44

Information Technology for Enhancing Team Problem Solving and Decision Making

44.1 Introduction

Fueled by a combination of decreasing costs and increasing capabilities, information technology (IT) has penetrated almost every successful workplace. Organizations have long focused on supporting the individual needs of their workers by offering applications such as word processors, spreadsheets, and database systems. However, with the advent of cost-effective communication technologies and ubiquitous Internet access, workplaces have become connected. As a result, the use of IT has shifted over the past 20 years from supporting pure computation activities toward coordination and collaboration activities within and between organizations. IT has become the essential vehicle for mediating interpersonal and group communication. As such, the nature and appearance of IT have changed accordingly. Information systems have taken the shape of socio-technical networks that are designed specifically to make information workers more effective at their jobs by means of making problem-solving and decision-making tasks more collaborative.
Collaboration technologies have enabled people to work together by sending, receiving, storing, retrieving, and co-creating information. This type of IT overcomes traditional collaboration constraints such as time, space, and hierarchy (Coleman and Levine, 2008; Lewin and Stephens, 1993). Although IT is often seen as an enabling technology, it can also be considered a requirement for effective organizational coordination and collaboration. Organizational work is increasingly becoming a group effort that requires flexibility and adaptiveness (Bunker and Alban, 2006; Ellinger, 2000; Hardy et al., 2005; Malone and Crowston, 1990; Tjosvold, 1988). Fundamentally, collaboration and coordination are the essential ingredients of organizational life: organizations form because people have to work together to create value that they cannot produce by themselves (Mintzberg, 1983). As coordination and collaboration require extensive information exchange, well-designed and usable systems are necessary to support the interdependencies between the actors in teams and organizations. Therefore, organizations require collaboration technologies that are capable of disseminating information fast, economically, reliably, and securely (Corbitt et al., 2000; Nunamaker et al., 2001).

This chapter addresses how organizations can enable teams to be more productive with collaboration technology. We first present a classification of the different types of collaboration technologies that organizations can use. Then, we introduce a model of team processes that describes the fundamental patterns of collaboration that teams can engage in, regardless of whether they use collaborative software applications or not. These patterns include Generate, Converge, Organize, Evaluate, and Build consensus. We describe key findings from past research, especially in the area of group support systems (GSSs), to illustrate how collaboration technology supports different types of team work in each of the five patterns. Next, we move from the team level to the organizational level where we discuss and illustrate the impact and added value of collaboration technology in an organization as a whole. We conclude this chapter by outlining three key future directions for collaboration technology research and practice.

44.2 Classification of Collaboration Technologies

This section examines the different types of collaboration technologies that are currently available. What began as an area with a few dozen professional applications in the early 1980s has grown to an industry for thousands of different systems, ranging from simple group texting apps to integrated work environments where teams communicate, deliberate, co-create, and store electronic artifacts (e.g., documents, models, and audio files). Taking a closer look at the typical capabilities that various collaboration technologies afford, Mittleman and colleagues classified them under four main categories according to their most fundamental capabilities: (1) jointly authored pages, (2) streaming tools, (3) information access tools, and (4) aggregated systems (Mittleman et al., 2009). The fourth category is for technologies that must integrate a mix of tools from the first three categories and optimize them to support work practices that cannot be achieved with a single technology. Each of these main categories can be subdivided into a number of subcategories based on the functions they are optimized to support. The complete classification scheme is presented in Table 44.1. Next, we discuss each of these categories in more detail.

