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분산 협업 환경에서의 콘텐츠 공유 모델

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Contents Sharing Model in Distributed Collaboration Environment

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요 약

본 논문에서는 분산된 협업 환경을 통합하는 콘텐츠 공유 모델을 제안한다. 확장 가능한 고해상도 디스플레이 자원, 로컬 및 원격 콘텐츠 공유, 다중 사용자 상호 작용 및 접근 제어 특성들을 통합하여 결합된 하나의 모델을 제공한다. 다중 사용자의 상호 작용은 모든 사용자가 상호 작용이 가능하다는 이점이 있지만, 그로 인해 오버랩이 발생할 수 있다. 그 오버랩을 관리하기 위해 접근 제어를 모델에 적용했으나 작업 흐름의 방해가 가능하다. 따라서 이 두 가지 사항을 중점으로 모델을 평가하기 위해 상호 작용성에 대한 이용자 연구를 실시했다. 그 결과를 바탕으로 제안된 콘텐츠 공유 모델은 상호작용과 그 흐름을 방해 하지 않아 작업에 집중할 수 있는 분산 협업 환경을 제공한다.

▸ Keywords : 협업, 콘텐츠 공유, 대규모 고해상도 디스플레이, 다중 사용자 상호 작용

Abstract

In this paper, we propose contents sharing model for consolidating distributed collaboration environments. We provide the combined model by integrating different features-scalable resolution display walls resource, sharing contents on local and remote, multi-user interaction, and access control. There is a benefit that every user can interact within an environment, but overlaps would occur because of multi-user interaction. To manage overlap issue, the model includes access control. Access control would interfere flow of work process. Therefore, we conduct user study to evaluate these two factors of the model. The result shows that the proposed contents sharing model makes it possible to concentrate in a work.

▸ Keywords : Collaboration, Contents Sharing, Large High-Resolution Surfaces, Multi-User Interaction

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I. Introduction

People are living in an environment surrounded by technology. The technology is continuously improving. Computers are getting faster and have more space to save data. Displays are getting bigger and have more pixels. Border of displays is getting smaller, so we can put displays next to each other to create bigger seamless displays wall. Network is getting faster. ESNet(Energy Science Network) provides 40Gbps to 100Gbps. In the future, people might have this network speed at their workspace. New interaction techniques were introduced. Touch interaction is not special anymore. Motion capture devices, like Microsoft Kinect and Leap Motion, are used as an input device. High technology is around us.

We can apply advanced technologies into the traditional concept to enhance workspace environment. Well-designed environment with advanced technology can improve task performance[1,2]. Andrews says that the goal of environment design should be to create an expressive environment with sufficient representational affordances to make meaningful use of the space[3].

In this paper, we present Contents Sharing Model to design distributed collaboration environment. The design of content sharing is a difficult problem in the contents collaboration environment because of issues from multi-user interaction and task-type dependence[4]. We developed prototype with proposed contents sharing model, and conduct user study. Our model includes scalable resolution display wall resource, sharing contents on local and remote, multi-user interaction, and access control.

Chapter 2 covers related works. The proposed Contents Sharing Model is described in Chapter 3. Details about software implementation are covered in Chapter 4. The conducted user study is described and its results are discussed in Chapter 5. The final chapter summarizes the research results and includes the long-term vision.

II. Related Works

To create a collaborative environment, we need to consider at surface to share, contents to share, and how to interact. Obviously, large high-resolution surface can create better a collaborative environment.

Leigh gives an overview of scalable resolution display walls[5]. In his paper, he mentioned that work in scalable resolution display walls involved similar activities in traditional paper-based war-rooms and project rooms. Scalable resolution display walls can create a consolidated collaboration environment. The design of large high-resolution displays can impact on task performance[6]. Our research considers scalable resolution display walls as resources.

Easy contents sharing is a necessary function, and multiple people need to interact simultaneously for a collaborative environment.

