

Continuously Connected Environment for Collaborative Telework

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Abstract. This paper describes our current study in the development of collaborative design environment which considers ICT (Information and Communication Technology) and architectural space. Our study group has been developing a computerized prototype environment for collaboration, which attempts to support synchronous design collaboration in a continuously connected project-room at distributing sites. The authors focus on communication in order to evaluate the collaboration environment. The objectives are as below. Objective 1 is that finding problems and its factors of the continuously connected project-rooms in the distributing sites. Objective 2 is that improving the problems of the continuously connected project-rooms in the distributing sites. In the conclusion, we have realized and extracted four major issues towards improving the distributing project-rooms environment in our future study, which is listed in the table with the objective 1. The authors improve the problems of the environment by using application and changing architectural space in the objective 2.

Keywords. Continuously connected, ICT, distributed site, communication, awareness

Introduction

Information and communication technology (ICT) has been rapidly structuring personal work environments between remote sites such as e-mail, mobile phone, and messenger system. And also the authors have focused on collaborative design environment rapidly developed via Internet using web pages or video-conference systems, such as VDS. Some research groups have developed typical systems effectively to access to database of information (Kurmann, 1999), to share process (Jeng, 2000), to support awareness

(Mieusset, 2000), to manage project (Morozumi, 1999), to teach architecture (Fowler, 1997; Kvan, 2000). Through our past eleven projects since 1996, the authors have developed several systems for visualization process, accelerate interaction and so on. Such VDS systems mainly focused asynchronous design collaboration via Internet (Virtual space). However these systems do not concern with continuously connected environment for group work. (Table 1.) Additionally teleconference systems have not yet been enriched with ICT very much, so that most of these consist of just a desk, chairs and video displays. An information infrastructure that has been expanded and improved makes it possible to connect networks continuously. The authors focus on the continuously connected environment enhanced by ICT for group work. In this paper, we discuss the possibility and effectiveness of a continuously connected environment for group work and point at the issues that need to be improved for collaboration work.

	Group work	Personal work
Continuously connected	We focus on this category	Messenger system
Connected on demand	Tele conference system	E-mail, BBS, Mobile telephone

Table 1. Ways of telework between remote sites

1. The prototype environment

In order to develop the prototype environment supporting effectively for exchanging and sharing information to create idea, the authors have studied the factors of collaborative design work considering ICT and spatiality. (Yamaguchi 1999)

The specifications of the prototype environment (Figure 1. and Figure 2.) are follows;

1) Space frame can be attached and removed easily for various instruments such as projectors, speakers, cameras, microphone, lightings, etc. The space structured by frames that creates a sense of being surrounded.

2) Four-multi big screens are on the white board wall, the glass partition and the roll screen, and the glass top table:

- The White board wall that can be used for a wide screen projection. (190inch)
- The Glass partition and the roll screen made by a white permeability film for rear-projection. (110inch) One can write in the glass partition by marker pens.
- The Glass top table on which surface is filmed for underneath projector has a function for drawing like a white board on the projected surface.

There is a central PC which is connected network and controls this environment, and it consists of applications for keyboard-mouse sharing, downward camera controlling, etc. Additionally, in order to support distributed collaboration, this prototype also provides

the desktop sharing application, the analog document sharing system with scanner, the scheduler for groups and WebHD which is data storage via internet.

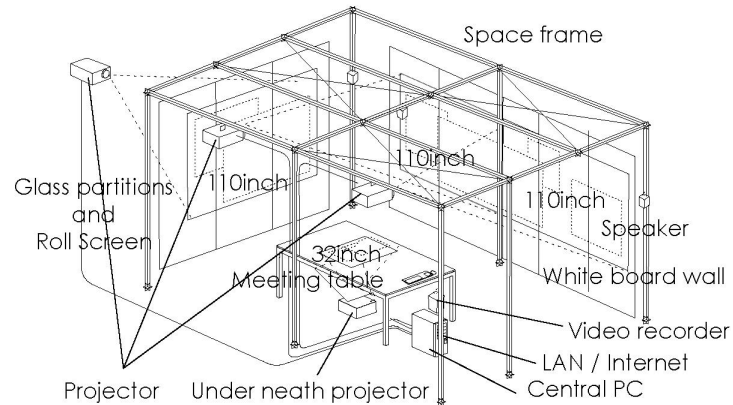


Figure 1. The prototype environment



Figure 2. The appearance of collaboration environment

2. Continuously connected distributed project-rooms

The prototype environment attempts to support not only a face-to-face local meeting but also distributed project-rooms. Although the TV conference systems via network has developed and been used as a common tool at an office or a home, the function of these systems tend to design connecting people to people for a face-to-face meeting of distributing sites, which means people connect the system when they want to have a

meeting with distributing people for a certain time. On the other hands, our approach to develop the prototype is to connect space to space continuously. What we expect is that visualizing other site on a big screen informs a situation and gives an awareness, which may produce communication effectively to collaborate between distributed sites.