44.2.1 Jointly Authored Pages

The most fundamental capability for all technologies in the jointly authored pages category is a digital page, defined as a single window to which multiple participants can contribute, often simultaneously. The pages might be able to represent text, graphics, numbers, or other digital objects. However, regardless of content, any contribution made by a participant will generally appear on the screens of the other participants who view the same page. A given technology based on jointly authored pages may provide a single page or multiple pages. Sometimes these tools allow for the creation of hierarchies or networks of pages. Jointly authored pages are the basis for several subcategories of collaboration technology including conversation tools, shared editors, group dynamics tools, and polling tools.
Conversation tools are those primarily optimized to support dialog among group members. E-mail is a widely used conversation tool as well as short message service (SMS) (i.e., cell phone text messaging) that has become a ubiquitous application. According to the International Telecommunication Union, 6.1 trillion text messages were sent in 2010 (ITU, 2010). Other conversation tools include instant messaging, chat rooms, and blogs or threaded discussions. Instant messaging and chat rooms provide users with a single shared page to which they can make contributions to a chronologically ordered list. Participants may not move, edit, or delete their contributions. Instant messaging and chat rooms differ from one another only in their access and alert mechanisms. With instant messaging, an individual receives a pop-up invitation that another individual wishes to hold a conversation, while with chat rooms an individual browses to a website to find and join a conversation. Blogs (otherwise known as web logs) and threaded discussions are optimized for less-synchronous conversations. Users make a contribution, then come back later to see how others may have responded. Blogs and threaded discussions are typically persistent (i.e., their content remains even when users are not contributing), whereas chat rooms and instant messaging are usually ephemeral (i.e., when the last person exits a session, the session content disappears).

Shared editor tools are typically a jointly authored page optimized for the creation of a certain kind of deliverable by multiple authors. The content and affordances of these tools often match those of single-user office suite tools (e.g., word processing or spreadsheets). However, they are enhanced to accept
contributions and editing by multiple simultaneous users. A wiki (the Hawaiian word for “fast”) is another example of joint document authoring. Wikis are simple web pages that can be created directly through a web browser by any authorized user without the use of offline web development tools.

Group dynamics tools are optimized for creating, sustaining, or changing patterns of collaboration among individuals making a joint effort toward a goal. The patterns these tools support include generating ideas, establishing shared understanding of them, converging on those worth more attention, organizing and evaluating ideas, and building consensus (Briggs et al., 2006). These tools are often implemented as multiple layers of jointly authored pages such that each contribution on a given page may serve as a hyperlink to a subpage. The affordances of such tools are typically easily configurable, so at any given moment a group leader can provide team members with the features they need (e.g., view, add, and move) while blocking features they should not be using (e.g., edit and delete).

Polling tools are a special class of jointly authored pages, optimized for gathering, aggregating, and understanding judgments or opinions from multiple people. At a minimum, the shared pages of a polling tool must offer a structure of one or more ballot items, a way for users to record votes, and a way to display results. Polling tools may offer rating, ranking, allocating, or categorizing evaluation methods and may also support the gathering of text-based responses to ballot items.

44.2.2 Streaming Technologies

The core capability of all tools in the streaming technologies category is a continuous feed of dynamic data. Desktop sharing, application sharing, and audio/video conferencing are common examples of streaming technologies.

Desktop and application sharing tools allow the events displayed on one computer to be seen on the screens of other computers. With some application sharing tools, members may use their own mouse and keyboard to control the remotely viewed computer. This type of collaboration technology is often used in distributed training or support settings.

Audio conferencing tools provide a continuous channel for multiple users to send and receive sound while video conferencing tools allow users to send and receive sound and moving images. Typically all users may receive contributions in both types of tools. Systems may, however, vary in the mechanisms they provide for alerts and access control as well as by the degree to which affordances can be configured and controlled by a leader.

44.2.3 Information Access Technologies

Information access technologies provide ways to store, share, classify, and find data and information objects. Key examples in this category include shared file repositories, social tagging, search engines, and syndication tools.

Shared file repositories provide mechanisms for group members to store digital files where others in the group can access them. Some systems also provide version control mechanisms such as check-out/check-in capabilities and version backups.

