Web-Based Resource Coordination for Effective Distributed Collaborative Decision Making

Rita M. Vick
University of Hawaii at Manoa
Honolulu, Hawaii USA
vick@hawaii.edu

ABSTRACT

Effective use of Web applications by distributed heterogeneous work teams depends on team ability to effectively discover, retrieve, and coordinate technological and human resources. Successful process and product delivery also depend on both push and pull delivery of information to meet both ad hoc and ongoing information resource needs. The described research extends current theory by analyzing resource coordination requirements during distributed decision-making under time and resource constraints. Results of this work suggest the real design, implementation, application, and diagnostic usefulness of an enhanced model of team process where development of a shared mental model serves as a portal to and mediator of distributed situated cognition.

Keywords

Collaborative Web applications, decision making, shared mental model, distributed situated cognition, teamwork, resource management, human-computer interaction (HCI), computer-supported collaborative work (CSCW)

1. INTRODUCTION

Web-based technologies have enabled the globalization of business and continue to support change in organizational form and function leading to growing recognition of the benefits of B2B and B2C collaboration among businesses and research institutions. Given increasingly rapid development of new knowledge, accomplishment of research and development goals depends on leveraging the distributed expertise of individuals. Distributed teamwork is a principal strategy for effective implementation of Computer Supported Collaborative Work (CSCW) systems to accomplish these goals.

Coordination of resources is a significant problem during collaboration. Global distribution of human, tangible, and intangible resources increases the need for coordination and exacerbates problems due to misalignment or lack of resources. The work-in-progress described here presents a framework for analysis of Web-based distributed group decision-making, which is a ubiquitous activity endemic to all information and communication transactions. Identification and analysis of resource management problems are critical to effective work process, productive workflow, and quality of work outcome.

2. THEORY BASE

This research presents a significant step forward in understanding and representing distributed situated cognition. DeSanctis and Poole's **Adaptive Structuration Theory (AST)** [1] describes the use of existing and emergent technological, human, and relational structures during use of collaborative technologies. Wright et al.'s **Distributed Information Resources (DIR)** framework [2] describes abstract information structures (e.g., plans, goals, history, action-effect relations), how these information structures (i.e., resources) may be represented during interaction, and how these information structures serve to inform the action of interactive work processes. The present research extends AST to include a **shared mental model** as mediator of resource coordination and assembler of emergent resource structures. The shared mental model is, itself, an emergent resource structure that serves as a **portal** to the **distribution of cognition** as this distribution changes throughout the team work process. Distributed cognition provides the glue that connects the emergent structures of the work process as described in AST with the emergent shared mental model that is the control mechanism determining the operation, extent, and termination of the work process as an open system. The shared mental model embodies **team memory** including placement and status of the components of distributed cognition throughout the work process (Figure 1). The proposed synthesis of the AST and the DIR frameworks has been tested using laboratory simulation of Web-based, naturalistic decision-making teams. The decision model developed during the team work process is the final product of the work process in the present study and it is the instantiation of (physical representation of) a team's shared mental model of its decision problem solution. Termination of the work process when dealing with ambiguous problems (e.g., policy issues) that have no "right" answer generally occurs due to exhaustion of resources (e.g., lack of new ideas, running out of time). Efforts at development of a better solution are discontinued based on recognition that, given situational constraints, a **"satisficing"** solution – i.e., a solution that is "good enough" – has been achieved. [3] This synthesis of AST and DIR, enabled by the shared mental model as mediator of resource coordination and cognition as distributed over contextual structures, initiates development of a cohesive model of distributed cognition.

3. METHODOLOGY

A **work context** was designed to enable gathering of detailed information about how **distributed teams** coordinate available resources when making decisions for design of collaborative work systems. Teams consisted of **culturally diverse** and **autonomous** mixed age and gender teams of three to five senior level undergraduate and graduate level computer science and engineering students. At the beginning of each work session, teams received a problem scenario to be resolved through completion of a decision model during the session. Teams worked under conditions of **uncertainty** (equipment or software failure, communication-related misunderstandings), **temporal constraint**, and **change** (task scope).