In order to understand that the contentiously connected environment affects daily activities, the authors have carried out the experiment in comparing local environment and distributed environment for ten days; first five days is local collaboration and second five days is distributed collaboration. The examinees are six postgraduates engaging in architectural proposal project.

Configurations of collaboration environment are follows.

a) Distributed environment; three personal desks are in each sites. The main screen connects two distributed project-rooms via TV conference system. The live images at another site are rear-projected on the big screen look like the same room. (Figure. 3) The remote environments are planned as separating the centralized environment and connecting them via tele-conference system with continuously connection, so that the environments have exact same factors as utilizing the collaboration environment and personal area of three members.

b) Local environment; six personal desks are in the prototype environment. (Figure. 3) The centralized environment is the collaboration room where six personal desks divided by two sides and a meeting table between them is set up.

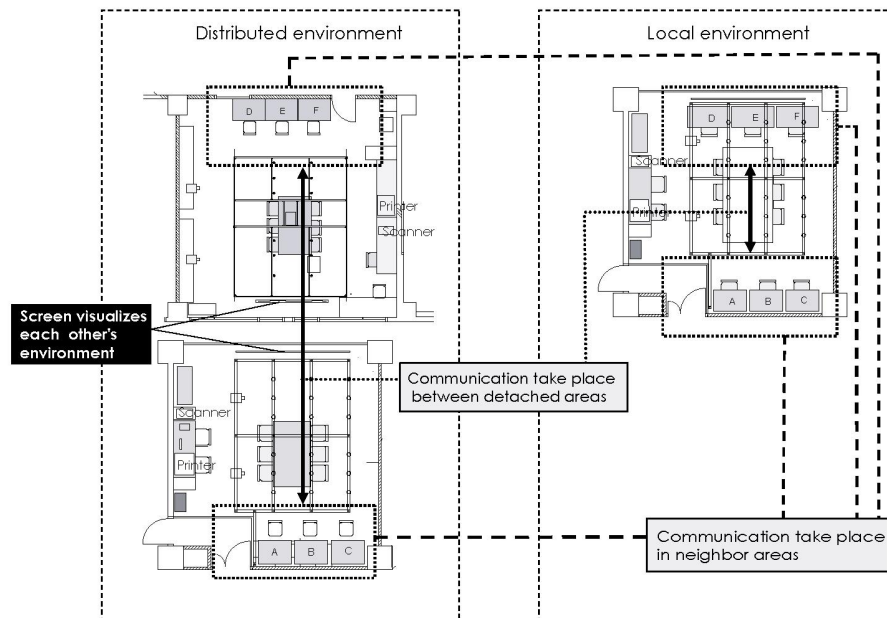


Figure 3. Distributed environment and Local environment

2.1. Analysis of the contentious connected distributed project-rooms

The communication that is observed from field survey, self-photography survey, and a questionnaire survey are analyzed. Examinee takes a photograph about problems of environment and comment with it in the self-photo survey. This will enable us to understand problems picked out by user about environment.

The authors classify all communications into “Communication take place in neighbor area” and “Communication take place between detached areas” according to the place where communications happened. (Figure. 3)

We pick out three aspects about collaboration based on the researches, and consider the factor. Three aspects are follows.

- The quantity of communication
- The quality of communication
- The place where communication is taken place

2.1.1. The quantity of communication

Comparing local environment and distributed environment, the rate of “communication in detached area” about time and frequency are lower in distributed environment than in local environment. (Figure 4. and Figure 5.) So, project members tend to communicate in local site. It is easier to communicate locally.

The reasons are follows;

The examinees understand the appearance of the distributed member’s work. They do not understand the atmosphere of situation and the place. So they fear to talk whether obstruct the distributed member’s work progress. Those psychological opinions appear a lot from the questionnaire and the self-photography.

The sound of local conversation is too low to listen, and the sound breaks due to network problem so that member at other site can not follow the conversation.

The examinees hesitate to talk excluding a thing necessary for the research activities, because it is difficult to recognize voice by mike and speaker.