Social tagging allows users to affix keyword tags to digital objects in a shared repository. For example, the website del.icio.us allows users to store and tag their favorite web links (i.e., bookmarks) online so that they can access them from any computer. Users are not only able to access their own bookmarks by keyword, but bookmarks posted and tagged by others as well. More significantly, users can find other users who share an interest in the same content. Social tagging systems allow for the rapid formation of communities of interest and communities of practice around the content of the data repository. The data in a social tagging repository are said to be organized in a folksonomy, an organization scheme that emerges organically from the many ways that users think of and tag contributions, rather than in an expert-defined taxonomy.
Search engines use search criteria provided by team members to retrieve digital objects from among vast stores of such objects (e.g., the World Wide Web, the blogosphere, and digital libraries). Search criteria may include content, tags, and other attributes of the objects in the search space. Some search engines interpret the semantic content of the search request to find related content that is not an exact match for the search criteria.

Syndication tools allow a user to receive a notification when new contributions are made to pages or repositories they find interesting (e.g., blogs, wikis, and social networks). Users subscribe to receive update alerts from a feed on a syndicated site. Every time the site changes, the feed broadcasts an alert message to all its subscribers. Users view alerts using software called an aggregator. Any time a user opens their aggregator, they see which of their subscription sites has new contributions. Therefore, users do not need to scan all contents to discover new contributions.

### 44.2.4 Aggregated Technologies

Aggregated technologies integrate several technologies from the other three categories and optimize them to support tasks and processes that cannot be executed using a single technology. Aggregated technologies deliver value that could also be achieved with a collection of stand-alone tools. There are many examples of aggregated technologies, among them virtual workspaces, web conferencing systems, social networking systems, and GSS. Virtual workspaces often combine document repositories, team calendars, conversation tools, and other technologies that make it easier for team members to execute coordinated efforts (e.g., SharePoint). Remote presentation or web conferencing systems often combine application sharing and audio streams with document repositories and polling tools optimized to support one-to-many broadcast of presentations, with some ability for the audience to provide feedback to the presenter (e.g., WebEx or SameTime). Social networking systems (e.g., MySpace, Facebook, or Flickr) combine social tagging with elements of wikis, blogs, other shared page tools, and a search engine so that users can find and communicate with their acquaintances as well as establish new relationships based on mutual friends or mutual interests. Thus, aggregated technologies may combine any mix of shared-page, streaming, and information access technologies to support a particular purpose.

GSSs integrate collections of group dynamics tools to move groups seamlessly through a series of activities toward a goal, for example, by generating ideas in one tool, organizing them in another, and evaluating them in yet another (e.g., ThinkTank or MeetingWorks). Specifically, a GSS is a collection of collaborative meeting tools designed to improve creative co-creation, problem solving, and decision making by teams (de Vreede et al., 2003). A GSS is typically implemented on a collection of personal computers that are connected through a (wireless) LAN or through the Internet. Sometimes, participants work in meeting rooms especially designed for electronically supported meetings. Other times, the participants simply move laptop computers into a standard meeting room and begin their work. Still other times, participants used lean GSS applications asynchronously, especially since the emergence of web-based GSS applications in the mid-2000s.

A GSS permits all participants to contribute at once by typing their ideas into the system. The system immediately makes all contributions available to the other participants on their screens. Nobody has to wait for a turn to speak, so people do not forget what they want to say while waiting for the floor. People do not forget what has been said, because there is an electronic record of the conversation on their screens. GSSs also allow a team to enter ideas anonymously. During the generation phase of creativity, it is often useful to get every idea on the table, but people often hold back unconventional or unpopular ideas for fear of disapproval from peers or superiors. Anonymity allows ideas to surface without fear of repercussion.

In the remainder of this chapter, we will focus predominantly on GSSs as they represent the type of collaboration technology that probably has received most attention from collaboration researchers during the past three decennia. Especially from the late 1980s until the late 1990s, an extensive body of GSS research was published (for overviews, see Dennis et al., 2001; Fjermestad and Hiltz, 1998, 2000;
Using Information Systems and Technology to Support Individual and Group Tasks

Nunamaker et al., 1997). Since the mid-2000s, GSS researchers have shifted from a predominant experimental focus to a focus on engineering and design science studies (see, e.g., Kolfschoten and de Vreede, 2009; de Vreede et al., 2009). The extensive scholarly attention for GSS is not surprising as this technology represents one of the few software applications that were originally developed by researchers in universities and subsequently became commercially available. Currently, there are a few dozen commercial GSS applications available in the market. Even though organizations have reported significant benefits from using GSS, sustained use of these applications has been challenging as will be discussed in a later section.

