The Impact of Display-rich Environments for Enhancing Task Parallelism and Group Awareness in Advanced Collaboration Environments

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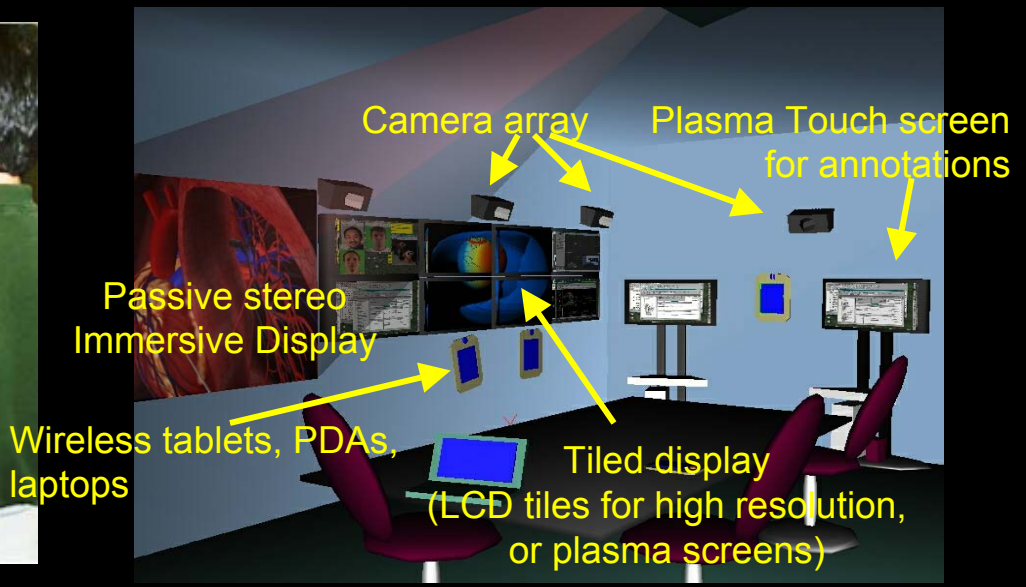
Amplified Collaboration Environment

- Amplified Collaboration Environments (ACEs) are *distributed* Project Rooms (or war rooms) which are enhanced with advanced visualization displays and computation.

War room (Olson & Olson)

