Challenges in Collaborative Space Mission Design

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My Research Interests

- **Distributed and collocated group design work**

- **How can the affordances of a "warroom" influence collaborative design?**

- **What technologies can benefit collaborative design for collocated and distributed work: e.g. life-size, wall-size HDTV**

- **What effects on design does group-to-group distributed collaboration have?**

Two trends: distributed and collocated design

- **Collaborative design across distance**

  - *Examples*: CAD shared app: Telefly system, "round-the-clock" software development
  - *Empirical studies*: coordination problems: transitioning, integration, communication (Herbsleb et al., 1999; Grinter, 1998)

- **Collaborative designing in same physical environment**

  - *Examples*: new generation of electronic meeting rooms (e.g. i-land: Streitz, 1999; interactive workspaces: Stanford; Discovery Collaboratory: Arias et al.)
  - *Empirical studies*: radical collocation (Teasley et al., 2000; 2002; Mark, 2002)

Dynamic Group Work Structures

- Framework for considering group work often assumes "stable" team membership/structures

- Distributed and collocated group work is far more complex:
    - team boundaries are fuzzy
    - people belong to multiple teams, working spheres
    - multiple roles
    - social relationships are dynamic

- In "warrooms", even locale cannot define a team structure

Some Background Theory

- **Social worlds (Strauss, Shibutani, Giddens)**

- **Co-presence (Giddens)**

- **Interaction when collocated: monitoring, adjusting behaviors, common use of artifacts, etc.**
  - **(e.g. Heath and Luff, Suchman, Harper et al., Robertson, Rouncefield et al., Schmidt and Wagner)**

- **Social networks**

Dynamic networks within a group

- **Some types of social networks**
  - intensional networks (Nardi et al., in press)
  - "knots" (Engestrom et al, 1999)
  - actor–network theory (Latour, 1996)
  - coalitions (Zager, 2000)
  - virtual community networks (Wellman, 1998)

- **Also:**
  - networks to exchange and process information even when people are collocated, also distributed

- **Analysis:** who interacts with who, in main and sidebar channels of communication

Example of collocated design work with dynamic networks

- In 1995, Team X formed at the JPL to serve as internal consultants to NASA in designing new space mission proposals, e.g. Mars Probe

- Team X designs a complex space mission in about nine hours

- How can physical collocation *and* technology together enable a team to produce a space mission proposal in such a remarkably short time?

Methodology

First study:

- **Fieldwork observing warroom for three months**
  - Sidebar conversations coded
  - Seventeen in-depth semi-structured interviews
  - Artifacts collected
  - HDTV experiment: videotaping, questionnaires, group interview

Current study:

- **Fieldwork observing remote sites**
  - video & audio tapes of each remote site, wave files of remote conversations

External Representations Used in the Warroom

Representation	Creator/Driver	H: Function
Individual workstations	Team member	Monitor others' work
Publish–subscribe	Entire team	Info flow
Spreadsheet	Entire team	Focusing agent
Orbit visualization program	Team leader	Visualizing information
Public display	Team leader	Shared view
Paper whiteboards	Team member	Visualizing information

Social networking: sidebars

- **Avg. number coded during three-hour session: 98 (large variability)**

- **Have lasted from few seconds to 53 minutes**

- **Avg. engineer speaks 20 minutes in sidebar, range is 7–110 minutes in a three-hour session.**

- **Sidebars used to process information from spreadsheet: question assumptions, negotiate, find other options, etc.**

Example: Initiating Networking for Spontaneous Sidebar

- **Power to Config. Graphics: Can we get any power during the flight? Will the cells be pointed out? Otherwise we'll need big monster batteries.**

- **Mission Design, Team Leader, Instruments are speaking across room to each other**

- **Structures overhears Power and Config. Graphics and joins them**

- **ACS overhears and joins conversation from across the room.**

- **……….**

An Exploratory Study Using Life-size HDTV with Team X

- **Large 128" x 72" screen showing HDTV as a "window" to show activity between rooms + audio**

- **Team X split into two rooms**

- **Real space shuttle mission proposal**

- **Telephones, with phone numbers, to support sidebars**

- **Day 1: audio directly sent in, video sent through Gigabit Ethernet (.8 second lag)**

- **Day 2: both audio and video sent through Gigabit Ethernet   (degraded audio)**

The Potential of High Telepresence

- **Video used as means for observing activity in remote room: not as good for supporting "networking"**

    - **< 20% of the time, video used for sidebars**

    - ***"Difficult to hold a local sidebar without disturbing people in other room"***

    - **A learning curve may exist**

    - **Requirements for sidebars across distance:**
        - **Need to understand who to speak with**
        - **Need seamless way to connect**

Networks at work in collocated environments

- Networks in collocated work easily break down over distance with the wrong technology support

- Delicate balance of automation and human processing

- Too much automation eases load, but may remove opportunity for creativity in design

- Flexibility is key: to move back and forth between electronic and social network

Current Work: Group-to-Group Distributed Collaborative Design

- Whereas distributed teams might be considered a "sphere of work", what happens when different "spheres of work" collaborate?

- Studying JPL, Marshall, Glenn, Sandia, began April 2002

- Four focii:
  - Requirements: conception as well as function
  - Information flow
  - Social networking
  - Technology use

Opportunities for New Technologies to Support Distributed Work

- How can we leverage people's ability to monitor others' work?

- Seamless support for sidebar conversations (intentional and spontaneous) without overload of information

- External representations that capture the *design rationale*, not just the result

- …….still working…

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