The Dynamo is a communal multi-user interactive surface[7]. It allows a number of users to simultaneously interact and supports sharing and exchange media. From their observation, completely free-for-all surface created problem of overlaps, that happened when one user's interactions interferes with another's interaction. Therefore, they developed hybrid approach. With the Dynamo, user can claim areas of the surface for use, and set permission to others. This is not for restricting interaction, but reducing overlaps to manageable level. They expected that social protocol can be used to coordinate other issues happened from the restriction. The Dynamo suggested access control between people. However, the Dynamo only considers one surface to share and co-located collaborative activities.

Jagodic presents the interaction system that supports distributed collaboration work[8,9]. His research is focused on how to make multi-user interaction and multi-modal work on large high-resolution display. Multiple users can simultaneously interact with local or remote data on large high-resolution displays. Through his observation, he suggests that social protocols may be enough for coordinating access control among users. He took completely a free-for-all surface approach. However, he did not provide comparison experiment to prove it. The result also can be different depending on situations.

The NiCE Discussion Room supports co-located group meetings[10]. The NiCE Discussion Room consists of NiCE whiteboard, NiCE paper, NiCE laptop input, and whiteboard overlays. They integrated digital and paper tools into a system with pen-based interfaces. Their research is focused on an intuitive collaboration environment that fosters group work. Users evaluated with positive reviews. However, they identified some difficulties for usage the environment from the field observations. The NiCE Discussion Room aims for co-located collaboration and does not consider sense of ownership. The research is more focused on incorporating paper and digital interface into a high-tech environment.

Our research is focused on creating Contents Sharing Model for distributed collaboration environment. We consider scalable resolution display walls, sharing contents on local and remote, multi-user interaction, and access control. A key contribution of this paper is integrating different features, providing combined model, and conducting user study to see how much interference of interaction was happened from the model.

III. Contents Sharing Model

1. Content

Definition of content is "something that is to be expressed through some medium, such as speech, writing, or any of various arts"[11]. For example, text, audio, graphics, animation and video are contents. Content in collaborative work session can be generated for and in the session. It is normally multimedia. Public contents are contents shared by the group, and private contents are those not shared. However, private contents can change to public contents.

2. Action

Action is the ability to control and create contents. To *navigate, play, stop, create frame, close frame, arrange the screen and annotate* are actions defined in this model. Actions divide into two categories. One is *control*. It consists of navigate, play, stop, create frame, close frame, and arrange the screen. The other is *annotation* which includes annotate action. *Public control* is applied to the synced group, and *private control* is only applied to the private space. *Public annotation* creates public contents and *private annotation* creates private contents.

3. Resource

Main resource is *screens*. There is *the screen set that consists* of one screen or multiple screens like tiled-display. Screens have frames. *Frame* is certain area of the screen. It can be whole screen, or part of the screen. Frame can have frames too. Top-level of frame is called as the main frame. Figure 1 shows example of screen hierarchy. Screen has one main frame, which can have multiple frames, and the frame can be divided into multiple frames.

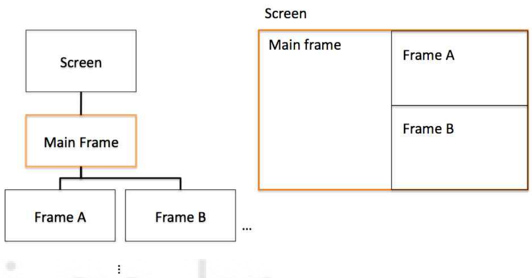


Fig.1. Screen hierarchy example

4. Ownership and Permission

Each frame has one *owner*. Ownership can transfer to others. The owner can create a sub frame, control/annotate own frame and its sub frames, and assign permission to users. There are *control permission* for control action and *annotation permission* for annotation action. Each frame has one owner and zero or multiple user that has control permission. There can be multiple users that can annotate on the frame. Figure 2 illustrated ownership and permission relationship for a frame. Instead of assigning a frame to an owner, free ownership also can set to a frame. If the frame has free ownership, everyone has control and annotation permission.

