Representations and Metaphors for the Structure of Synchronous Multimedia Collaboration within Task-Oriented, Time-Constrained Distributed Teams

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Outline

- Background and Inspiration: FAST Exercises
  - Formation of Common Analysis Picture
  - GroupMeld™ Collaboration Framework
  - Inspired by FAST exercises but have not yet been used in an actual FAST exercise
- Tech Talk
- Quasi-Experiment with N-ABLE™ Team
- Reflection: Why just the N-ABLE™ Team?
- Observed Structure of Collaboration
  - Agenda
  - Subgroup
  - Chapter
- New Representations and Metaphors for Collaboration Structure
- Conclusions and Future Work

Background

- The National Infrastructure Simulation and Analysis Center (NISAC) program is often called upon to quickly analyze the impact on critical infrastructures of a potential future event
  - Fast Analysis and Simulation Team (FAST) exercises
  - Time-limited (from four hours to several days)
- A FAST exercise consists of groups of groups
  - National Laboratories
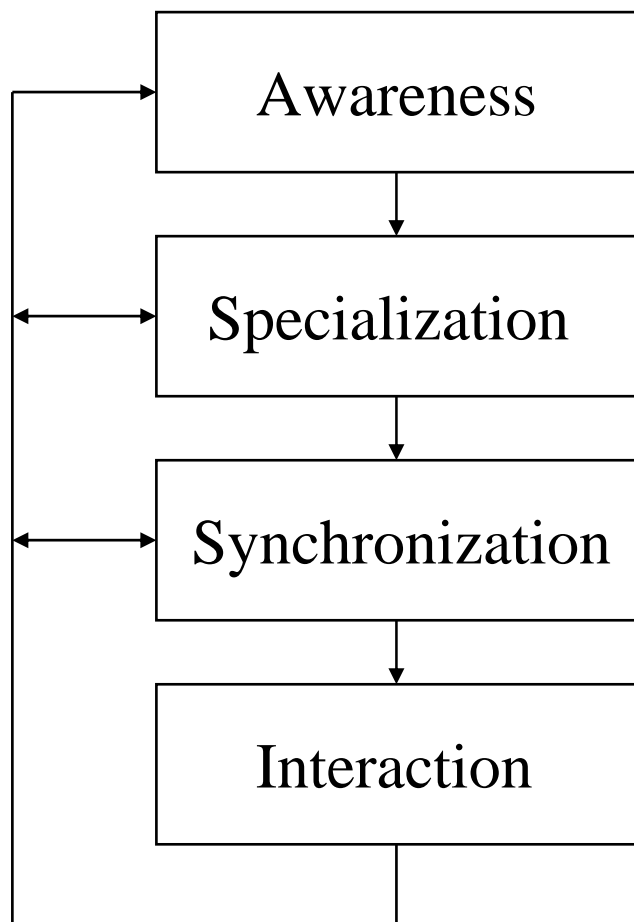 - Simulation analysis teams
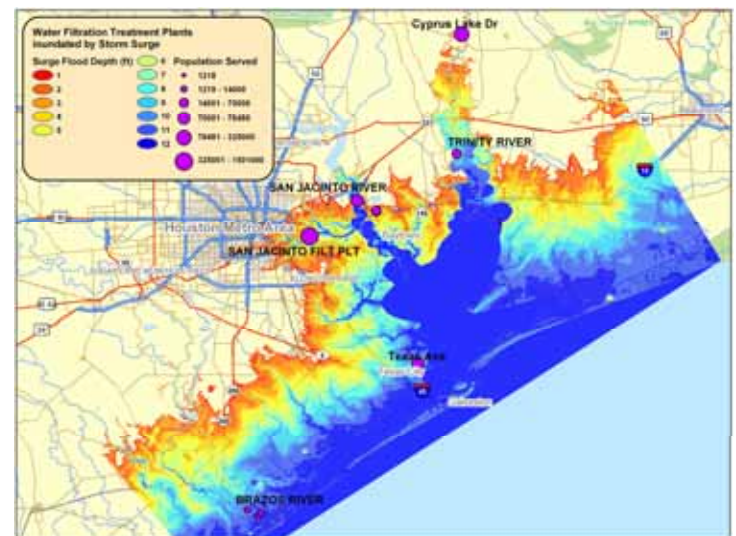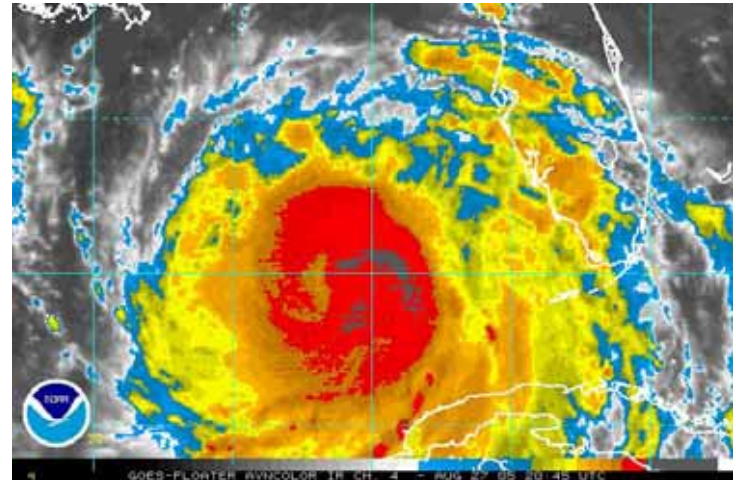
Background *(cont'd)*
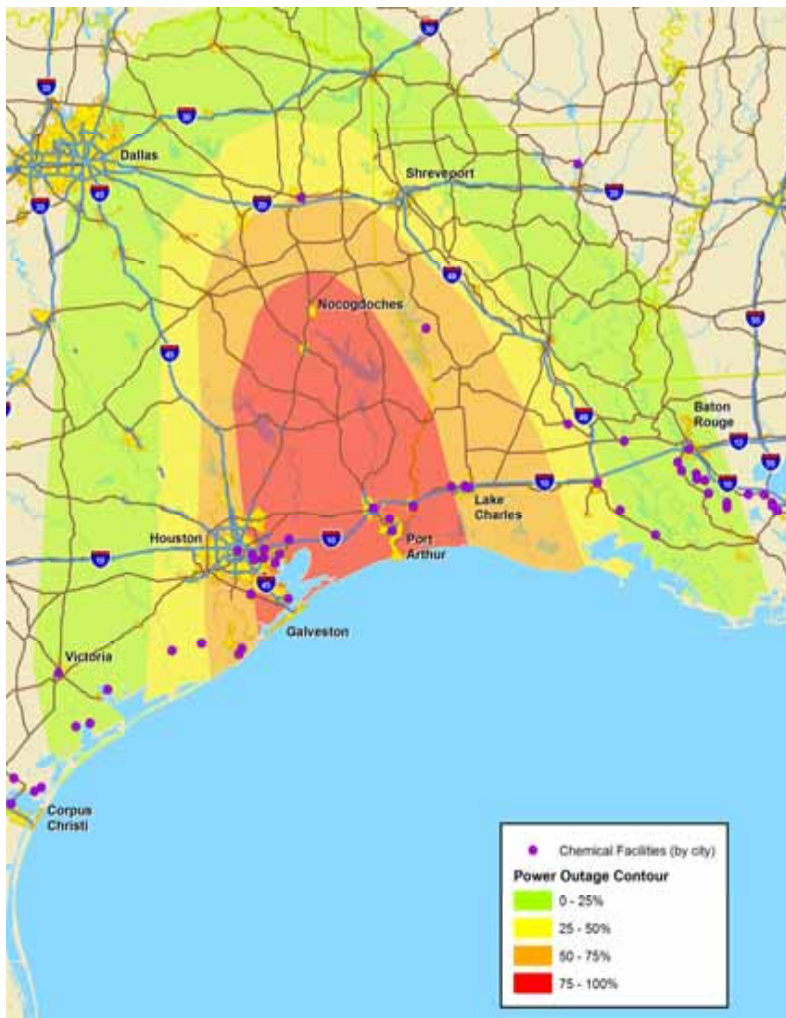
- The type of collaboration that is characteristic of a FAST exercise is "collaboration in a crisis"
  - Geographically distributed
  - High-stakes
  - Time-constrained
- Much time is spent establishing a common analysis picture (common mental model) of problems and solutions

Forming A Common Analysis Picture

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┌─────────────────────┐
│     Awareness       │
└─────────────────────┘
          ↓
┌─────────────────────┐
│   Specialization    │
└─────────────────────┘
          ↓
┌─────────────────────┐
│   Synchronization   │
└─────────────────────┘
          ↓
┌─────────────────────┐
│    Interaction      │
└─────────────────────┘
```

- ## Awareness