The **communication support system** used was NetMeeting, which supports minimalist assumptions with regard to conferencing functionality, ease of use, cost, and implementation requirements for hardware, software, and connectivity (http://www.microsoft.com/windows/netmeeting/). If necessary, it can be integrated into existing Web pages and tailored to specific user needs. Virtual teams can locate team members through use of public servers that provide dynamic directory services, they can use direct IP addresses if known, or they can deploy Microsoft Site Server to procure dynamic directory services. Meeting privacy can be assured by remaining "unlisted" on server directories.

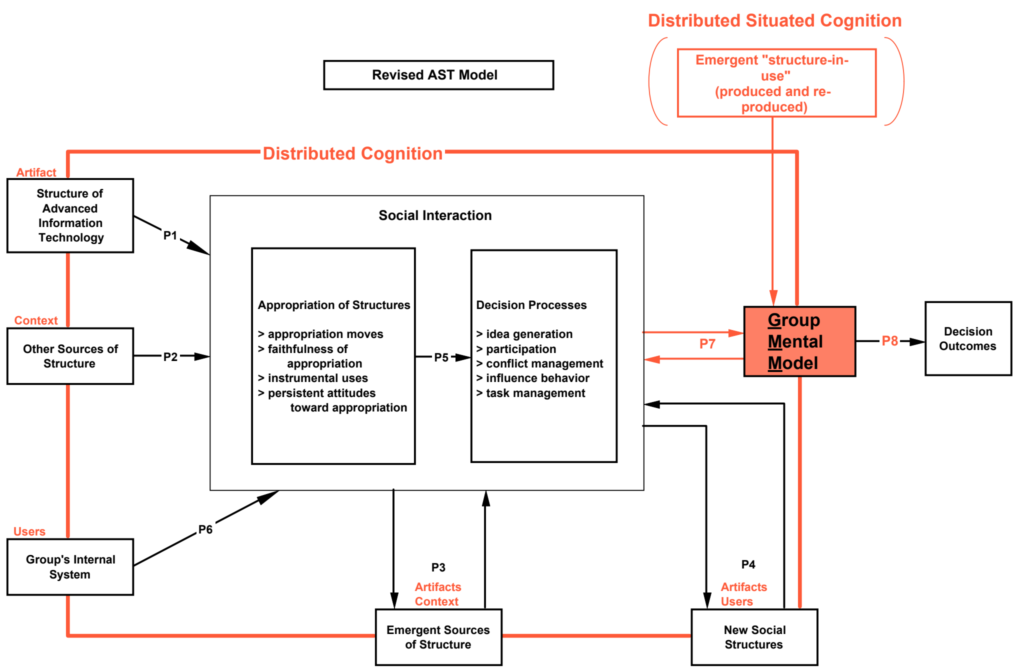

Figure 1. Proposed extension of AST model.

Decision process support was provided by TeamEC™ decision software (http://www.expertchoice.com/). TeamEC™ can be used for solution of qualitative as well as quantitative decision problems as varied as policy issues that have no single "right" solution, financial and human resource budgeting decisions, and analysis of software development productivity factors. Decision makers use the software to structure a decision tree consisting of goal, objective/criteria, alternative, and sub-alternative node levels, leaves, and branches. Decision logic is based on the Analytic Hierarchy Process (AHP) pairwise comparison methodology. TeamEC™ enables group decision-making by providing tools for brainstorming and ranking ideas; top-down, bottom-up, or direct model building; and assessment based on importance, preference, or likelihood using verbal, numerical matrix, or graphical comparison modes. Sensitivity analysis and synthesis of individually developed models are useful options. Decision rationale can be documented for subsequent analysis and/or justification of decision results.

Resources available to teams in the present study included communication support technology (NetMeeting) and public Internet Locator Service (ILS) servers, decision structuring software (TeamEC™), the situated context of computer laboratory hardware and connectivity, paper- and Web-based problem scenarios, Web-based course content material (related to group work, decision making, CSCW system design), human knowledge and skill bases dispersed among team members, and access to all other Internet-provided information for use in the production of the deliverables (Figure 2). Effective use of these resources depended on how they were instantiated and coordinated by each team. At the end of each work session, team chat transcripts, models, and whiteboards were saved. Teams remained intact through an average of ten sixty to ninety-minute sessions and engaged in persistent conversation over this period of time. The data collected allow for analysis of each team's process in terms of idea generation, model building activity, situation assessment (task management) and resource coordination (including damage control). The team deliverable (the decision model) will be analyzed in terms of validity of structure and content. Taken together, this data details development of the shared mental model, documents specific instances of resource coordination effectiveness, signals specific points where resources inform action, and highlights action-effect relations indicative of the varying distribution of cognition during the interaction process.