### 44.3 Types of Team Work: Patterns of Collaboration

Notwithstanding the plethora of collaboration technologies that are available for teams to facilitate their work, fundamentally teams need more than just technology to achieve productive collaboration efforts. Productive collaboration originates from the purposeful alignment of people, processes, information, and leadership with the technology the team uses (de Vreede et al., 2009). A critical component in this socio-technical setting concerns how teams move through their collaborative processes. Researchers have identified distinctly different ways in which a team’s problem-solving and decision-making processes proceed, called patterns of collaboration. Patterns of collaboration are observable regularities of behavior and outcome that emerge over time when a team moves toward its goals (de Vreede et al., 2006).

There are six different patterns of collaboration (Kolfschoten et al., in press; de Vreede et al., 2009):

- **Generate**: To move from having fewer concepts to having more concepts in the set of ideas shared by the group.
- **Reduce**: To move from having many concepts to a focus on fewer ideas deemed worthy of further attention.
- **Clarify**: To move from less to more shared understanding of the concepts in the set of ideas shared by the group.
- **Organize**: To move from less to more understanding of the relationships among concepts in the set of ideas shared by the group.
- **Evaluate**: To move from less to more understanding of the instrumentality of the concepts in the idea set shared by the group toward attaining group and private goals.
- **Build commitment**: To move from fewer to more group members who are willing to commit to a proposal for moving the group toward attaining its goal(s).

Most of the behaviors in which a team engages as it moves through a collaborative process can be characterized by these six patterns. For example, when a team moves through a product development activity, they may **generate** innovation ideas, **clarify** these ideas by re-stating them so that all members understand their meaning, **evaluate** the expected profitability and ease of implementation of each innovation idea, **reduce** the list to the innovations that are most promising, and **build commitment** on the actions to take to develop a complete business case for each innovation.

Researchers have studied phenomena relating to each of the six patterns of collaboration. With respect to the **Generate** pattern, for example, studies report the number of ideas a group produces (Connolly et al., 1990), or their originality, relevance, quality, effectiveness, feasibility, and thoroughness (Dean et al., 2006). People generate by creating new ideas (Reiter-Palmon et al., 1997), by gathering previously unshared ideas (Bock et al., 2005), or by elaborating on existing ideas with additional details (de Vreede et al., 2010). For the **Reduce** pattern, researchers address, for example, the number of ideas in the shared set, the degree to which a reduced idea set includes high-quality ideas and excludes low-quality ideas (Barzilay et al., 1999), and the degree to which reduction of idea sets yields reductions of actual and perceived cognitive load (Simpson and Prusak, 1995). Groups reduce idea sets through idea filtering (Chambless et al., 2005), generalizing ideas (Yeung et al., 1999), or selection (Rietzschel et al., 2006).
Researchers of the *Clarify* pattern focus on, among other things, reductions in ambiguity, reductions in the number of words required to convey meaning, and establishing mutual assumptions (Mulder et al., 2002). Among the phenomena of interest for research on the *Organize* pattern of collaboration are shared understandings of the relationships among concepts (Cannon-Bowers et al., 1993), cognitive load (Grisé and Gallupe, 2000), and the simplicity or complexity of the relationships among concepts (e.g., complex structures may signify sequence, hierarchy, and networks of relationships, which in turn may model, e.g., semantics of chronology, composition, heredity, or causation [Dean et al., 2000]). Research on the *Evaluate* pattern addresses projections of possible consequences of choices and the degree to which those consequences would promote or inhibit goal attainment (Westaby, 2002). Rating, ranking, and inclusion/exclusion are common means of evaluation (Gavish and Gerdes, 1997). Research on such techniques focuses, for example, on the degree to which participants can accurately project the likely outcomes of the proposals they consider (Laukkonen et al., 2002). Finally, phenomena of interest for the *Build Commitment* pattern pertain to the degree to which people are willing to contribute to the group’s efforts (Montoya-Weiss et al., 2001). Issues of commitment arise in many phases of group work, starting with the formation of the group (Datta, 2007), and continuing through every proposed course of action and every choice group members make as they move through their activities (Saaty and Shang, 2007). More detailed findings of information systems research in each of these areas are described in the next section.

