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A Mobile Collaborative Decision Support Architecture

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Abstract Advances in the mobile communication technology has increased the possibility of linking interdependent or individual decision making units together in an organization, and providing them with tools to facilitate decision support and problem solving. This paper explores how we align a mobile system with collaborative decision support as a critical enhancement. The designer of mobile collaborative decision support architecture (MoCoDSA) should consider making the communication patterns and protocols in different ways, thus creating realistic system architecture for decision support and problem solving within the resource constraints. The effectiveness of a MoCoDSA system depends upon a number of factors such as the task characteristics, the decision maker characteristics, the nature of the system, and application environment. This study explores to develop a design framework of a general collaborative decision support system in a mobile environment.

Keywords Collaborative decision making, system architecture, task characteristics, mobile system

1 Introduction

As mobile system technologies advance and the market becomes mature, users also find that a mobile system becomes an integral part of their professional life. However, contributions on developing their applications suitable and effective for decision support, especially involving multiple participants, have relatively been sparse (Danninger, et al., 2007). We need to consider a general system modeling in order to have a balanced and holistic perspective on application design, decision support and problem solving process and should also focus on its effectiveness as well as assessment.

We plan to develop a theoretical framework as a basis of a future mobile decision support system. In doing so, the study explores the following questions: can we build a foundation of effective mobile decision support system architecture? How do we create an adaptive architecture in a constantly changing technology environment? How do we relate the effective decision support proposition with operational efficiency?

A mobile collaborative decision support system encompasses a domain application structure and context, information technology infrastructure, and task and group/organizational considerations in achieving the decision makers' goals and strategies (Chung, 2005). It should be made clear that building an advanced system that focuses on the communication aspect--typically text, audio, or video—does not address the essence of collaborative decision support. At the same time, designing a system that would serve all aspects of such a comprehensive need is neither feasible nor realistic.

In this paper, we focus on building a mobile collaborative decision support system model that can play a critical role of translating decision support and problem solving strategies into an architectural arrangement. More specifically, we discuss several issues. First, we explore the mobile system architecture from a task, application domain, and group collaboration perspective. Second, we emphasize the design consideration and implementation issues from a resource management perspective. Third, by delineating the characteristics of the design alternatives, the study examines the parameters that determine the appropriate choice for a specific implementation.

2 Collaborative Decision Support

Organizational decision support typically requires communication and coordination among multiple organizational units involved in a problem solving task. Based on the task characteristics, Hackathorn and Keen (1981) have identified three types of support needed for problem solving and decision making in an organization: personal support, group support, and organizational support. Personal support is necessary for tasks that are independent. A single decision maker independently conducts a task in interaction with a counterpart, either a mobile device or another person. For this, typical communication components and standalone decision support tools might serve the purpose well. Most individual decision support applications using a cellular system are typical examples of such personal support. Group support is required for a task in which a group of decision makers jointly learn or solve problems. Group technology provides support to this kind of tasks. The conference call capability of a cellular phone is an example of a communication component. A multi-person game is another example. A task comprising multiple interdependent subtasks and involving several decision support units in a specific sequence requires group or organization-wide support in a collaborative setting. Deiglmayr and Spada (2010) focused on collaborative inferences in group problem solving. Based on information sharing in a distributed environment, they examined whether such collaborative inferences could generate new information beyond individual inference of each participant. Braun and Graether (2007) designed a portal for mobile devices that includes a social interaction function.

Therefore, it is necessary to consider the tools to support decision support and problem solving as well as the tools for communication and coordination among these separate but interdependent units. A typical mobile system does not address such collaborative decision support and problem solving requirement yet.

3 A Mobile Collaborative Decision Support Architecture (MoCoDSA)

In a collaborative application environment, a mobile system model that focuses on decision support and problem solving involving multiple participants is termed as mobile collaborative decision support architecture (MoCoDSA). In this paper, the term MoCoDSA is used to denote a mobile system that supports decision making, problem solving, communication, collaboration, and coordination among a network of decision support and problem solving nodes in a group or an organization.

Each node in the network is a decision support unit that may comprise a single person using a task/person specific device independently or a group of decision makers using a group technology offered by a mobile unit. In the latter case, each node is responsible for some part of a larger and more complex decision support and problem solving. These tasks can be characterized by having the following attributes: they are complex and require diverse skills and knowledge for decision support and problem solving. They can be broken down into a number of subtasks each of which can be solved by one or a group of participants. Their subtasks are interrelated. The outcome or process in one subtask may become input to other subtasks, and, thus, may constrain the next process or outcome generated in these dependent subtasks. There may be an orderly relationship among the subtasks although they are not necessarily aligned to a hierarchy. Some of the subtasks may involve synthesis and refinement of decision support passed on by prior subtasks. The decision support and problem solving process for such tasks may span more than one level in the task hierarchy and/or more than one application area. Examples of tasks that satisfy these criteria are emergency response training or an integrated product design.