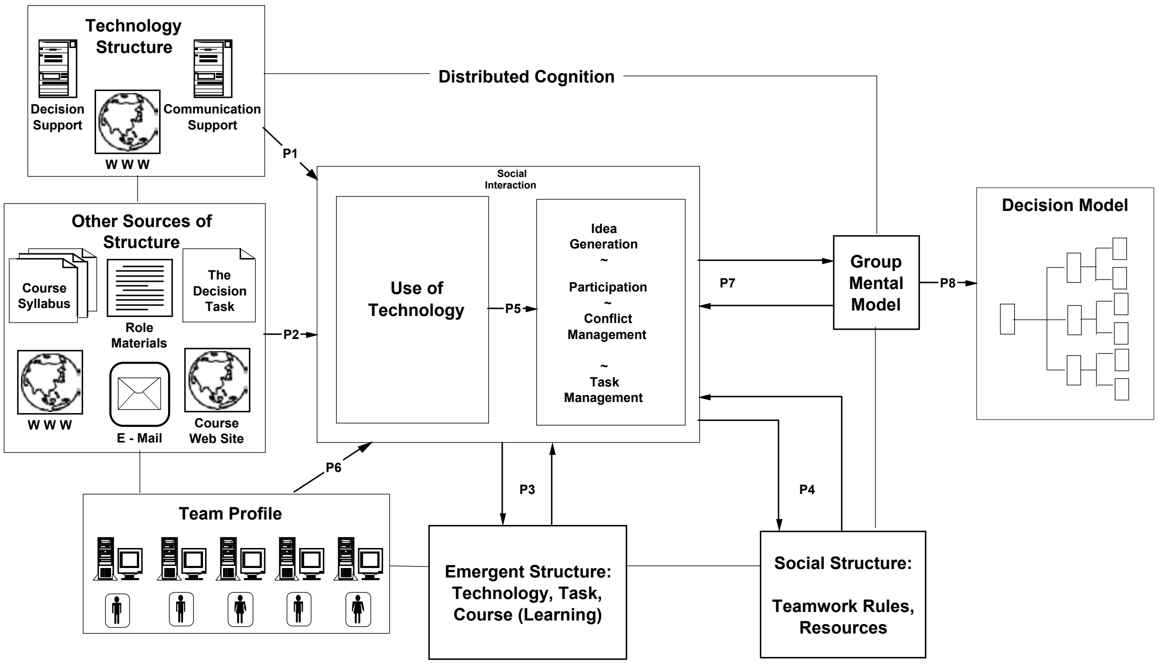

Figure 2. Extension of AST model as instantiated in teamwork sessions.

Work sessions will be compared within and between teams. It is expected that analysis of these repeated measures of team process and performance will provide insight into team learning and work processes. Detailed analysis of meeting phases is expected to provide evidence of dynamic, reentrant, and cyclical problem solving. Specifically, conversational interaction will be analyzed in conjunction with the accompanying model to identify specific points in the work process where excess demand on resources, overload of resource-generated information, or resource failure has caused disruption of the work process. These incidents can then be analyzed to determine method and effectiveness of team recovery. Chat transcripts will be micro coded for specific interactions and macro coded to examine the overall gist of particular phases of the team process.

4. CONCLUSION

In terms of theory development, the proposed analysis will provide evidence critical to further development of the proposed shared mental model and distributed cognition extensions of AST which, in turn, will enable development of an effective model of distributed cognition. Practical implications of this study for distributed teamwork include improved knowledge of how information resources are coordinated, how ad hoc use of information sources can be accommodated, how to design effective information access, and how to leverage technological, human, and archival resources for maximum effectiveness. This will enable improved workflow process modeling in conjunction with improved design of Web-based CSCW applications and required information support systems. The necessary complexity of these systems will require embedding of adaptive artificial intelligent agents capable of "pushing" information should human agents fail to "pull" information as required. Institutionalization of CSCW systems is vital for effective information sharing given the increasingly complex global work environment where accelerated development of new knowledge makes it impossible for any one person to know everything. The suggested framework for analysis of context-based interaction, knowledge sharing, and information use is a critical step along the way to enabling development of unobtrusively adaptive and organizationally aware CSCW systems.

5. REFERENCES

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