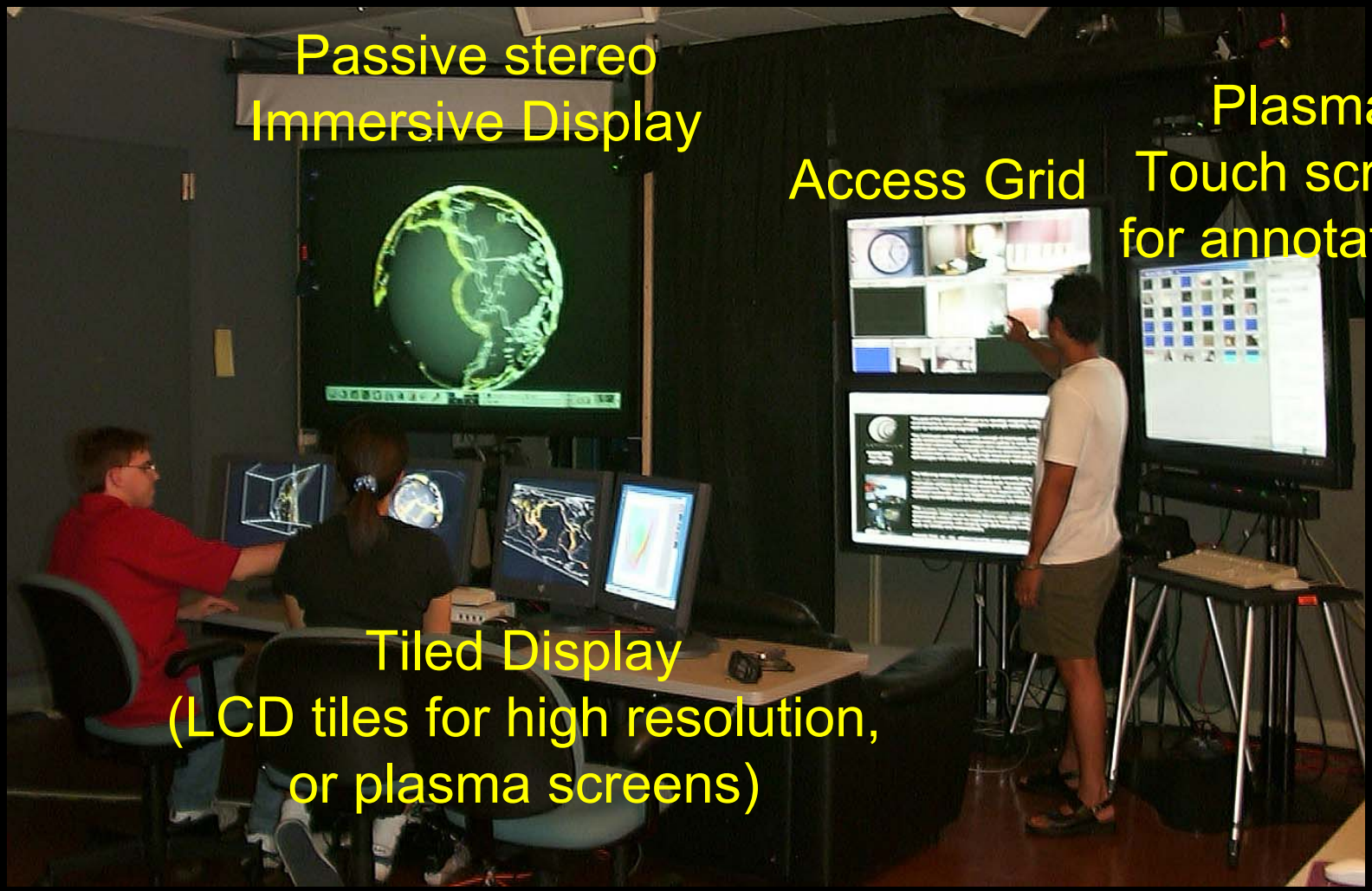


Amplified Collaboration Environment

Motivation: Maximally Co-located Project Rooms or Warrooms

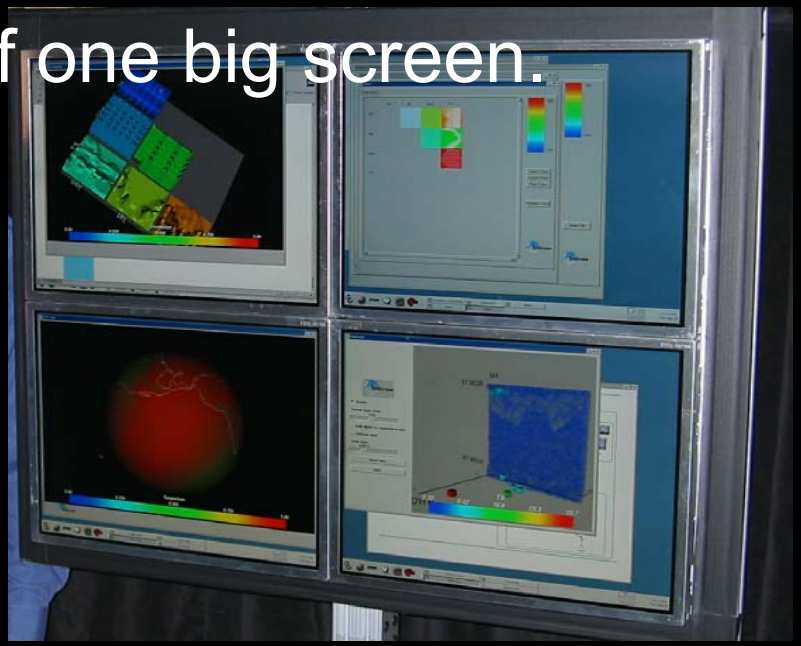
- Study of 9 project rooms
- Comparison of war room groups with norm showed performance of war room group well above corporate average
- Characteristics of war room
  - Persistence of information
  - Spatiality of human interaction and deictic reference
  - Group awareness
  - Immediacy of access to information and experts

The Continuum at EVL : ACE for Collaborative Scientific Investigation



Tiled LCD Display

- Treat tiled display as a large digital “corkboard” on which information can be posted permanently for long term collaborative work.
- SpaceGlider as a remote control of all Continuum displays as if one big screen.