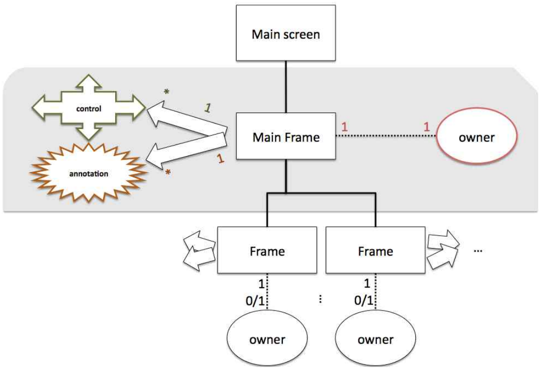


Fig.2. Relationship among frame, ownership and permission

5. Modes

Each frame sets one of the following modes.

• Passive Sync Mode

Personal Screens(PS) synchronize with the main screen, as in Figure 3. All changes on the main screen are updated to personal screens too. However, there is no interaction on personal screen during passive sync mode. Users in passive sync mode do not have any ownership and permissions. Therefore, it does not produce any contents and actions.

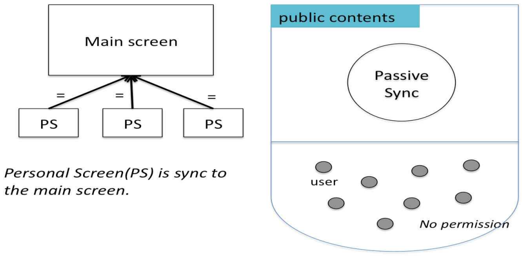


Fig.3. Passive Sync mode

• Unsync Mode

Personal screens are not sync to the main screen. Users in this mode have ownership for their private space only. Users can work independently. Therefore, this mode creates private contents and private actions(See Figure 4).

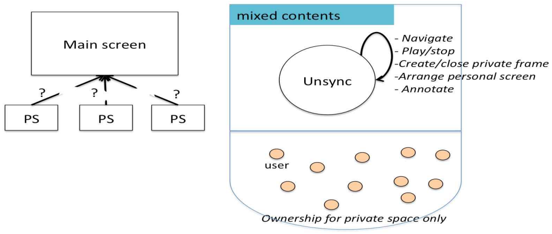


Fig.4. Unsync mode

• Active Sync Mode

The main screen synchronizes with Personal screens. All changes on the personal screen are updated to the main screen. The screens in passive sync mode will be updated too, and updated contents also sent to the screens in unsync mode. According to permission, active sync mode separates to three groups of users: owners, control permission group, annotations permission group, as Figure 5 shows.

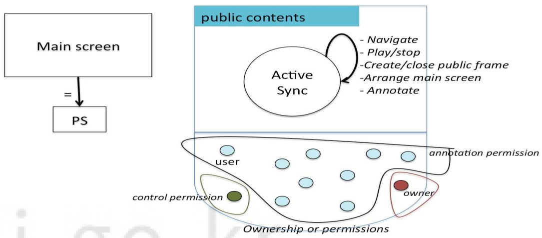


Fig.5. Active Sync mode

Annotation permission group can have independent internal-viewport, so internal-viewport is not sync to main screen.

Table 1 shows comparison for contents, actions, permission, ownership between the different modes.

