ON THE DEVELOPMENT AND THE USE OF GROUP WORK CAD FOR WINDOWS-PCS

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With the development of high-bandwidth communication technology, designers' interests seem to shift gradually from a single-user, single-domain system to a network-based group-work design system. So long as one regards that the design activity develops only in a concurrent, but asynchronous fashion, it is possible to say that file transfers through computer networks have already opened up the possibility of a hands-on collaborative design process in which all participants do not have to gather in the same place. However, few CAD systems support group design work that develops in a concurrent synchronous fashion. This paper discusses a basic model of group work CAD systems that the authors have developed for Windows PCs linked with LAN. Reviewing procedure of system operation, the authors conclude that the system could stimulate and accelerate a process of group work design.

1. Background and objectives of the study

With the development of high-bandwidth communication technology, designers' interests seem to have shifted from a single-user, single-domain system gradually to a network-based group-work design system. The authors, having analyzed processes of group work architectural design, have developed a network-based group work CAD for UNIX workstations (GW-CAD1). An outline of this study was already reported at the CAAD Futures '95 (Singapore), in which the authors reported both the achieved level of system uses and technical limits to be solved, after reviewing the process of the students' work with the system.

It is the aim of this paper to report functional features of the GW-CAD1 and its uses that the authors have developed as the revision of the former system. In the new version the system works on distributed network PCs. In a practical situation, designers would need communication support tools such as a tele-video conference system, shared sketching tools such as a white board, besides 3D-modeling system. As there are several commercially developed system for the former two tools, this paper focuses on the development of 3D-modeling system assuming the use of those commercial systems at the same time.

2. Review of GW-CAD1

2.1 Advantages of the system

In [3] the authors reported those advantages of the systems found during the experiment:

1) Roles of ad-hoc meetings

An ad-hoc meeting for spontaneous information exchange among a part of the team members, such as to get critical feedback and to achieve fast problem solving, has an important role in a group work design.

2) Proposed window configuration
The proposed system in which each terminal has two CAD windows, one for normal type independent works (Personal Window) and the other for data exchange and shared manipulation of some member's CAD model (Common Window), could provide designers a seamless environment for both ad-hoc meetings and independent CAD works.

3) View data exchange
During a design discussion, the designers could change the viewing condition of the CW from their own terminals so that they could discuss their models in the best view.

4) Archiving of design history
The utility to record models presented in the CW at any time of design development could help to review and trace design processes later.

2.2 Technical limits of the system
With all those advantages, it became clear that the proposed system has technical restrictions as the followings.

1) Increasing CPU loads of the host machine
The CPU loads of the host machine became quite heavy with the increase of terminals' participating, because the host was designed to control all the CWs connected and CAD data exchange among terminals.

2) Restriction of the models in the CW
GW-CAD1 did not allow the direct operation of the models in the CW even when a designer want to fit the other members' design.

3) Poor interface of the retrieving-utilities of design archives
The design could be saved automatically when users exchange the 3D model. But designer faces difficulties in finding necessary data, because the system lacked utilities visually indicate contents of files.

4) Inflexible participating and withdraw
The GW-CAD does not allow any terminal to withdraw or participate during GW sessions.

3. The study of GW-CAD for Windows-PCs (GW-CAD2)
3.1 Technical consideration
1) The platform
To develop GW-CAD that could solve technical limits described above became a major objective of this study. As the cost performance of network PC has become quite high these days, in addition to the fact that the operating system for network PCs, such as windows NT, allows a much easier environment of system management than the UNIX, the authors decided to develop a GW-CAD for WindowsNT-PCs (GW-CAD2).

2) The network environment
As the NFS could not adequately achieve distributed group work, the authors adopted TCP/IP protocol which is standard in the Internet. It can access the terminal connected beyond its domain.
3.2 Improved point of GW-CAD2

GW-CAD2 has the same display layout as the GW-CAD1 has: the CW and the PW, but it has two more windows. One is the control window that indicate status of the system, the other is design history window.

