process, planning consists of assemble of a design team, assignment of the tasks to specific designers, planning of modifications and future developments. These activities define the tasks to be performed, the outcome, the performers and the duration of the tasks. Planning activities require communication of two or more individuals. Design participants perform planning activities asynchronously or synchronously at different stages of the schematic design process. There are a number of computer mediated techniques used develop for supporting the requirements of synchronous and asynchronous planning activities.

3.1.1 *Synchronous Request Routing*

Design participants' expectations and working conditions require techniques that achieve varying capabilities for planning activity. Expected capabilities are achieved by establishing communication in varying modes. One methodology requires establishment of synchronous communication through real-time text, audio, video, file and application sharing among participants throughout the planning process. *Request routing via video conferencing* and *request routing via real-time chat systems* fall into this category. Audio and video enabled video or text-based chat systems enable groups to create discussion databases, and manage real-time group discussions in cross-platforms.

3.1.2 *Asynchronous Threaded Request Document Sharing*

Another methodology for supporting planning is asynchronous communication through *threaded request document sharing via electronic mail* and *distributed task whiteboard*. Lotus Notes' electronic mail system is an example of application that embraces these two utilities. Lotus Notes is used for distributing one-to-one or one-to-many Notes documents, files such as spreadsheets, word processing file and other documents, by Local Area Network (LAN) based users during electronic request document sharing. Lotus Notes enables encrypting of sensitive requesting documents through the system.

Another application that establishes request document sharing via threaded electronic mail is AutoDesk's WorkCenter and WorkCenter for the Web. WorkCenter is a design document management application that is used for automating workflow of AutoCAD-based design team. Workflow capability of WorkCenter enables creation of requests, routing of request, viewing of addressed requests. Request document contains information about the description of the requests, who the request is addressed to, the assigned deadline for finishing the requested actions, the request priority, the desired responses and the attachments of additional reference documents. Figure 6 illustrates varying capabilities of above described methodologies for supporting planning activity.

Figure 6: *Requirements of computer supported methodologies for supporting planning activity*

| PLANNING | Request routing via video conferencing | Request routing via electronic mail | Request routing via threaded text-based Web conferencing | Request routing via distributed task whiteboard |
|---|---|---|---|---|
| **Synchronous communication** | ❑ | | | |
| **Asynchronous communication** | | ❑ | ❑ | ❑ |
| **Multiple user involvement** | ❑ | ❑ | ❑ | ❑ |
| **Communication by:** | | | | |
| **Audio sharing** | ❑ | | | |
| **Video sharing** | ❑ | | | |
| **File sharing** | ❑ | ❑ | ❑ | ❑ |
| **Bitmap image sharing** | ❑ | ❑ | ❑ | ❑ |
| **Vector image sharing** | | ❑ | ❑ | ❑ |
| **Application sharing** | ❑ | | | |
| **Simultaneous co-authoring** | ❑ | | | |

## 3.2 **Support for Design Activity**

Design participants perform synchronous or asynchronous design activities alone or collaborating working environments. A recent study conducted by Maher et al (1998) has shown that collaborative designing is practiced in different modes. Maher et al (1998) identifies three different types of collaborative designing. The first type of collaborative designing is *mutual collaboration,* in which participants work together by making negotiated decisions during the entire design session. The second is called *exclusive collaboration*, in which designers work on separate parts of the problem, negotiating occasionally by asking advice from the other. The third type of collaboration is *dictator collaboration.* In dictator collaboration, design decisions are made by a dictating designer, and agreed upon by other designers. As shown in Maher et al's study (1998), when designers play different roles during collaborative design session, the amount of synchronous and asynchronous mode of collaboration changes respectively. Currently employed methodologies support these two modes of collaborations in different ways. They focus on varying requirements of alone or collaborative designing activities which occur in same time – same place, same time – different place, different time – same space, different time – different space.

Asynchronous collaboration is established by the exchange of design documents. Design documents are exchanged among participants in different ways. *Routing design documents via electronic mail, file transfer protocols (FTP);* or *collection of design documents in shared databases* are ways of exchanging documents among design participants. Synchronous collaboration is achieved through *real-time co-authoring*. Real-time co-authoring is practiced via bitmap-based whiteboards, or shared CAD applications on shared windows.

Methodologies employed for synchronous and asynchronous design practice achieve certain capabilities and meet certain requirements of collaborative designing. Figure 7 categorizes these methodologies according to their sustainability for asynchronous and synchronous mode of collaboration. It illustrates the capabilities of certain methodologies, and their deficiencies when compared with each other.