### 44.4 Supporting the Patterns of Collaboration

This section examines past research on technology support for each of the patterns of collaboration. For this purpose, the *reduce* and *clarify* patterns will be combined into a pattern called *converge* as research in this area often addresses both patterns simultaneously.

#### 44.4.1 Generate

Idea generation (i.e., brainstorming) is the practice of gathering in a group and generating as many ideas for identifying or solving a problem as possible. Early brainstorming research conducted by Taylor et al. (1958) and later by Diehl and Stroebe (1987) indicated that nominal groups—groups in which ideas are pooled after individuals independently generate them—tended to generate more ideas than groups with team members who collectively interacted to generate ideas. This productivity loss in traditional lab teams occurred due to members being overwhelmed with information (i.e., cognitive load), social loafing, groupthink, and evaluation apprehension (Diehl and Stroebe, 1987). However, these experiments did not focus on teams that utilize strategic collaboration methods and technology. As such, later research showed that, under certain conditions, groups can improve key outcomes using collaboration strategies and technologies (for reviews, see Briggs et al., 1997; Dennis and Valacich, 1999; Fjermestad and Hiltz, 1998).

Nonetheless, effectively communicating pertinent instructions, monitoring participant contributions, dealing with conflict, and facilitating the flow of information/conversation can cause production losses even when a facilitator is charged with managing these issues. Fortunately, when combined appropriately, synergies between collaboration processes and technology can simplify and magnify the power of facilitation techniques. Collaboration technology, such as GSS, helps a facilitator simultaneously display tasks and instructions that group members need to understand in order to minimize the aforementioned challenges of collaboration and maximize the benefits of teamwork. In other words, this technology allows the facilitator to control what decision-making tasks group members see, how they can contribute to the group, and when they can contribute. Thus, it is easier for facilitators to break-down the collaboration process into simpler, independent activities.

During the idea generation process, technology can also be used to make team members focus on generating ideas rather than evaluating them. When team members assess the merit of ideas or try to
come to consensus while generating ideas, the quality, quantity, and originality of ideas tends to suffer (Basadur and Hausdorf, 1996). Further, technology allows team members to simultaneously contribute a massive number of ideas and transfer those ideas to subsequent collaboration activities, such as moving ideas into categories (i.e., idea organization) or voting on them (i.e., idea evaluation). Technology also can be used to greatly reduce interpersonal conflict that occurs during idea generation. For instance, GSS software can be configured so that participants contribute their ideas anonymously. This anonymity tends to improve collaborative problem-solving outcomes by reducing participants’ social fears, such as being judged, retaliated against, or condemned for disagreeing with an authority figure (e.g., supervisor, boss, professor, and client) (McLeod, 2011).

Moreover, being the foundation of most collaborative problem-solving and decision-making efforts, idea generation is typically credited with initiating group creativity and innovation. Creativity is defined as a novel, useful, and socially valued product, idea, or service (Amabile, 1982). Creativity occurs when an ill-defined problem is assessed from multiple perspectives (Mumford and Gustafson, 1988). As such, idea generation is at the core of team creativity because this collaboration pattern requires participants to engage in divergent thinking. Frequently, participants see ideas generated by others that inspire them to make connections and recommendations that they would not have thought of by themselves. Here, ideas from teammates serve as new idea “seeds” that can inspire creativity. To test this assumption, de Vreede et al. (2010) divided large groups into subgroups that were forced to generate ideas in a serial manner by building on the ideas of previously engaged subgroups. This technique proved to be more effective at facilitating creativity than parallel group member idea generation. Other studies have provided further support for the notion that certain types of instructions or methods for generating ideas can be used to maximize group creativity (Sosik et al., 1998; Zurlo and Riva, 2009). These studies highlight the importance of effectively pairing collaboration techniques and technology.