Iterative Design Studies of using the Continuum for Intensive Collaborative Work

- Iterative improvement of 2 networked Continuum spaces.
- Observe and explore design issues for interaction of lots of displays and multiple simultaneous inputs.
- Observe how display-rich environments affect group awareness and parallelism in distance collaborations.
- Provide Access Grid community with an understanding of how people might work as the AG begins to bring in more than just video conferencing.

Overview of Study Methods

- 1 pilot study and 4 iterative design studies *with system configuration variations*.
- 19 students (all subjects participated in two studies).
- A group of 3~4 students was distributed in 2 Continuum spaces and performed a set of collaborative scientific tasks:
  - Web-based search and information fusion.
  - Information visualization of multivariate statistical data.
  - Collaborative brainstorming and design.
- Measurements
  - Observational notes; Video recording; Pre- and Post- test survey; Group interview; Data logging on computer usage.

Pilot Study

- A group of 3 students performing 3 collaborative tasks: concentration game, info search, and info viz
- System Configuration (Day1 – Distributed)
  - Access Grid
  - Shared Whiteboard via NetMeeting
  - Projection Display & KVM switcher (for group discussion)
  - Shared Tiled Display (1x4 format; 2x2 format) & Switcher
  - 1 keyboard and mouse per site (NetMeeting model)
- System Configuration (Day2 – Co-located)
  - Whiteboard
  - Projection Display & KVM switcher
  - Shared Tiled Display (1x4 format) & Switcher
  - 1 keyboard and mouse per user

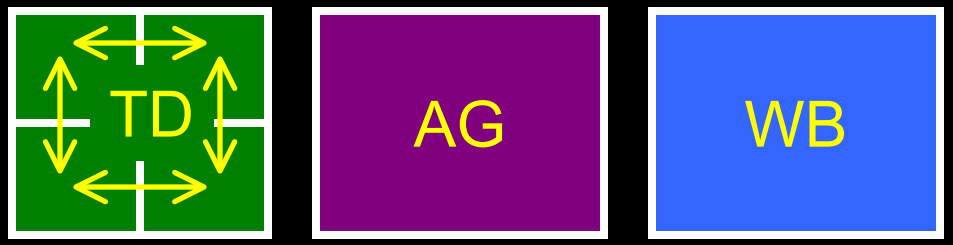
Observations – Pilot Study

Usage Patterns of Continuum Technologies

- Sense of ownership for the resources (e.g. grab and use different tile for individual workspaces - visual access to all the workspaces but input access was not shared)
- Tiled display offered multiple individual workspaces while maintaining necessary awareness between distributed users; useful for multiple linked views and side-by-side comparison
- Need to provide individual input per user for parallel work.
- Projection display used 1~2 times when students wanted to examine the patterns of data in a bigger format in info viz; Shared touch screen was used only for recording answers
- Treat Continuum's displays as one big screen (e.g. cut-and-paste); Flexible tiled display that can project up to single large high-resolution data visualization

Design Study 1 : Enhancing the Continuum to support the illusion of seamless displays

- System Configuration
  - Access Grid (4 camera sources & 2 microphones in full-AG setting; 1 camera and microphone in mini-AG setting)
  - Shared Whiteboard via NetMeeting
  - Shared Tiled Display (2x2 format)
  - SpaceGlider (connecting 4-node Tiled Display)
  - Individual keyboard and mouse per user
  - Physical layout (eliminate Projection Display)

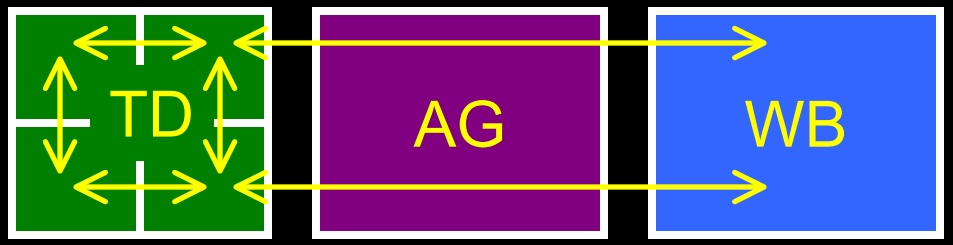


Observations – Design Study 1

- Wanted more microphones and cameras in mini-AG setting!
- Shared whiteboard conflicts between remote participants
- Shared tiled display (distributed corkboard mechanism)
  - Casual glancing over at others (e.g. to get search strategy)
  - But, not supported awareness of group task progress
- SpaceGlider mouse sharing problem
  - Mouse identification & Multiple mice conflicts
- Data transfer between displays
  - Desire to cut-and-paste texts
  - Desire to move the window from one tile screen to another (Users treated TD as one continuous display)
  - Read-and-write collaboration (via voice channel)
  - Using pen/paper to transfer notes from TD to WB