### 3.2.1 *Exchange Design Ideas via Shared Electronic Whiteboard*

Real-time co-authoring of design decision via shared electronic whiteboards is a technique that enables synchronous mutual collaborative designing. In this study, applications such as Microsoft's NetMeeting, Netscape's Conference and Show-Me were utilized for evaluating collaborative designing methodologies that suggest real-time co-authoring via shared whiteboard. These applications enable two or more participants to share and exchange text-based and bitmap-based CAD information on multiple pages on an electronic whiteboard. Whiteboard is used to sketch ideas, share presentations and mark up documents. Whiteboard enables importing of documents, graphics, and presentations. Design decisions are documented on electronic board during real-time video conferencing. Revisions made at different stages of the design process are recorded when saved contents of the whiteboard periodically during the process.

### 3.2.2 *Exchange Design Ideas via Shared CAD Applications*

Mutual collaboration via shared CAD applications occurs when an application-sharing capability is provided during real-time collaborative designing. Application sharing lets multiple parties browse, view, edit any CAD document in any application, even if one participant's computer doesn't have that program. Evaluation of a proposed design decision according to some predefined criteria (e.g. cost, energy conservation) is supported when designers work with relevant CAD applications during collaborative designing. Multipoint CAD data conferencing enables designers to share applications on their computers and work together by allowing other designers to see the same information on their screens.

Recent studies on co-authoring on shared workspaces or by CAD application sharing demonstrated the complexity of such a methodology and delineated its capabilities and pitfalls. A recent study conducted by Maher et al (1998) delineated interesting observations about the consequences of real-time co-authoring when applied during schematic architectural design processes. In this study, Maher et al (1998) studied the difference between computer mediated collaborative design and computer-assisted individual design. This study compared the amount and content of semantic information recorded during a computer mediated collaborative design session and an individual design session. This observation concluded that, when a designer is actively collaborating with another designer through shared whiteboard and audio enabled video conferencing, much of the time is spent discussing the design decisions verbally.

### 3.2.3 *Exchange Design Documents via Shared Database*

In most architectural design professional settings, designers are connected to each other via a local area network (LAN) - Intranets. Designers may have the right to access to project info files located in various domains. Most contemporary database management systems maintain document check-in and check-out information, and enable file access control, document revision control. The first person to open a file (such as DWG file) is the only editor that can save changes to the original drawing. All subsequent users can open the same file only in Read Only mode. If more than one designer is working on a project, a design decision made by a designer should be consistent with other decisions made by other designers. This means that more than one designer may work on a single drawing, and modify the same drawing. Changes made by subsequent users are saved only with a new drawing name. Organization of project documents and management of access to project database are ways of avoiding disaster with multiple document users or authors. This aspect of the design process is known as *workflow management*.

An example of an implementation that enables mutual collaborative designing via distributed database is AutoCAD's WorkCenter. WorkCenter is an application for managing technical documents for AutoCAD-based design teams. The built-in document management tools enable custom defined organization of documents, provide secure check in and out of documents in a multi-user environment, and automatically manage revisions over the course of design activity. AutoCAD's WorkCenter for the Web is an Internet server product that provides controlled access to drawings and data organized in a WorkCenter vault. Authorized users - no matter where they are or what platform they use - can search, view and copy WorkCenter drawings and related documents.

### 3.2.4 *Routing Redlined Design Data*

Redlining is a technique used for marking up of CAD data or portions of a CAD data without changing the base data. Redlines record comments, questions and instructions over a drawing that are acted upon by another design participant (i.e. designer, project manager, client). Collaborating designers share insights, ideas, comments and instructions among each other by recording redlined information on a CAD drawing. Redlining applications such as AutoDesk's AutoCAD 14, View and Whip! plug-in for Web browsers are used to mark up vector-based drawing, and share among other design team members.

### 3.2.5 *Solitary Designing in Interpersonal Workspace*

Research in computer aided architectural design has mainly concerned with the needs of the lone working design participants. Many computerized visualization and design performance evaluation techniques have been developed, implemented and utilized for supporting single user interpersonal workspace. Techniques used for supporting alone designing in interpersonal workspaces allowed a designer to concentrate fully on developing design alternatives. Interpersonal workspaces provide well-detailed and worked out techniques that fit into the requirements of lone working designer. However, they establish no support for synchronous mutual creation, modification, visualization and evaluation of design decisions. According to Bock (1992) alone interpersonal workspaces are idealized environments, since few people actually work alone.