  - "Who am I working with?"
  - "What are they doing?"

- ## Specialization
  - Fluid creation and dissolution of subgroups
 - Reflects hierarchical task decomposition

- ## Synchronization
  - Looking at the same thing (data) …
  - … in the same way (view)
  - "What You See Is What I See" (WYSIWIS)

- ## Interaction

GroupMeld™ Collaboration Framework

- **Real-time multimedia collaboration**
  - Group awareness and status
  - Chat
  - Screen image sharing with annotation capability
  - Shared whiteboard
  - File transfer
  - Audible pages

- **Three-level collaboration scope**
  - Full group ("public")
  - Subgroup ("restricted")
  - Person-to-person ("private")

- **Three usage models**
  - Programmatically embedded inside a simulation application
  - Standalone GroupMeld™ collaboration application
  - Hybrid (invoked from the same Java Virtual Machine as another application)
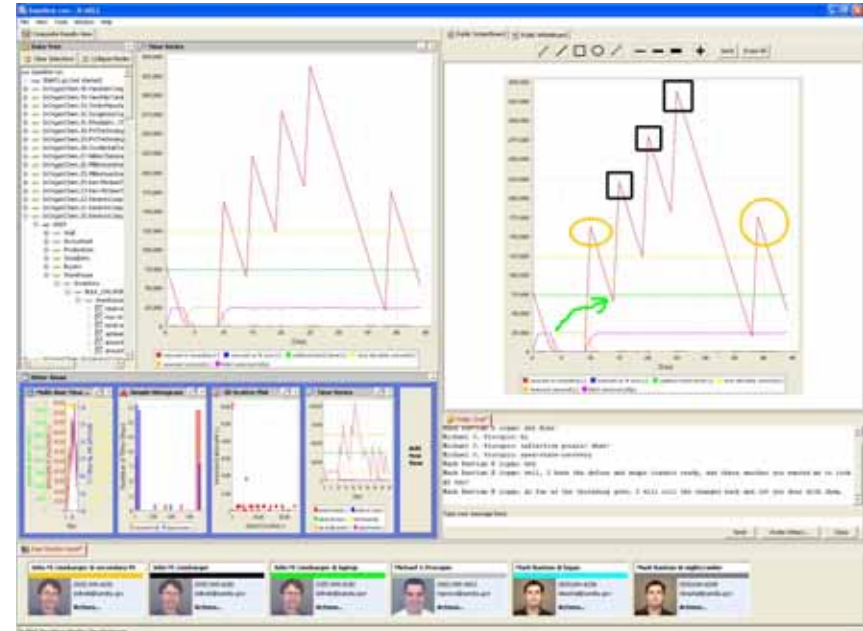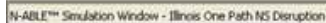
- Peer-to-peer network topology
- Developed in Java
  - Deployed as a uniquely named package in a JAR file
  - Tested under Windows, Mac OS X, and Linux
  - Special code for Mac OS X
- RMI over IIOP used as the distributed communication mechanism (*i.e.,* Java's implementation of CORBA)
- CORBA naming service used to keep track of collaborators and subgroup structure
- Reader-writer locks used to control access to data structures shared between threads
- Java drag-and-drop API used to drag panel images onto the ScreenBoard
- Performance Optimizations
  - Images sent as a byte array in JPEG format
  - Annotation objects sent as lists of mouse coordinates

Quasi-Experiment

- **Quasi-Experiment**
  - A single team in a field setting
  - Complex, long-duration tasks requiring specialized expertise

- **Motivation**
  - Improvement depends on measurement
  - Measurement depends on observation

- **Operating Hypotheses**
  - Synchronous collaboration capability improves the ability of a distributed team to form a common mental model of problem and solution