Design Study 2 : Introducing Tablet PC for individual input control and Improving mini-AG setting

- System Configuration
  - Access Grid (4 camera sources & 2 microphones in full-AG setting; 2 cameras & 2 microphones & a magnifying filter on the close-up camera in mini-AG setting)
  - Shared Whiteboard via NetMeeting
  - Shared Tiled Display (distributed corkboard mechanism)
  - SpaceGlider (connecting Tiled Display and Whiteboard)
  - Tablet PCs (screen echo)
  - Physical layout

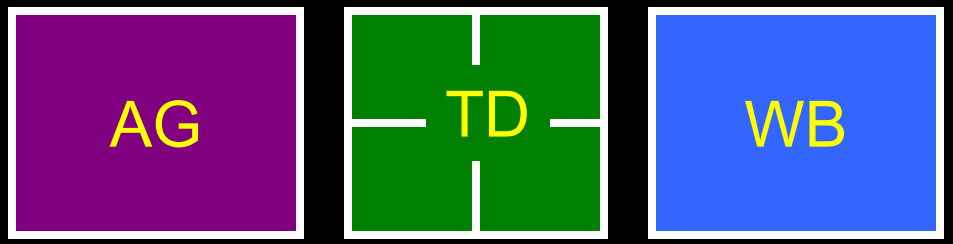


Observations – Design Study 2

- Improved mini-AG setting helped increase interaction between remote users; But, users suggested reducing video sources
- Shared whiteboard conflicts; conflict resolution using video
- Shared tiled display (as workspaces for remote collaboration)
- Tablet PCs (as personal workspaces)
  - Reduced users' casual glancing on the shared tiled display
- SpaceGlider mouse sharing problem
- Users felt *no continuity of the workspace* (due to SpaceGlider connecting between TD and WB)
- Data transfer between displays
  - Cut-and-paste; Move the window from one display to another; Read-and-write collaboration (via voice channel)
  - Using Tablet PC to transfer notes from TD to WB

Design Study 3 : Enhancing the Continuum to support the flexible shared workspace for easy transition between individual work and group work

- System Configuration
  - Access Grid (4 camera sources & 2 microphones in full-AG setting; 2 cameras & 2 microphones & a magnifying filter on the close-up camera in mini-AG setting)
  - Shared Whiteboard via NetMeeting
  - Flexible Shared Tiled Display (distributed corkboard mechanism and full-screen; distinct background colors)
  - Switcher (jump between 4 tiles and whiteboard)
  - Tablet PCs (screen echo)
  - Physical layout

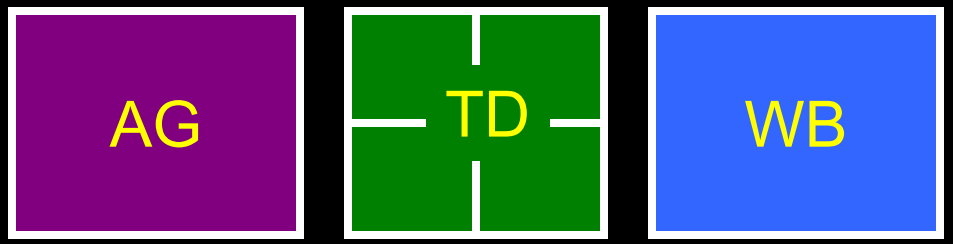


Observations – Design Study 3

- Increased number of overhear/help/collaboration between remote users over AG (may because of user's second time use of the system); Better performance (time & quality of work)
- Increased volume of shared whiteboard usages; Speaking a plan loud or using video sources for resource sharing
- Flexible shared tiled display
  - Full-screen used for group discussion and personal uses
- Tablet PCs (as individual workspaces)
- Fewer mouse conflicts by Switcher; Users liked Switcher
- Data transfer between displays
  - Read-and-write collaboration
  - Still request for cut-and-paste (when moving large texts)
  - Disappeared desire to move the window