Figure 7: *Requirements of computer supported methodologies for supporting designing activity*

| **DESIGN** | **Exchange design ideas via shared whiteboard** | **Exchange design ideas via shared CAD applications** | **Exchange design documents via distributed database** | **Routing redlined design document** | **Solitary designing in personal workspace** |
|---|---|---|---|---|---|
| **Designing in shared workspace** | ❑ | ❑ | | | |
| **Designing in interpersonal workspace** | | ❑ | ❑ | ❑ | ❑ |
| **Mutual collaboration** | ❑ | ❑ | | | |
| **Exclusive collaboration** | | | ❑ | ❑ | |
| **No collaboration** | | | | | ❑ |
| **Multimedia representation of designs decisions** | ❑ | ❑ | ❑ | ❑ | ❑ |
| **Importing of reference documents** | ❑ | ❑ | ❑ | ❑ | ❑ |
| **Simultaneous integration with other CAD applications** | | ❑ | | | ❑ |

Figure 8: *Requirements of computer supported methodologies for supporting sharing activity*

| **SHARING** | **Document sharing via Web Publishing** | **Document sharing via electronic mail** | **Document sharing over Intranets** | **Document sharing via push technology** |
|---|---|---|---|---|
| **Synchronous sharing** | | | ❑ | |
| **Asynchronous sharing** | ❑ | ❑ | ❑ | ❑ |
| **One-to-one sharing** | ❑ | ❑ | ❑ | ❑ |
| **One-to-many sharing** | ❑ | ❑ | ❑ | ❑ |
| **Sharing of multimedia documents** | ❑ | ❑ | ❑ | ❑ |
| **Encryption of shared data** | | ❑ | | ❑ |
| **Identification of access levels to shared data** | ❑ | ❑ | ❑ | ❑ |
| **Retrieval of shared data over distributed space** | ❑ | ❑ | ❑ | ❑ |
| **Sharing of data according to meta-data (name, size, date)** | ❑ | ❑ | ❑ | ❑ |
| **Sharing of data according to data contents** | ❑ | | ❑ | |
| **Pre-viewing of data content before sharing** | ❑ | | ❑ | |
| **Notification of changes to shared data** | ❑ | | ❑ | ❑ |

### 3.3 **Support for Sharing Activity**

Collaboration in design requires sharing of ideas through exchange of design project documents. At early stages of the schematic architectural design, sharing activity consists of sharing of users/client requirements data. For enabling mutual and exclusive collaborative creation and modification of designs, participants share project data which is presented in any conventional representation technique. Colored bitmap images, 2D/3D vector drawings and other multimedia documents together with explanatory text documents are ways of communicating design decisions between the client and the design team. Design data is shared by transforming it from one domain (i.e. architecture office) to another domain (i.e. client's office). Computer mediated techniques provide ways of transferring asynchronously or synchronously the digitized design data from one domain to another. In achieving this objective, they establish various different capabilities (figure 8).

#### 3.3.1 *Document Sharing via Electronic Mail*

One method that is abundantly practiced for sharing design data is document sharing via electronic mail. The most distinct advantages of e-mail is its immediacy, single or multiple recipient capability, multimedia document attachment capability. An e-mail message clearly identifies what files are being transferred, in what format and file size. A number of files can be attached to an e-mail and sent to a number of recipients.

#### 3.3.2 *Document Sharing via Push Technology*

More sophisticated solution to notification through e-mail is the Internet's "push" technology. A push application and a push server send updated information (such as revised DWG files) to subscribers. Push filters are set for individual participants, and they identify which changes needs to be notified to which individual. An example of the implementation of push technology in architecture is seen in Architekton architecture firm (Sage 1997). Architekton architecture firm implemented a push technology, called Marimba Castanet, in a situation where a general contractor involved in coordinating numerous subcontractors on a large construction project. As reported by Sage (1997), changes to the base DWG occurred on a daily basis, and updates to the subcontractors' fields are pushed on a daily (or hourly) basis by using a push software and a push server. Marimba Castanet Transmitter (server) and Castanet Tuner (client) work together to keep software applications and contents of a project up-to-date. Castanet automatically distributes, installs, and updates channels via the Internet.

#### 3.3.3 *Document Sharing over Intranets*

The developments in computer network technology have accelerated the exchange of digitized documents among remotely located workspaces. Architectural workspaces connected by local area networks (LANs) or wide area networks (WANs) establish connection between workspaces and enable sharing of design documents via file transfer. Large multi-office architectural practices often use private networks (Intranets) to connect themselves by upgrading phone services with ISDN or T1 lines. The transmission media employed in private networks, both guided (copper wire and fiber optics) and unguided (wireless) determines the transmission rate. Communication systems using these transmission media (such as ISDN, N-ISDN, ATM, Cellular Radio, Communication Satellites) presents different qualities of service for data communication. Speed, cost, error detection and error correction capabilities of the communication system determines the quality of the service that will be gained from the transmission of design documents over Intranets. Different private networks can also be linked with each through the Internet or other WANs (extranets), and this establishes a wider communication network among different design participants.