  - The benefits of collaboration vary depending on the time duration of the analysis project

- **Data captured**
  - Post-experiment questionnaire
  - Group chat transcript
  - Collaboration transaction log

Quasi-Experiment *(cont'd)*

- **Team members**
  - Six members of N-ABLE™ agent-based modeling, simulation, and analysis team; four was a quorum
  - Each had previous experience with an earlier version of N-ABLE™, which did not use the synchronous collaboration framework
- **Team characteristics**
  - Mostly co-located along same hall; one downstairs, another 300 miles away
  - Cross-platform: Split between Macintosh and Windows machines
- **"Instrumented real work"**
  - Except for the pilot, the six experiment problems were real N-ABLE™ analysis questions, not hypothetical problems for the experiment
  - The realities of research on customer-funded projects
- **Structure**
  - Pilot experiment followed by six randomized experiments (two short, two medium, two long)
  - Entire calendar month (March 2005)
  - 11,477 collaboration transactions

Quantitative Results

- Synchronous collaboration capability improved the ability of the team to form common mental models of both problem and solution

- The improvement was slightly less for solution than for problem

- The improvement (at least for problem) was slightly greater for quality (*i.e.,* depth of understanding) than for time

- The hypothesis that the benefits of collaboration varied by the time duration of the analysis project was not supported
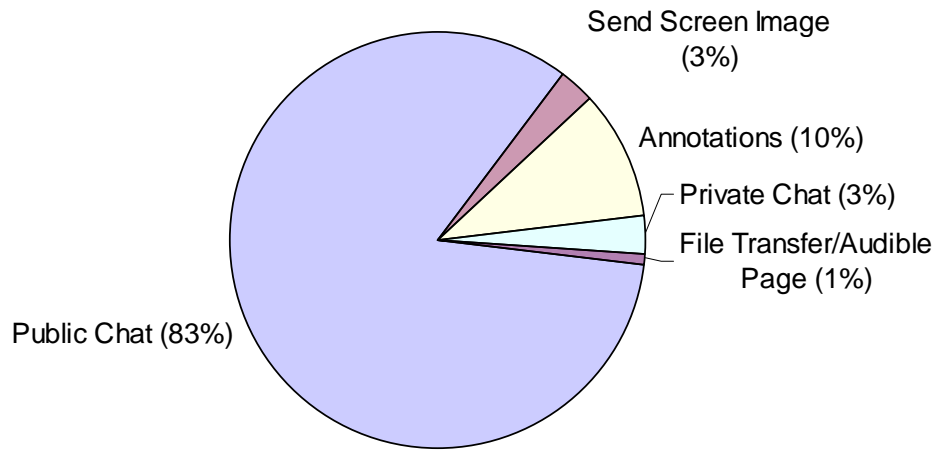
	Improved Overall with Collaboration		Improved Time with Collaboration		Improved Quality with Collaboration	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Common Mental Model of Problem	4.45	0.71	4.29	0.77	4.48	0.62
Common Mental Model of Solution	4.23	0.67	4.13	0.83	4.13	0.81

(Scale is 1 [Strongly Disagree] to 5 [Strongly Agree])

Stage	Mean	Std. Dev.