Design Study 4 : Evaluating a presentation model for the shared workspace

- System Configuration
  - Access Grid (4 camera sources & 2 microphones in full-AG setting; 2 cameras & 2 microphones & a magnifying filter on the close-up camera in mini-AG setting)
  - Shared Whiteboard via NetMeeting
  - Presentation-model Tiled Display (only single individual's workspace is shared at a time; distinct background colors)
  - Switcher (jump between individual's tile and whiteboard)
  - Tablet PCs (screen echo)
  - Physical layout



Observations – Design Study 4

- Performance degraded as compared to Study3 groups.
- More two local pairs collaborative work & just inform remote partners about answers or task progress
- Presentation-model tiled display
  - This model provided more private workspace & no casual glancing over at others.
  - ‘Show me’ pattern (e.g. one asked another to show your workspace or one informed others about showing my workspace)
  - Wanted the shared tiled display (distributed corkboard model) back!
- Tablet PCs (as individual workspaces)
- Liked Switcher against SpaceGlider
- Data transfer between displays (e.g. cut-and-paste)

Discussion :

Summary of 4 Iterative Design Studies

- Study1
  - Shared tiled display & individual keyboard & SpaceGlider
  - They used TD for various purposes (multiple views side-by-side, glancing over at others' work); need close-up view
- Study2 (to address resolution problem)
  - Shared tiled display & TabletPC & SpaceGlider
  - Tablet as personal workspace; TD for remote collaboration.
- Study3 (to address size problem)
  - Flexible shared tiled display & Tablet PC & Switcher
  - They can still work on Tablet when it is maximized.
- Study4 (to compare with shared tiled display model)
  - Presentation-model tiled display & TabletPC & Switcher
  - They want more resolution to display more data side-by-side! & Somewhat reduced interaction between members.

Discussion :
Task Parallelism and Group Awareness

- Task Parallelism
  - Number of input controls (one per site vs. one per user)
  - Task types (Mixed-mode vs. tightly coupled collaboration)
  - Group working styles (work together vs. divided work)
  - Need awareness support when user's working in parallel
- Group Awareness
  - SpaceGlider mouse identification -> name tags
  - Shared tiled display or whiteboard conflict -> audio/visual cue for indicating who is using shared resources
  - Task progress awareness problem -> group activity history
  - Awareness support by user's casual glancing and fully visible group work activities over shared tiled display.
  - Overhearing between remote users and displaying spatiality of human interaction over AG.

Discussion :
Video Conferencing and Multi-users Shared Input Control

- Video Conferencing
  - Audio! (collaboration halt by audio fails and repair by using text chat)
  - Video sources (how to position camera? one collaborator *wide-angle* close-up view; additional views of shared resources for conveying spatial references)
  - A group as a whole used all video sources.
  - Video source placement issue – need to be explored
- Multi-users Shared Input Control
  - SpaceGlider mouse sharing problem (accidental intrusion)
  - Give turn-taking protocol instead of Take for SpaceGlider?
  - Switcher is good for multiple users' sharing resources
  - A sense of ownership for the shared resources when using Switcher

Discussion :
Private/Public Workspace and Display-rich Environment UI

- Private and Public Workspace
  - Public workspace (e.g. Shared WB, Shared tiled display) provides information fully visible and supports awareness
  - Personal workspace (e.g. TabletPC)
  - Private to public mechanism (i.e. Presentation model) was not good for Continuum's tiled display setting
  - Some users requested private (not shared) workspace, mainly for email.
- Display-rich Environment User Interface
  - One continuous display (e.g. cut-and-paste, moving the window from one display to another, SpaceGlider)
  - Used various channels (e.g. Tablet/paper, shared notes, verbal) to move data between displays
  - Proximity of displays (e.g. putting them closer together)

Conclusion

- Iterative design studies with the technology variations
  - SpaceGlider vs. Switcher (multi-user shared input control)
  - Screen-less keyboard/mouse vs. Tablet PC (proximity of display)
  - Shared tiled display (distributed corkboard model) vs. Flexible shared tiled display vs. Presentation-model tiled display (power-point presentation mechanism)
- Shared tiled display (distributed corkboard mechanism)
  - Supported parallel work and group awareness between distributed sites
  - used for multiple linked views and side-by-side comparison
- Explored design issues for display-rich environment user interface and advanced awareness tool