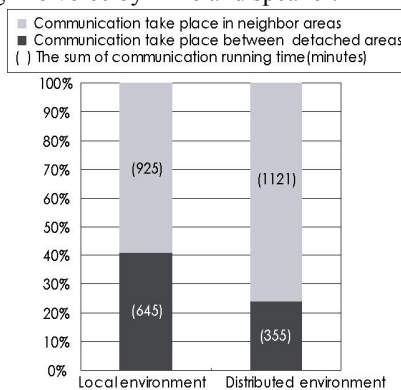


Figure 4. The sum of communication running time

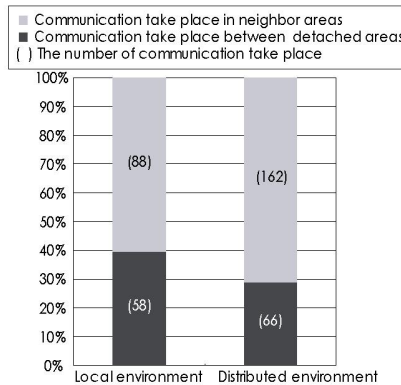


Figure 5. The number of communication take place

2.1.2. The quality of communication

Distributed environment is difficult to support informal communication. (Figure 6.) In distributed environment, communication except research activity was difference between roommate and distributed member. It is difficult to communicate casually. The informal communication is set low priority of conversation.

We guess the reason, pointed out by the self-photography survey and questionnaires, is also Voice recognition and awareness. Members feel possibility to interrupt and disturb the progress at the other site due to less understanding of the context.

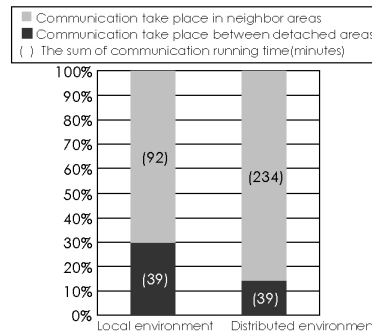


Figure 6. Informal communication

2.1.3. The place where communication is taken place

Communications taken place depend on particular place. Figure 7 shows that communications are done around the table between distributed members. We guess that communication depends on video-conference systems' placement because means for communication is only it.

Additionally, it is pointed out that the conversation excluding around the table are difficult by the self-photography survey. More than two conversation groups cannot communicate in the same screen. The screen which shows other site is the only channel to communicate to distributing members. Member need to move the position where microphone and camera can capture their voice and figure.

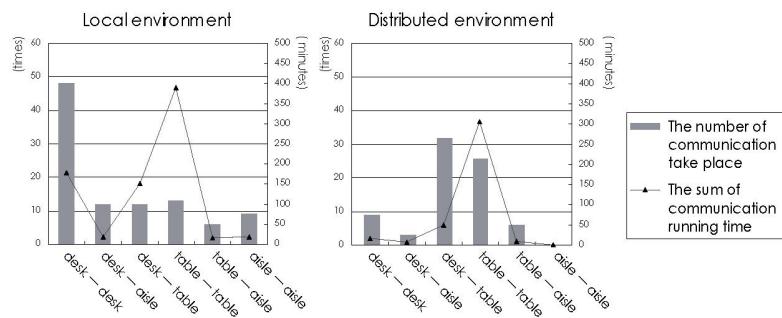


Figure 7. Positional relationship of communication

2.2. The results of contentious connected distributed project-rooms

The Effects which contentious connected environment give to communications and their factors we considered are collected as follows

Communication problems between distributing sites	The factors to occur the problems
It is difficult to communicate casually.	The casual communication is set low priority of conversation. Members feel possibility to interrupt and disturb the progress at the other site due to less understanding of the context.
More than two conversation groups cannot communicate in the same screen.	The screen which shows other site is the only channel to communicate to distributing members.
Communication take place depend on particular place.	Member need to move the position where microphone and camera can capture their voice and figure.
Project members tend to communicate in local site.	It is easier to communicate locally. The sound of local conversation is too low to listen, and the sound breaks due to network problem so that member at other site can not follow the conversation.

Table 2. The results of contentious connected distributed project-rooms

3. Reconstruction of the prototype environment

For the sake of compensating the distributed environment's defects that extracted from the preceding experience, the authors modify the environment as below. (Table 3.)

Modifications on the prototype	Aim
Sharing the desktop computer continuously	To increase informal communication take place between detached areas by supporting awareness of operation with PC in distributed environment
Changing layout of personal desks	To increase trigger of communication take place between detached areas by supporting awareness of situation in distributed environment

Table 3. Modifications on the prototype and Aim

The examinees using modified prototype are same members as preceding examination. The communication that is also observed from field survey, self-photography survey, and a questionnaire survey are also analyzed.