Table 1. Mode comparison table

Mode	Active sync	Passive sync	Unsync
Update	Public contents Public actions		Public contents
Generate	Public contents Public actions Internal-viewport actions	-	Private contents Private actions
Permission/ Ownership	Should have at least one activated permission or ownership	-	Private ownership

6. Model

Public contents are updated to all modes simultaneously. According to permission and ownership, users will be in different mode in different frames. When a user joins to a session, user will be in passive sync by default. User can activate private ownership to change to unsync mode, and user can deactivate private ownership to go back to passive sync mode. When user gets control or annotation permission, user moves to active sync mode, and user can move back to passive sync mode by releasing permission. Even if user has ownership or permission, user can activate private ownership to change to unsync mode. Figure 6 describes our Contents Sharing Model. By activating, deactivating, obtaining permission, releasing permission, accepting ownership, or transferring ownership, user can be in a different mode in Contents Sharing Model.

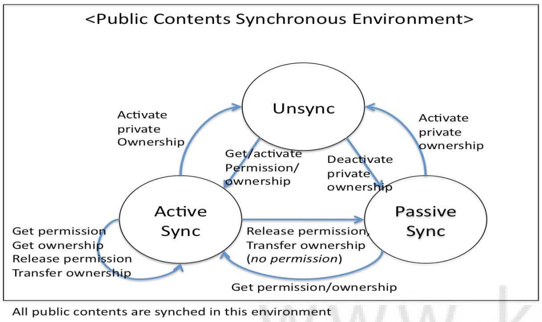


Fig.6. Contents sharing model

IV. Implementation

To verify our Contents sharing model, we implemented prototype of Contents Sharing System (CSS). CSS consists of three parts. One is session configuration via web. The second part is the server to manage session and content data, and distribute data and controls to all participated nodes. The last is client display. Web part is developed with Ruby and Rails. Database is using sqlite3. Server and client display is developed based on Scalable Adaptive Graphics Environment(SAGE). SAGE is high-performance graphics middleware for ultra-scale collaborative visualization. SAGE supports seamless large, high-resolution display surface and visualcasting[12].

User can create new session, upload data, and configure screen set via web interface, as Figure 7 shows. Server gets information, and saves into session database and contents database. Figure 8 is screenshot for session configuration website. User can create a new session, upload data for the session, and configure screen set.

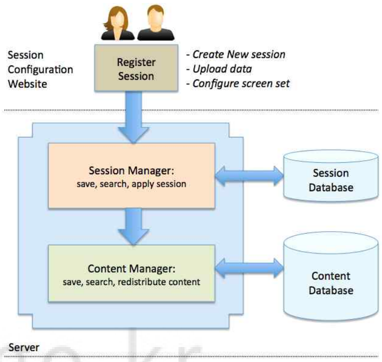


Fig.7. Session creation

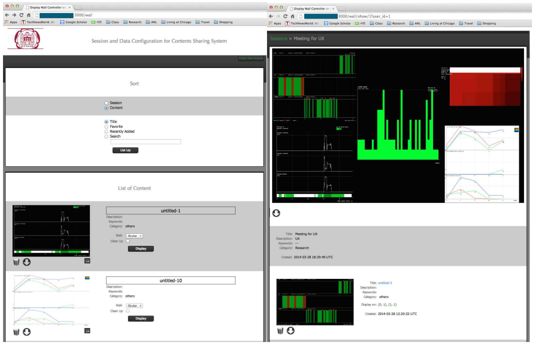


Fig.8. Session and data configuration web site

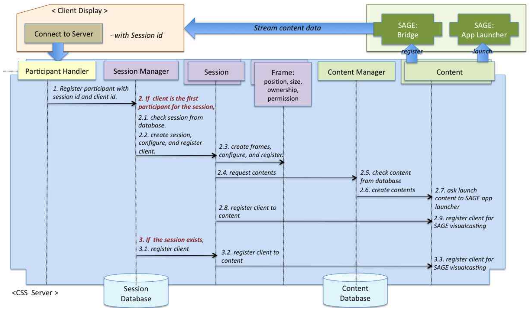


Fig.9. Sequence diagram to see how client display, CCS server, and SAGE work together

Figure 9 shows how client display, CSS server, and SAGE work together. Session class in Figure 9 handles Contents Sharing Model.