Awareness of Team	4.65	0.48
Awareness of Task	4.23	0.76
Synchronization of Data	4.4	0.76
Synchronization of View of Data	4.32	0.69

Quantitative Results *(cont'd)*

Rounded Collaboration Transaction Percents

Pie chart labels:
- Send Screen Image (3%)
- Annotations (10%)
- Private Chat (3%)
- File Transfer/Audible Page (1%)
- Public Chat (83%)

- Most useful capability
  - Chat (52%)
  - ScreenBoard (36%)
  - WhiteBoard (12%)
- Least useful capability
  - Whiteboard (71%)
  - File Transfer (19%)
- Other synchronous mechanisms
  - Face-to-Face (84%)
  - Phone (16%)
- Other asynchronous—Email (75%)
- Percents by Media
  - Text (86.5)
  - Graphics (12.75)
  - Generic Object (0.75)

Qualitative Results

- **Group insight (common mental models) often occurred while the group was collaborating around a shared screen image**
- **Collaboration generally did not proceed linearly but episodically, in chunks or chapters or cinematic "scenes"**
  - The line of demarcation between scenes was the transmission of a shared screen image
  - Sometimes "conversation packages" formed of related screen images, annotations, transferred files, and chat messages
  - Other times the series of chapters exhibited a hierarchical structure
    - Subchapters of a larger chapter
    - Often a task on the implied agenda or task list for the analysis project
- **Face-to-face collaboration was necessary for certain kinds of tasks**
  - Problem space characterization and initial division of labor
  - Software design
  - Why? Can't talk and draw at the same time

Reflection: Why Just the N-ABLE™ Team?

- To date, only N-ABLE™ has adopted the GroupMeld™ framework
- Though inspired by FAST exercises, GroupMeld™ has not yet been used in a FAST exercise
- **Why?**
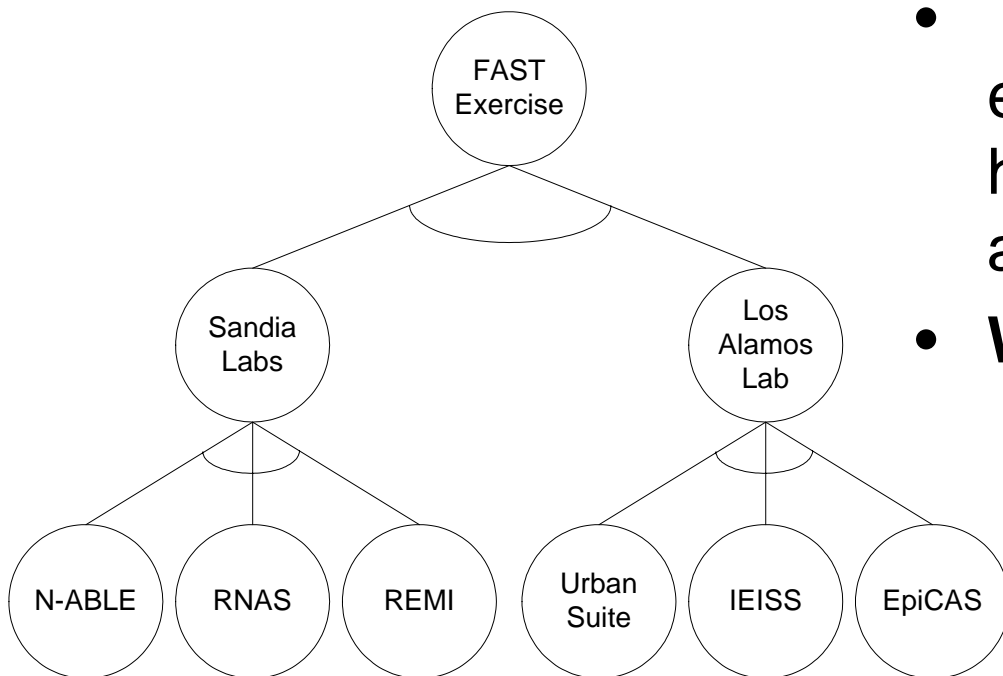
Reflection *(cont'd)*

- Good technological fit with N-ABLE™
  - Java-based
  - Heavy use of application-specific generic objects
  - Other teams use commercial tools, .NET tools, or Web-based tools
- Good functional and strategic fit with N-ABLE™
  - Sheer volume of data generated by agent-based simulations requires collaborative analysis, which is impractical to perform face-to-face
  - Branded system intended for both external and internal customers demands tight integration