<table>
<thead>
<tr>
<th>Common Window (CW)</th>
<th>Control Window</th>
</tr>
</thead>
<tbody>
<tr>
<td>* common space to view and manipulate models</td>
<td>* display access status of terminals</td>
</tr>
<tr>
<td></td>
<td>* control of multiple members' action</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Personal Windows (PW)</th>
<th>Design History Window</th>
</tr>
</thead>
<tbody>
<tr>
<td>* space for personal modeling work</td>
<td>* review history of design development process</td>
</tr>
<tr>
<td></td>
<td>* hierarchically laid-out icons display relationships among files</td>
</tr>
<tr>
<td></td>
<td>* clicking icon opens corresponding file for reviewing and editing</td>
</tr>
</tbody>
</table>

Figure 1. Window of GW-CAD2

Those are basic configuration of GW-CAD2.

1) Distributed network system among multiple designers
GW-CAD2 exchanges the 3D-model using TCP/IP protocol so that geographically distributed designers could use.

![Network diagram](image)

Figure 2. Network environment

The authors used following hardware and software in the case studies:

- Hardware: Pentium 133MHz, resolution 1280x1024
- OS: Windows NT 3.51/4.0
- CAD: AutoCAD R13
- Voice/Chat/White board: Microsoft Net Meeting (connection between terminal of different domain)
2) Flexible connecting and disconnecting

Designers can freely participate or withdraw group discussion at any time in the GW-CAD2. While designer-A and B communicate, it is possible for designer-C to participate in that discussion. As the terminal of designer-C automatically receives all models in the CW, designer-C can start discussing in the same conditions as the other two.

When designer-A withdraw discussion, the revised member list in which name of A is removed is sent to the other members. After a while designer-A can participate session again.

![Diagram](image)

Figure 3. Participate and withdraw

The mechanism for translating data is the following.
3) Direct manipulation of the CW

GW-CAD2 supports the direct manipulation of the CW. The designer can log-in to the CW, just press the "log-in" button. The other designer can not manipulate the models in the CW until the logged-in designer pushes the "log-out" button. The designers can watch the status of the use of the CW.

The mark of the direct operation

Name of members

Figure 5. GW-CAD control window
The mechanism for translating data is the following.

1. CW
2. PW
3. Trigger Check
4. Different domain
5. put common model

Figure 6. Designer A pushes the "log-in" button (1), and the system sends the message "direct CW" to the other members (2). The control window is marked with red button (3). When designer A has done his operation, he pushes the "log-out" button (4). If the common drawing data was sent to all members (5), the trigger control changes the CW display (6) and the access control window (7).

4) Graphic retrieval of design history
The design history system consists of two sub windows. One is a design history window; it has icons arrayed in a tree form that represents the sequence that is developed. The other is a design view window; it has an enlargement window of design history data and a text box of comments.

Figure 7. Design history window
The mechanism for translating data is the following.

![Diagram](image)

Figure 8. Designer A pushes the "archive" button (1), and the system makes the design history itself (2), and sends 3D-models and 3D-vector data to the other members (3). If the trigger is checked, the design history is made in remote PCs.

4. Evaluation
The authors conducted an experiment using three PCs; two of which are connected to the same domain LAN, one of the rest is connected to the different domain LAN. It takes 2-3 seconds to transmit 100Kbyte 3D-model data of all 1Mbyte. This is not so fast yet, but it could provide sufficient speed, considering to the laborious procedure that conventional environment asks designers.

As the system allows designers participate or withdraw at any time, it became easy to start the ad-hoc meeting during a personal design work.

The function of the design history that is useful for the designer, because he/she could refer and use a archived data.

5. Results of the study
To achieve workability of the system even when three or more PCs are networked, the authors redesigned the system to distribute computing loads to each terminals. With this arrangement, the new system gained such an advantage that the designers can freely participate or withdraw from group discussions at any time.

Each PC uses almost the same user interface as that for the former system, but some new utilities are added.

1) designers can easily archive CAD data as a record of design discussion.
2) a series of archived data can be retrieved and quoted as the base of developing a new alternative by referring to icons arrayed in a tree form that represents the sequence that is recorded.
3) there are buttons that indicate the list of the terminals who have logged into the system.

As for the direct manipulation of the CW, the authors have improved the control access window, though the other members' operation can not be watched by a remote designer. The participants in the experiment hoped to watch the others' window and mouse or cursor actions.

Beyond this stage, the authors have a plan for developing the design history by using Internet WWW browser. It will be able to be a more flexible design archive system.
Bibliography