While the aforementioned studies were conducted by means of synchronous collaboration, more and more collaboration is currently being conducted asynchronously online. Asynchronous collaboration overcomes temporal and spatial challenges faced by traditional synchronous collaboration. Although little published research addresses best practices for online asynchronous collaboration, a study by Michinov and Primois (2005) provides great insights. The researchers found that initiating social comparison between participants can improve the productivity and creativity of distributed teams. Specifically, Michinov and Primois learned that motivation to perform can be increased by simply labeling who contributes ideas to group brainstorming sessions. Based on these findings, team leaders and facilitators should consider the trade-offs of idea anonymity when collaboration is asynchronous. It may be the case that the performance-enhancing effects of social comparison may be more valuable to alleviating the “cold” nature of asynchronous collaboration than protecting participants from evaluation apprehension.

Despite the importance of the idea generation stage of collaboration, the best brainstorming interventions provide little utility to a group if generated ideas cannot be understood, connected, and built upon. Therefore, the following sections describe how subsequent patterns of collaboration improve group problem solving and decision making.

### 44.4.2 Converge

After generating ideas for identifying or solving a problem, collaborators must converge on the shared knowledge necessary to address the problem. Convergence is a critical activity in group work that lays the foundation for shared understanding and the overall advancement of a group’s task. To converge has been defined as “to move from having many concepts to a focus on and understanding of a few deemed worthy of further attention” (de Vreede and Briggs, 2005). Group work concerns convergence when a group deliberates on and reduces the amount of information they have to work with (de Vreede and Briggs, 2005).
Essentially, convergence lays the foundation for shared understanding and the overall advancement of the group’s task (Davis et al., 2007). In doing so, a primary goal of convergence is to reduce a group’s cognitive load in order to address all concepts, conserve resources, have less to think about, and achieve shared meaning of the concepts. However, convergence is time consuming and has been shown to be a painful process for groups (Chen et al., 1994; Easton et al., 1990). de Vreede and Briggs (2005) identify four aspects or subprocesses that can be combined in order to create useful variations in convergence activities. These include (1) judging or identifying which of the existing concepts merits further attention; (2) filtering or selecting a subset from a pool of concepts that will receive further attention; (3) generalizing or reducing the number of concepts under consideration through generalization, abstraction, or synthesis and then eliminating the lower-level concepts in favor of the more general concept; and (4) creating shared meaning or agreeing on connotation and establishing a shared meaning or understanding about the labels used to communicate various concepts.

To date, convergence has received limited scholarly attention. Researchers have argued that convergence activities in group work are complicated due to a variety of reasons, including information overload at the start of a convergent task, the cognitive effort that is required for convergent tasks, and the need for a higher granularity of meeting ideas to be stored (i.e., meeting memory) for future decision making and analysis (Chen et al., 1994). To address these issues, GSS researchers have argued about the most effective mode and means of communication for convergence issues. For example, Dennis and Valacich (1999) propose that verbal communication is most appropriate when a team needs to converge and establish shared meaning. Verbal communication is mostly recommended for efficiency, because it provides the fastest feedback. Other researchers argue for combining electronic and verbal communication modes during convergence: participants can benefit electronic tools during convergence due to the fact that key concepts can be identified and represented with a minimum of cognitive load on the group members (Briggs and de Vreede, 1997). These insights have been consolidated in media synchronicity theory (MST) that suggests that individuals would prefer highly synchronized communication media (i.e., face-to-face) for convergence communication, which relate to shared understanding, and less synchronized media (e.g., e-mail) for conveyance communication, which relates to facts or alternatives (DeLuca and Valacich, 2006; Dennis et al., 2008). Furthermore, MST argues that decision-making tasks require convergence before proceeding to the next task as well as the conveyance of specific information (e.g., facts or alternatives) (Dennis et al., 2001).