If a user is in Passive Sync mode, the client displays locked actions, and Session of CCS server will register the user's client display to Content that will register the client display to SAGE Bridge. SAGE Bridge will distribute the contents including additional meta information (position, size, native resolution, public annotation etc.).

If a user activates private ownership to change to Unsync mode, client display activates actions availability, does not send control data to CCS Server, and ignores updates getting from SAGE Bridge.

If a user gets permission or ownership, the mode moves to Active Sync mode. All actions send to CSS server. Session applies the actions to contents according to which permission user has, and SAGE Bridge distributes all changes to all other participants.

V. Experimental Case Study

1. Participants and Equipment

Two sites were joined to the experimental meeting. Duksung Women's University used 4x1 tiled display(4320x1920 resolution), and three undergraduate students(3 females) participated. Two students used their laptop. The other watches the tiled-display and did not have interaction device. University of Illinois at Chicago used 3x3 tiled display(3840x2160 resolution), and one graduate student(1 female) joined to the meeting. Figure 10 shows the setup.

Fig.10. Configuration for two sites

2. Tasks and Procedure

Participants had 4 sessions during 4 weeks. The task was to share information, or idea. Participants shared design idea of UNICEF funding poster, information about the new devices, knowledge about Virtual Reality, and design idea for digital contents access on large, high-resolution display. Each participant had approximately 15 minutes presentation, and 15 minutes discussion time. All participants had 1-hour training session, and they all use a computer everyday.

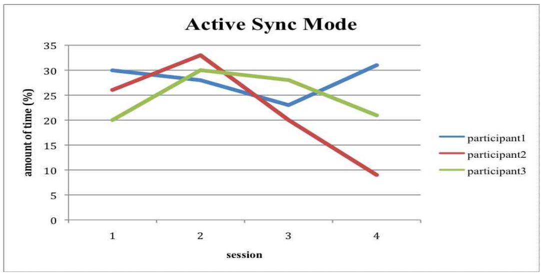
3. Results and Discussion

Task included presentation and discussion, so we expected taking over permission or ownership between participants and switching modes during the session. Restricting ownership and permission can interrupt interactivity. Therefore, our evaluations focused on interactivity and flow of interaction.

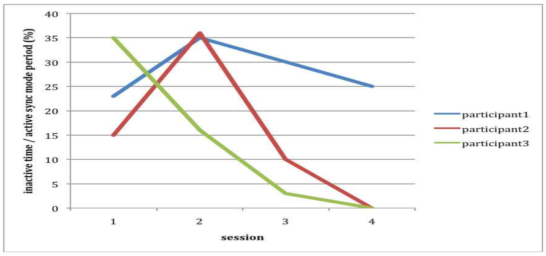
- Interactivity

We calculated how long participants were actively interactive during the session. Figure 11(a) shows percentage of Active Sync mode period during each session. If participant did not send any action control in 30 sec, we consider that participant is in Active Sync mode, but interactivity is inactive(Figure 11(b)). Horizontal axes are individual sessions, and vertical axes show percentage of session period. Overall average percentage of time of active sync mode is 25%(SD=6.4%). Participant-1 has 28%(SD=3.1%) active period for four session, Participant-2 has 22%(SD=8.8%), and Participant-3 has 24.8% (SD=4.3%). The Participants were in Active Sync mode for average 25% time period of each session. Average inactive percentage of Active Sync mode is 19%(SD=13.1%), and inactive percentage is getting decreased. Participant-1 has 28.25%(SD=4.7%) idle period when she was in Active Sync mode, Participant-2 has 15.3%(SD=13.1%) idle period, and Participant-3 has 13.5%(SD=13.8%) idle period. In other words, overall average active percentage of Active Synce Mode is 81%(SD=13.1%), and active percentage is getting increased through the sessions.