3.1. *Sharing the desktop computer continuously*

Comparing to Local environment based on self-photography survey and questionnaire, the informal communication is placed low priority in all conversation at Distributed environment. It is difficult to communicate casually between distributed members.

In order to understand that the sharing the desktop computer continuously make trigger for informal communication between detached members, the authors have proposed and examined to use VNC tool in this environment. We aim to support awareness of the triggers with VNC tool. The VNC is an application that is developed by AT & T Cambridge Institute, which has a function to enable remote members to share the desktop computer. Incidentally, the preceding experiment shared the desktop computer on demand.

3.1.1. *The results of sharing the desktop computer continuously*

We have compared the ratio of formal communications and informal communications in the continuously connected environment. (Figure 8.) The ratio of the informal communication gets doubled, so that we assume VNC send more information to trigger the informal communications in the continuously connected environment. The communication which is caused with "sharing the desktop computer continuously" is 11% of all communication. "Sharing the desktop computer continuously" supplies the trigger of communication. Additionally, the sum of communication running time gets 29.5% growth, comparing to no using VNC.

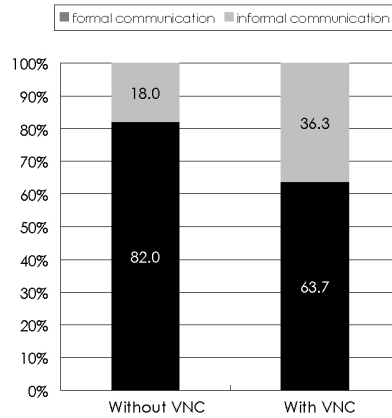


Figure 8. Comparison for informal communications

Figure 9 shows experimental environment's evaluation of awareness on a scale on which 5 is perfection. For comparing, evaluation of original distributed environment points 3rd scale. The experimental evaluation bases on the questionnaire.

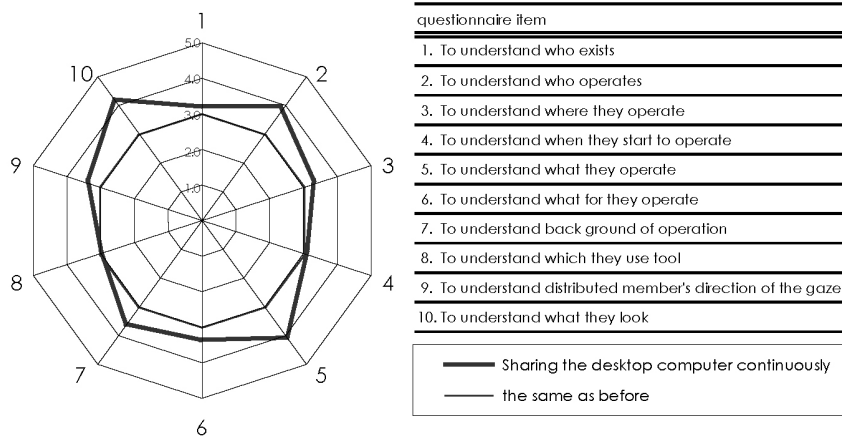


Figure 9. Evaluation of awareness for sharing the desktop computer continuously

Sharing the desktop computer continuously is effective in awareness about understanding member's intent of activity in No.5, No.6 and understanding object which is looked at in No.10.

3.2. Changing personal desks layout

In the first experiment, rather than jumping distributed member's situation to the eye naturally, the examinees identify it as the occasion demands, because examinees show their back to the camera. Therefore the trigger of communication take place in detached area is limited. We modify distributed environment to increase awareness and to take place communication easily by directing personal desks toward screen.