In the MoCoDSA, it is necessary to facilitate horizontal integration (cross-functional) and vertical integration (different levels of the organizational hierarchy) of a mobile system used by various participants to support collaborative decision support and problem solving. Thus, the design consideration of a mobile system needs to address these issues.

The topology of such a MoCoDSA is a “graph” in which the “nodes” represent the decision support and participating units and the “arcs” represent the communication channels connecting these units. A MoCoDSA can be viewed as a graph comprised of a set of nodes and a set of arcs that connect the nodes. In the MoCoDSA, each node is supported by three components: (1) decision support and problem solving support and information services, 2) a set of decision support and problem solving tools in each unit and 3) a communicator which handles communication with other nodes. See Figure 1.

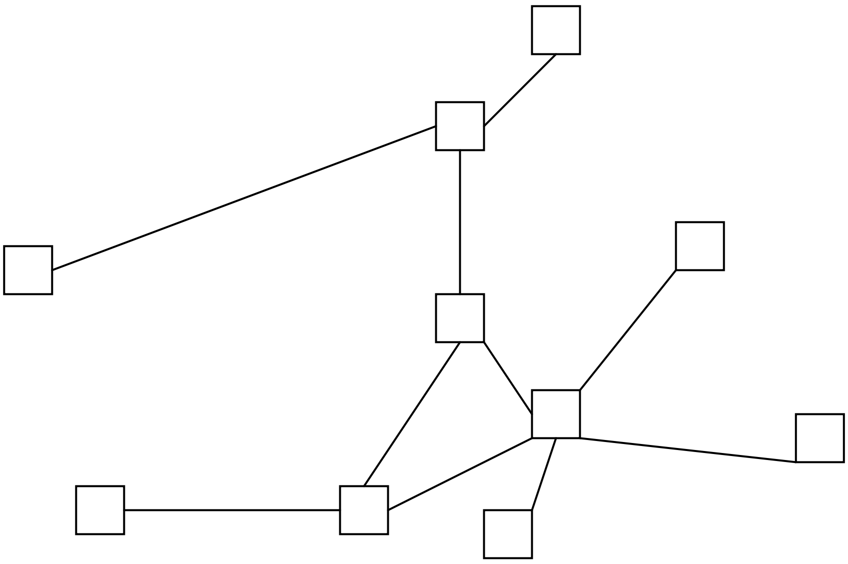

Figure 1 A Graph

Mathematically, a graph *G* is a set of vertex (nodes) *v* connected by edges (links) *e*. Thus *G*= *(v, e)* (Rodrigue, et al., 2006). A node *v* is a terminal point or an intersection point of a graph. It is the abstraction of a location such as a user, decision-maker, or a computing device. An edge *e* is a link between two nodes.

The link (i, j) is of initial extremity i and of terminal extremity j. A link is the abstraction of a transport infrastructure supporting movements between nodes. It has a direction that is commonly represented as an arrow. When an arrow is not used, it is assumed the link is bi-directional.

A collaborative system as a network enables flow of communications, information, or decisions which are occurring along its links. The graph theory thus offers the possibility of representing collaboration as linkages. For example, a set of two nodes as every node is linked to the other.

4 Design Considerations of a MoCoDSA

Silver (1990) provides a relevant discussion for understanding differences in problem solving and decision support resulting from the designer's attitudes toward change. He uses two attributes, "system restrictiveness" and "decisional guidance," to distinguish different strategies for support system design. These attributes are extended to address the communication and coordination mechanisms used in a MoCoDSA. As the problems faced by an organization become increasingly complex, the organization tends to exhibit division of labor and a greater specialization of roles (Bonczek, et al., 1979). As a result, organizations incorporate a structure of communication and authority to enable them to perform efficiently in the environment. The structure of an organization is supposed to determine, or at least ease, the problem of task decomposition. The structure of roles in an organization serves as a guide to determine who is knowledgeable to address which part of problem solving. Rathwell and Burns (1985) envisioned the distributed decision making as a loosely coupled dynamic network of nodes without any central controlling node. In such cases, decision support and problem solving process consists of well defined, formal procedures that regulate the interaction among the nodes of a MoCoDSA. With this type of a MoCoDSA, the process is institutionalized and aligned with the architecture of an organization, i.e., it follows the problem solving and organizational control structure (Linthicum, 1999).