Additionally, Figure 12 and 13 depict the activity maps for all participants. We analyzed the tracked data from mouse input. Darker areas in Figure 12 indicate higher degree of activity. RGB colors in Figure 13 indicate three different participants' interactions, and other colors are mixed color from RGB. (Red + Green = Yellow, Green + Blue = Cyan, Red + Blue = Magenta, Red + Green + Blue = Black). The result shows that participant fairly have permission or ownership during the session, and actively interacts when they are in Active Sync mode.



(a)



(b)

Fig.11. (a-top) Percentage of Active Sync mode period during each session (b-bottom) percentage of inactive time during Active Sync mode

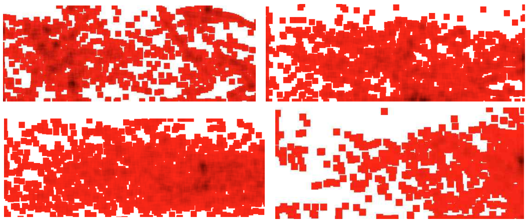


Fig.12. Activity maps on the display from four sessions

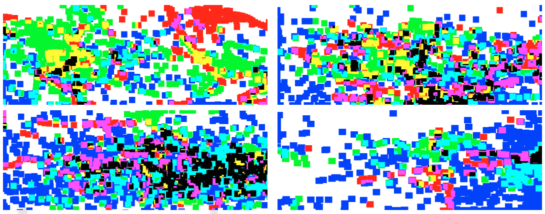


Fig.13. Activity maps on the display from four sessions

• Flow of Interactions

It is easy to change mode to Passive Sync or Unsync mode. However, to move to Active Sync mode, participant needs to request permission or ownership. This action can be conflicted with the flow of interaction. Therefore, we analyzed the case study result to show the interruption happened from requesting permission or ownership that can be ignored.

This is the transcript that covers the start of the conversation to get permission or ownership.

S: my turn

M: me

K: It is my turn.

K: Something wrong.

When a person said, other people noticed that they needed to do something to set permission or transfer ownership to the person. Situation is very explicitly guessed. Participants were not frustrated or confused by that. Someone who could run the operation did what she was expected to do.

Owners usually set free ownership during discussion time, so all participants had permission by default.

We analyzed the total amount of time spent in main topic-related talk, time for loading contents, and the amount of time spent for arguing or complaining to get permission or ownership, or switch modes during each session. Table 2 shows the percentage for each. The percentage of time for arguing and complaining is considered the amount of time Contents Sharing Model is caused. The percentage of time for loading data is a different design issue for workflow and digital contents access on Large, high-resolution display. In this paper, we focus on the effect of our suggested Contents Sharing Model. As Table 2 shows, participants had more interruption at the first session, and average time for arguing and complaining is 1.55%(SD=0.9%). If we ignore the first session, average of interruption time from Contents Sharing Model is about 1.0%(SD=0.24%). The result presents that participants can focus on their main topic once data is loaded. It means that our Contents Sharing Model does not restrict their interaction flow and does not interfere task.

Table 2. Percentage of content talk, loading data, and arguing and complaining in each session

Session	% Topic-related Talk	% Loading data	% Arguing and Complaining
1	82.13	14.67	3.2
2	86.7	12.1	1.2
3	89.07	10.26	0.67
4	86.53	12.34	1.13

VI. Conclusion and Future Work

In this paper, we presented Contents Sharing Model and case study. The model includes contents, actions, display resource, permission, ownership, and three different modes to support collaborative environment. Passive Sync, Unsync, and Active Sync mode are supported to provide public, private, and mixed space to participants, as they like to.

We present evidence that our Contents Sharing Model was successful to providing a collaborative environment. Our case study shows that it does not interrupt to have permission and ownership to flow of interaction, interactivity, and focus on task.

In the future we would like to involve more participants and more remote sites to explore how the number of participants or remote sites affects our Contents Sharing Model. Additionally, we would like to look for how to reduce loading data issue.

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