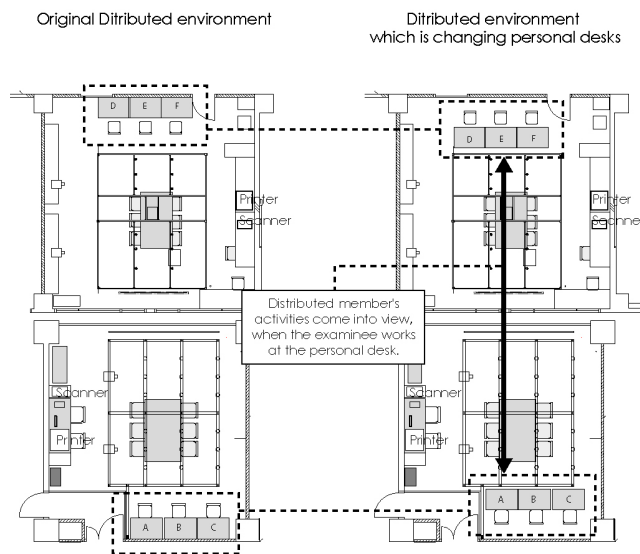


Figure 10. Changing personal desks

3.2.1. The results of changing personal desks layout

After distributed environment changes, the ratio of communications between detached personal desks get higher. As a result, distributed member's activities come into view, when the examinee works at the personal desk. This is attributed to the fact that it becomes easy to understand distributed member's situation and to take the timing to talk. The times of participation in the middle of communication increase 1.8 times as much as before in environment which is changed personal desk layout. (Figure 11) The authors consider that distributed members become easy to detect “when they begin to speak” and “what story they tell”, and then distributed members understand situations which are conducive to participate in communication.

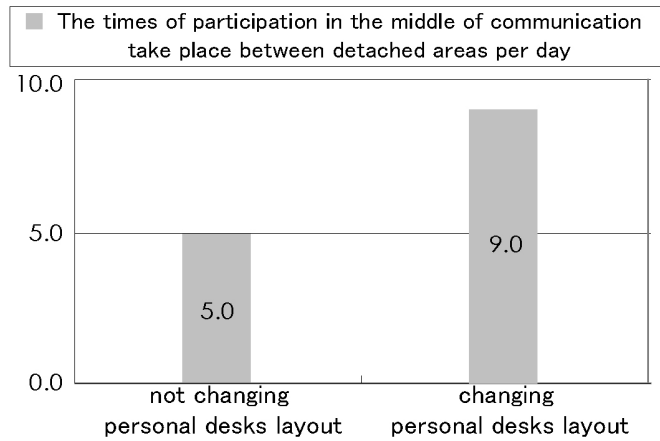


Figure 11. Participation in the middle of communication

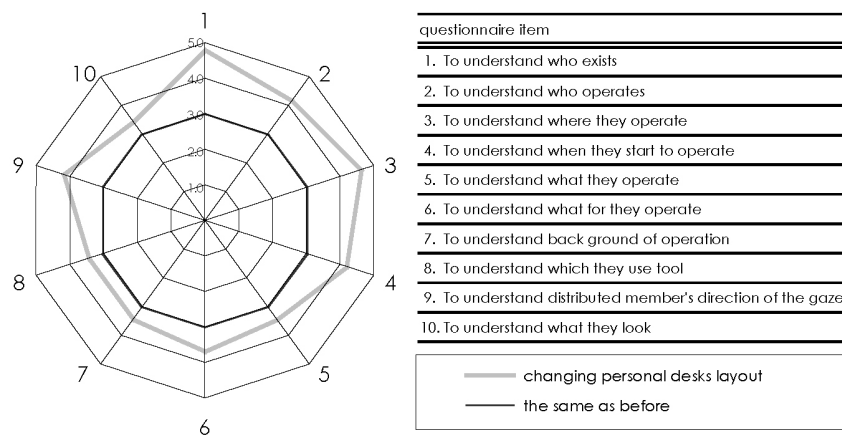


Figure 12. Evaluation of awareness for changing personal desks layout

Figure 12 shows experimental environment's evaluation of awareness. Changing personal desks layout is mainly effective in awareness about understanding member's existence in No.1, No.2, No.3, and No.4. Distributed member's situation and behavior jump to the eye naturally as a result of facing up to screen visualized distributed member's personal work continuously.

4. Discussion

The authors evaluate the environments of the continuously connected project-rooms at distributing sites in this paper. Through the self-photography and questionnaire survey, and communication analysis, we extracted four major problems which explain communication barrier between distributed sites, and considered and listed the factors that related to the problems.

The environment is modified in aspects of digital tool and architectural space with being clear to distributed environment's defects and their factors. We have improved the situation of taking place communication and awareness in distributed environment. In case of using VNC, sharing the desktop computer continuously as trigger activate communication because it works the awareness of "intention of doing" and "understanding the object".

Changing personal desks layout is mainly effective in "notice the existence of distributed members". It is meaningful to make architectural modification, such as changing personal desks layout without adding any information equipments and applications.

Future studies might consider examining more awareness supporting between distributing sites of continuously connected project-rooms based on the result of this paper. For example, gaze awareness and directional sound systems. Furthermore, the Augmented Reality (AR) interface can be developed considering not only continuously connected project-room but also local meeting environment.

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