Detienne (2006) describes the specific characteristics of cooperative work interdependencies related to the nature of a design problem and the fundamental function of design cooperative work arrangement. The study exemplifies these two characteristics of the design work stress specific cooperative processes: coordination processes in order to manage task interdependencies, establishment of common ground and negotiation mechanisms in order to manage the integration of multiple perspectives.

In the base level of MoCoDSA, only communication support, such as electronic mail, instant messaging, or voice communication, is provided. A cell phone system is an example. In this case, MoCoDSA functions are simply to provide the communication channels among the nodes. In this sense, a communication medium by itself is passive and does not provide much structuring or support to the process. However, decision support and problem solving based on process structuring favors an active, yet constraining, involvement in the process. The decision support nodes supported by a comprehensive MoCoDSA implementation have latitude to select among different decision support and problem solving support tools. Thus, a MoCoDSA can be designed to provide guidance to the process. Guidance constitutes an active, yet flexible, involvement in the process.

We view the design of MoCoDSA is primarily contingent upon a number of factors including the technology constraints, infrastructure management, and task/application characteristics, among others. See Figure 2.

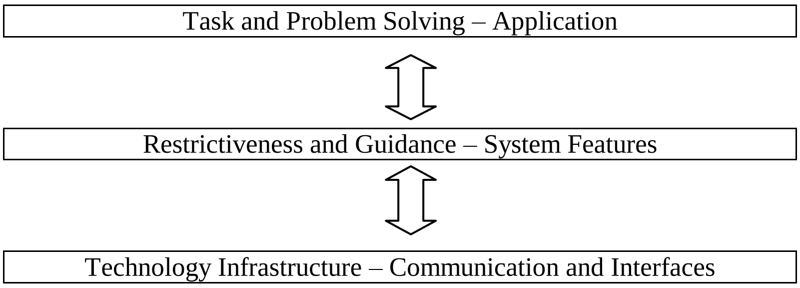

Figure 2. An Architectural Sketch

The appropriate design alternative for a particular MoCoDSA will be situation specific. In fact, designing a particular system involves three interrelated criteria: (1) the trade-off between efficiency and effectiveness, (2) the boundary of decision support and problem solving, and (3) the degree of alignment of the decision support and problem solving process with the architecture (Chung, et al, 1993, 2005, 2009).

5 Toward Operationalization and Evaluation

A real MoCoDSA falls somewhere in between the extremes of these criteria. An appropriate design alternative for a specific MoCoDSA depends upon a number of factors such as the task characteristics, the decision maker characteristics, the system capacity, and the environmental factors. These factors, to a great extent, determine the goodness of fit of a sophisticated a comprehensive mobile system. At the operational level, planning, designing, operating, and controlling such a sophisticated collaboration system to ensure achieving the intended goals of mobile decision support task is difficult to manage. It is because they are often challenged and defeated by the immediacy of decision support and problem solving caused by the factors often outside the control of decision makers. Decentralization of network services, diverse architectural arrangement, internal application demand, and mobility make coherent and coordinated infrastructure management more difficult. Moreover, a multi vendor environment as well as the rapidly advancing technologies further complicate the problem.

Spada, et al. (2005) study exemplify assessing collaborative process by defining characteristic dimension of collaboration. Burkhadrt, et al. (2009) measure and compare the quality of collaboration in a technology-mediated design domain. Their dimensions of communication process include grounding, coordination processes, task-related processes, symmetry of individual contributions and motivational processes.

6 Conclusion

Advances in the mobile communication technology have increased the possibility of linking interdependent decision support and problem solving units together in an organization, and providing them with communication, decision support and problem solving tools to facilitate the decision support process. This model is termed a MoCoDSA. The designer of a MoCoDSA has the choice of making the communication patterns and protocols in different ways, thus creating a realistic MoCoDSA for practical decision support. The kind of a MoCoDSA that will be effective in a particular setting depends upon a number of factors such as the task characteristics, the decision maker characteristics, and the nature of the system and application environment. The success of a MoCoDSA is also dependent on the designer's sensitivity to the nature of the interdependent tasks, feedback, synthesis and refinement of multiple subtasks and their processes, decision support and problem solving tools, and communication capabilities, among others. In this paper we tried to elaborate on the concept of the MoCoDSA, and described some alternative design choices.

The next research steps will further identify and examine various MoCoDSA design features, and experimentally investigate the effectiveness of alternative MoCoDSA designs in different settings. Future research efforts will be directed towards the development of a MoCoDSA prototype and empirically verify the validity of the framework proposed.

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