- Counter-intuitively, as the timeframe for a FAST exercise tightens, group collaboration decreases
  - Any collaboration tool must be absolutely friction-free
  - Groups are not directly measured on how well they work together
- Political and firewall barriers between Laboratories
- Perception that GroupMeld™ duplicates functionality available from commercial collaboration tools
- Low perceived value of collaboration capability

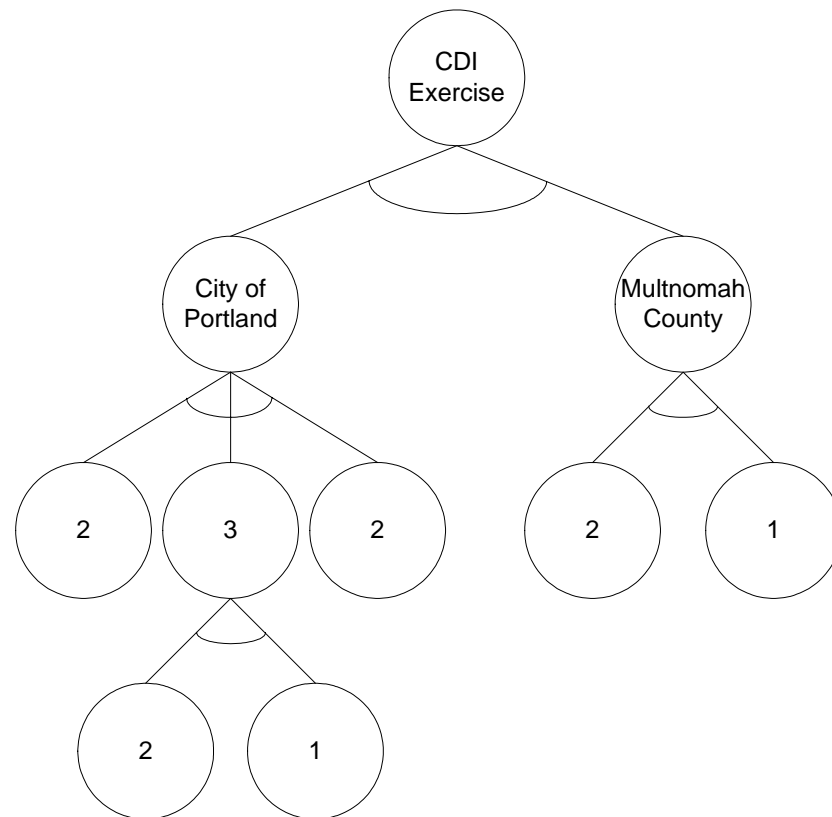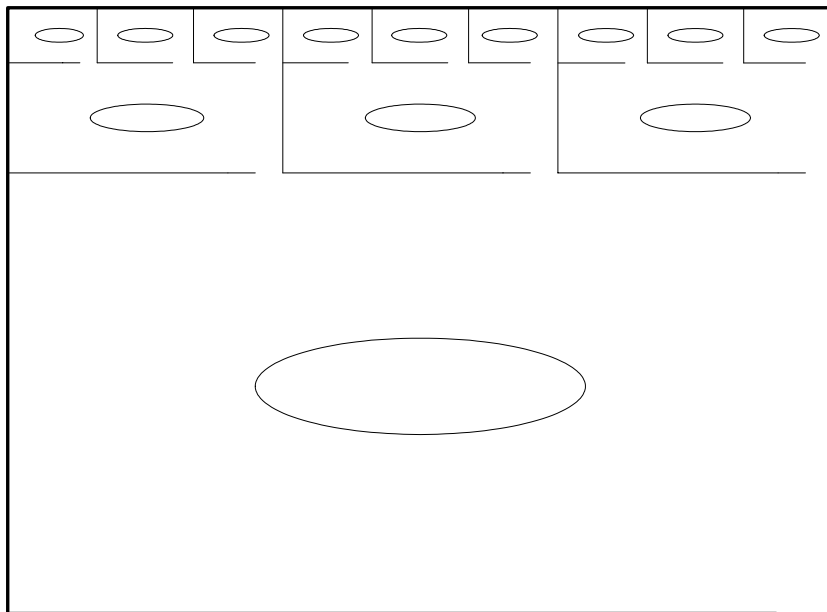# Observed Structure of Collaboration

- Three levels of collaboration transaction structure were observed
  - Agenda
  - Subgroup
  - Chapter (or "episode" or "scene")
- New representations and metaphors are needed to explicitly model this structure
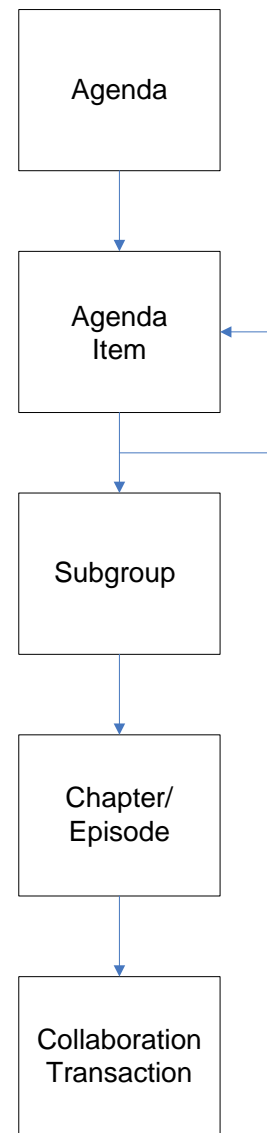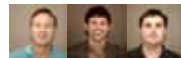
New Metaphors

Agenda-Based Awareness

| Task Name |
|---|
| ⊟ Is milk supply chain in balance? |
| ⊟ Run simulation 1 |
| Create model for simulation |
| Submit to simulation engine |
| Validate the results |
| ⊟ Run simulation 2 |
| Create model for simulation |
| Submit to simulation engine |