### 3.3.4 *Document Sharing via Web Publishing*

Constructions of private networks are costly, and require management and maintenance. The World Wide Web is a large wide area network, and all that is needed to utilize it is an access to the Internet. One technique for sharing project-related documents among other design participants is to share them via *Web publishing*. Web publishing enables storing of design data in distributed or centralized shared spaces on the Web. It enables synchronous multi user access to this distributed space, and asynchronous transfer of published data from this distributed space to any Internet access provided workspace. Web protocols such as HyperText Markup Language (HTML) and Virtual Reality Markup Language (VRML) enable embedding of multimedia design data, and linking of them with hyperlinks. Notification of additions and changes to published data is handled through web site registration and routing e-mail massages to registered users.

Many architecture firms adapt Web publishing in order to share project information among design participants. Literature consists of reported experiences gained from the utilization of Web publishing for sharing architectural data among design team, prospective clients, and present clients (Sage 1997, Padjen 1997). Many architectural firms develop project specific Web sites (also called project home pages) for design participants to check-in and out project specific design information. In project specific Web pages, design participants share drawing specifications, field reports, manufacturer drawings, and any other job documents. Documents are checked-out, modified and checked-in at any time by any participant. Documents that are modified at isolated workspaces are checked into the Web pages by given another name to protect the integrity of the general documents (Padjen 1997).

In design document sharing via Web publishing, design team publishes design data on a series of Web pages that are accessed by the general public. However, connectivity to Web public domain raises security concerns. Currently security issues are handled in two different ways. The first is to create password-protected project Web pages. Password protected project Web pages limit admission to the project team, usually including the owner, architect, contractor, and consultants. The second is to define different levels of access through low or high level firewalls.

There are some issues that need to be considered in publishing design documents (drawings) and associated files in shared Web databases. Ross (1997) outlines them as follows:

- Translate design documents into a suitable file format (DWG – AutoCAD binary files, or DXF – AutoCAD ASCII file, SVF – SoftSource Simple Vector Format, DWF – AutoCAD Drawing Web Format).
- Store design documents where users can get at them.
- Provide the proper security, so that only authorized users see the files.
- Provide a way to handle modified design documents and notes coming back from remote users.
- Index everything so that old files are purged (or archived away from the active files) and the most current files are available for viewing.
- Make sure that users have the proper viewing software.
- Make sure users can handle layer scheme, pen width, fonts, and other drawing features.

## 4. CONCLUSION

Group support systems and collaborative computing (groupware) solutions provide support to group of people engaged in a common task (or goal) and provide an interface to a shared environment (Ellis et al 1992). These solutions have introduced increased capabilities for computer supported collaborative work in architectural design. With underlying computer-supported methodologies, design participants are finding ways to move from personal workspaces to common task and shared environments.

The increasing developments in network protocols, transmission media and Communications-Intensive Information Systems (CIIS) promise to ensure faster, timely, errorless and secure reception of information. This might be considered a solution to difficulties faced by design participants in moving vast amount of time-sensitive information among in architectural design. However, with all the capabilities available with today’s group support systems and groupware products for sharing information, it’s also easy to become confused and bewildered. Observations indicate that without careful planning and designing, simply connecting interpersonal workspaces into networked, shared environments creates an unfortunate paradox (Bock 1992). As pointed out by Nunamaker (1997) unstructured interactions (i.e. document sharing, discussion and news groups) usually suffer from two series problems: first *lack of focus*, which leads to disjointed ideas, separate often hidden agendas and information overload; second *lack of convergence*, which results in no conclusions nor decisions, no business outcome results, no consensus and no shared understanding.

The implications of currently available computer mediated techniques on schematic design process can be summarized as follows:

- systematic and automatic transmission of updates,
- simultaneous multi-user document access,
- faster modifications,
- sharing of resources, personnel without travel
- synchronous and asynchronous co-authoring,
- information processing in shared and distributed databases,
- recording keeping and monitoring of design ideas
- record keeping and monitoring of design participants actions

Many design participants may be satisfied or interfered by the implications of these solutions. Some design participants may seek to achieve these implications in their working environments, and some may not. Certain group support systems may improve the outcomes in one type of workspace, while they impair outcomes in other workspaces. Design participants should be aware of benefits and imperials that might be gained as a result of this synergy. From a design participant perspective, the author outlined some of the factors that participants should consider when conceptualizing functionality for group support systems for schematic design process. Consideration of these factors in selection and adjustment of group support systems is anticipated to result in a situation where design participants take positive advantage of the group support methodologies during the schematic design process.

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