| Validate the results |
| ⊟ Run simulation 3 |
| Create model for simulation |
| Submit to simulation engine |
| Validate the results |

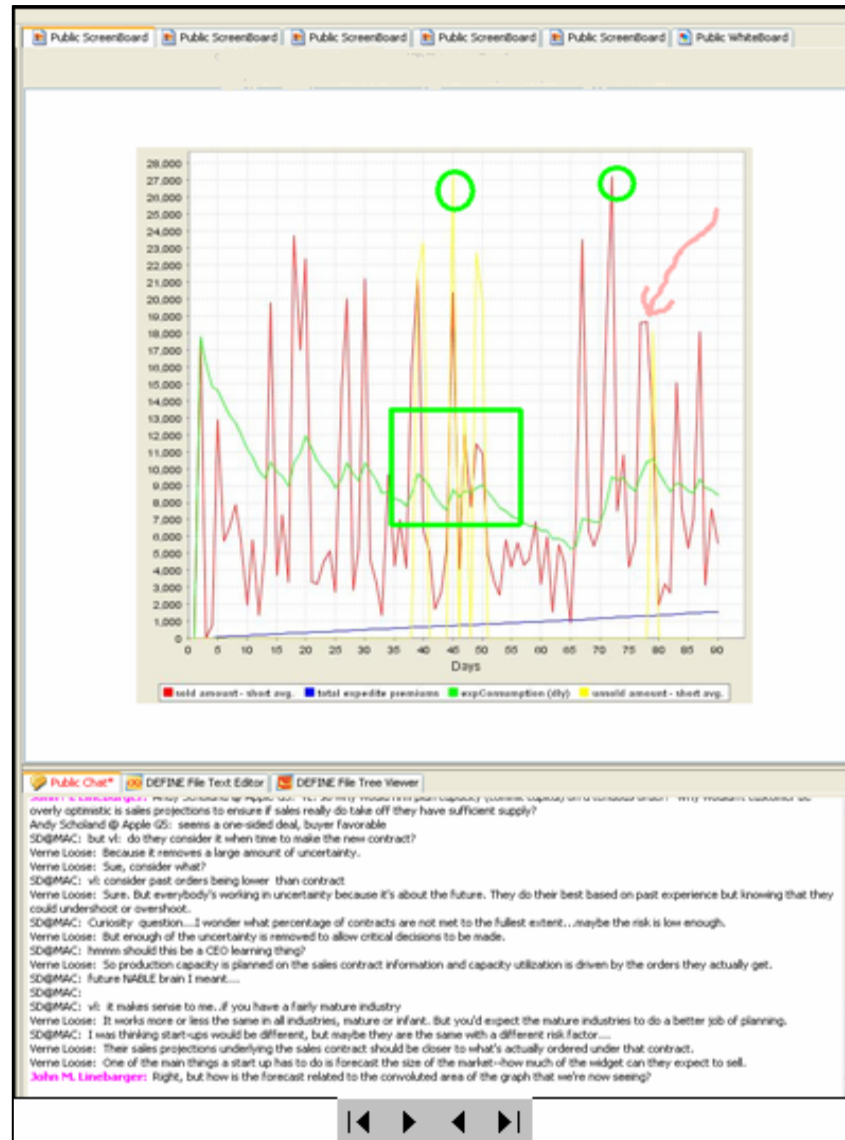# Foregrounding Collaboration Context
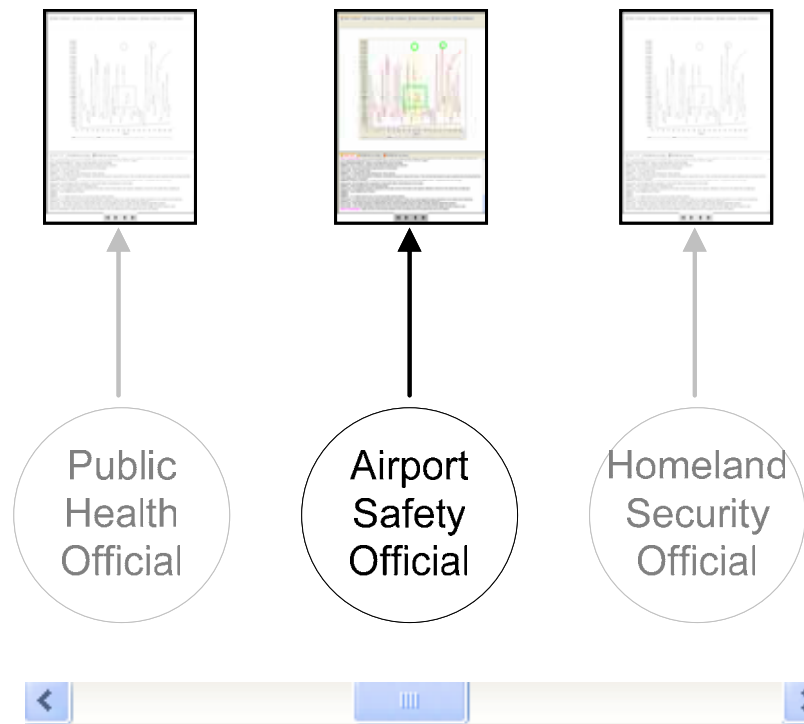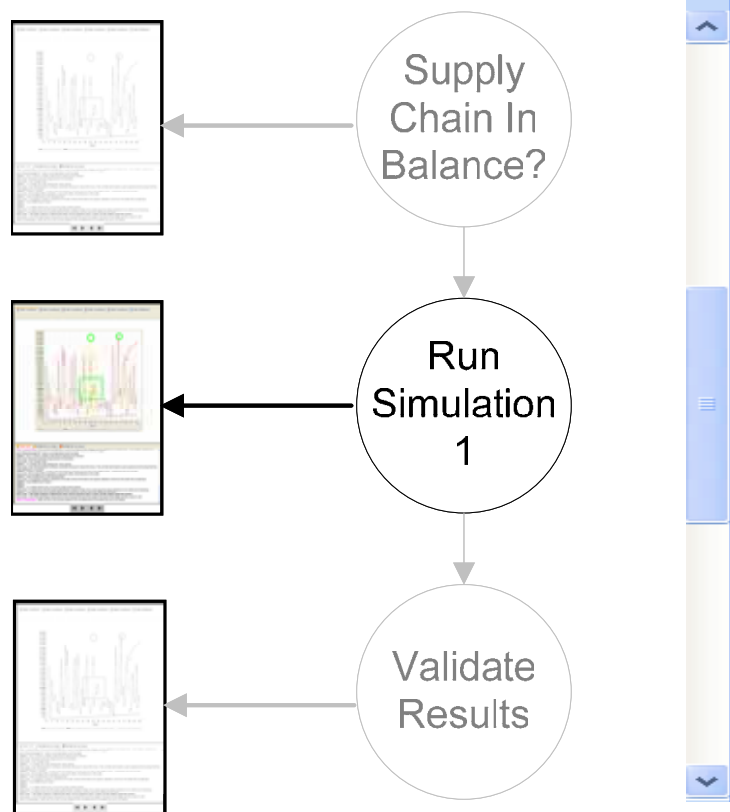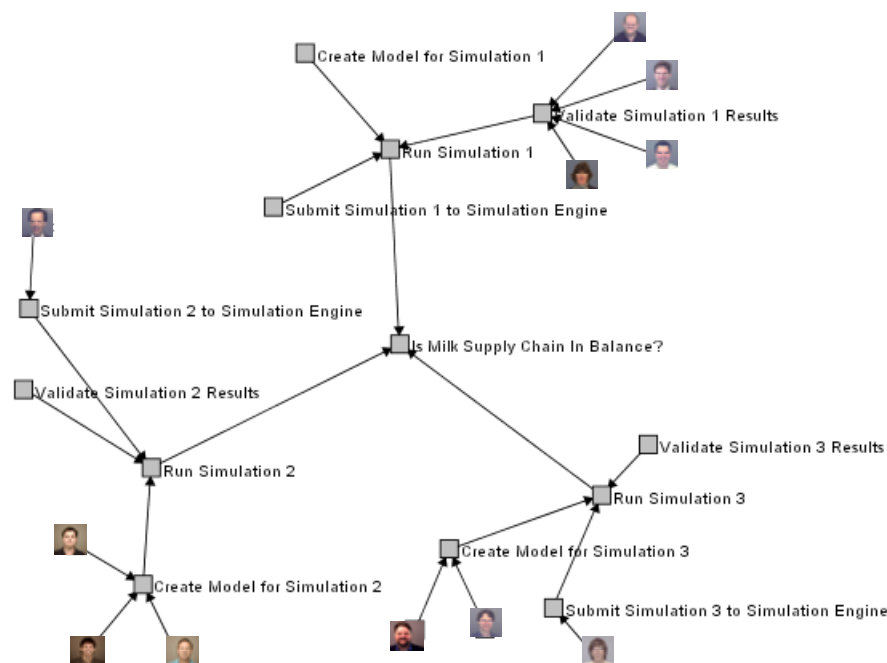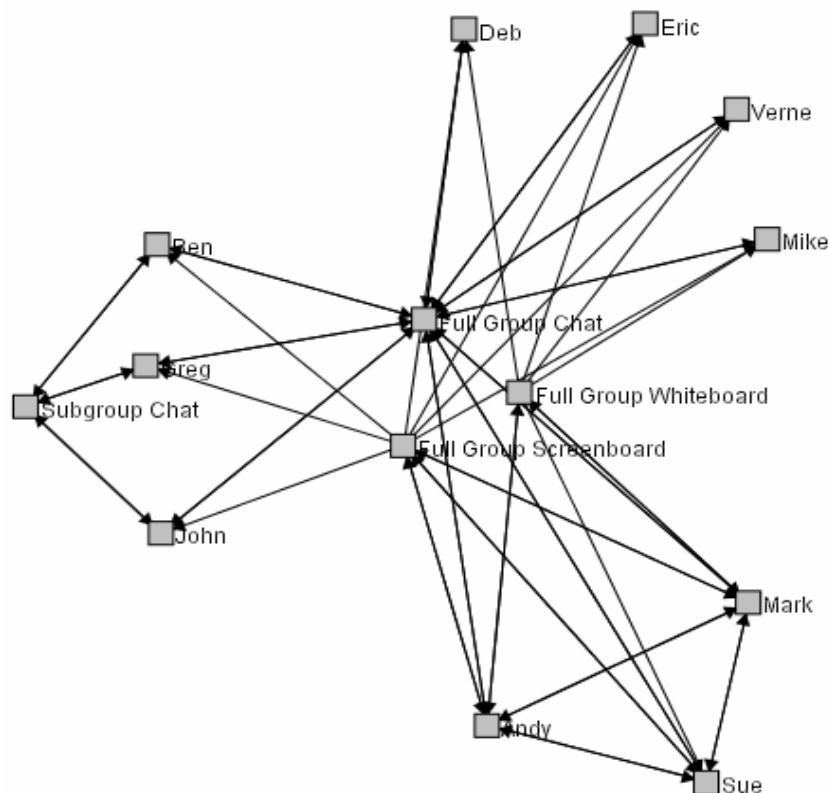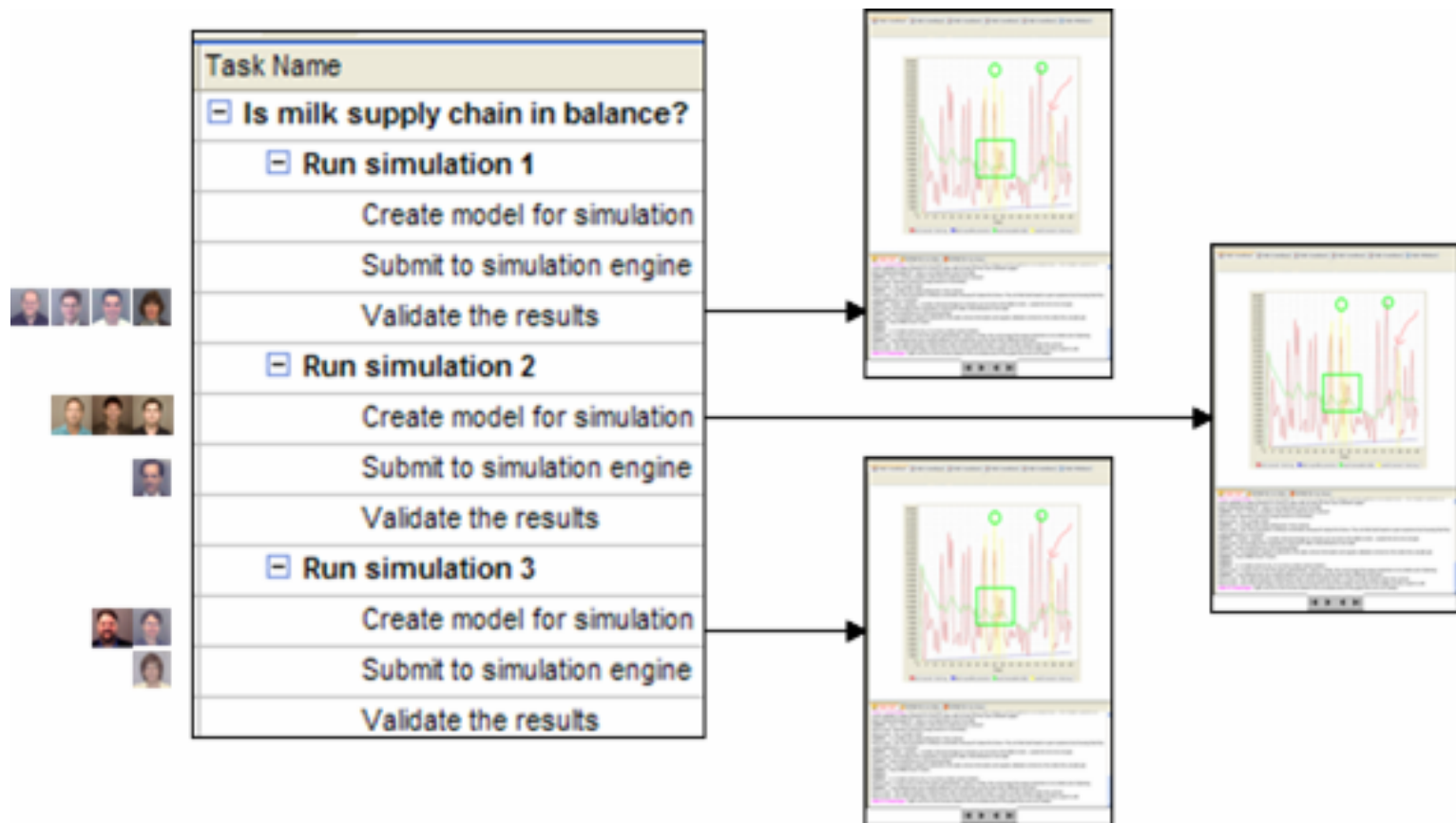
Linking the Representations Together

Integrated Use Case

- Collaboratively create the agenda for the collaboration session

- Divide into subgroups to carry out the agenda
  - Manipulate infinitely recursive conference room widget, collaboration tree widget, or agenda widget
  - Use slider interface to foreground the active collaboration context

- Determine chapter boundaries by fiat or vote

- Use network views to get a snapshot of the state of the collaboration

- Play back the history of the collaboration using the VCR chapter view interface as part of a post mortem analysis

Conclusions

- The perception of the N-ABLE™ analysis team was that collaboration capability improved their ability to form common mental models of both problem and solution
- Application-centered collaboration (collaboration through an application) appeared to focus the interaction and keep it on point
- Text chat is not enough! Group insight (*i.e.,* common mental model) was most often formed by chatting around a series of shared, annotatable screen images
- Collaborators generally participate in several collaboration contexts at the same time
- Collaboration was not amorphous or linear but structured
  - Episodic structure appeared to follow an implied agenda
  - Explicit representations for collaboration structure are needed

Future Work

- Currently in "maintain and market" mode for funding reasons
- Should funding become available:
    - Implement and measure the benefits of the proposed representations of collaboration structure
    - Save chapter views to a repository
    - Allow multiple active ScreenBoards
    - Support fully recursive subgrouping capability
    - New communication architecture needed
        - Traverse firewalls
        - "Send once to central open server and all members pull from there" as opposed to "push to all peers in the session"