In contrast to the research that addresses convergence issues from the group members’ perspective, recent research from a facilitator’s perspective has shown that facilitators find convergence to be one of the least demanding patterns of collaboration, behind divergence (Hengst and Adkins, 2007). Yet, the same study found building consensus to be the most demanding pattern of collaboration, and the authors suggest that building consensus is most often done with convergence and organization subprocesses. Other researchers have proposed a set of performance criteria to provide a framework to compare and contrast different convergence techniques (Davis et al., 2007). These criteria include both result-oriented (e.g., level of shared understanding and level of reduction) and process- or experience-oriented criteria (e.g., ease of use for the team members and satisfaction with technique by the facilitator). Initial studies have applied some of these criteria (see, e.g., Badura et al., 2010), but clearly more research is required in this area.

In conclusion, a review of previous research suggests there is little structural attention on the topic of convergence. Moreover, there is very limited, detailed guidance available how to best structure convergence activities in groups (Briggs et al., 1997; Hengst and Adkins, 2007).

### 44.4.3 Organize

Groups cannot solve problems and innovate by means of simply compiling ideas and developing a shared understanding of them. As a result of idea generation and convergence, a large amount and complexity of the information shared between collaborators puts a burden on their time and attention.
In order to reduce demands on limited human resources and to overcome limitations on understanding, groups need to organize the information they generate. This section examines what is known about the organization stage of the collaborative problem-solving process and how this phenomenon has been conceptualized.

At the core of the organization stage of the decision-making process is the idea that collaborative organization activities are intended to facilitate greater understanding of the relationships among concepts. Little research has taken place in the general area of organizing information as team work. However, a special form of the organize pattern, group modeling, has received some focused attention (Renger et al., 2008). Broadly speaking, through collaborative modeling participants are able to create a shared understanding about a collection of concepts and their interrelationships. Often group model activities take place as part of an effort to represent a system design.

Early studies on IT-supported versus “pencil and paper” design modeling established that facilitation practices and IT can be leveraged to greatly improve collaborative design modeling processes and outcomes (Dean et al., 1995). For instance, the use of IDEF0 modeling was initially limited to collaboration in small groups because a group would first use flip charts, whiteboards, or transparencies to delineate information they were attempting to organize, then a facilitator would have to transcribe that information into a single-user tool that created graphical models. This process frequently led to misinterpretations of data and/or group members feeling that they had less control over the models than desired (Renger et al., 2008). Later group modeling systems integrated GSS and IDEF0-specific functionalities and allowed for active participation such that several participants would have direct control over how concepts are graphically, syntactically, and semantically modeled (Dean et al., 2000; Dennis et al., 1999). Other group modeling approaches that have been successfully employed in field settings include jointly understanding, reflecting, and negotiating strategy (JOURNEY Making) (Ackermann and Eden, 2005), which uses cognitive mapping techniques to support strategic planning and policy making, and group model building (Andersen et al., 2007), which refers to “a bundle of techniques used to construct system dynamics models working directly with client groups on key strategic decisions” (Andersen et al., 2007, p. 1).

The study of collaborative modeling has evolved with its use in practice, yet quantitative studies on specific comparative strengths and weaknesses of various technology-supported modeling methods are scant. A meta-analysis conducted by Renger et al. (2008) examined various outcomes in the collaborative modeling literature. It was found that across 22 group modeling studies, six studies yielded positive effectiveness results, three studies found high levels of participant satisfaction, and five studies discovered evidence of shared understanding resulting from certain collaborative design approaches. Thus, collaborative modeling has yielded effective outcomes when used to facilitate the organization stage of collaboration. Additional research is needed to identify context effects on collaborative modeling, as well as head-to-head comparisons of different modeling methods to determine which approaches are most effective under specific circumstances.

### 44.4.4 Evaluate

Another critical part of team work occurs when groups evaluate the merit of ideas. Admittedly, evaluation tends to happen at each stage of a collaboration process, but the most effective team efforts tend to prevent premature idea evaluation. That is, the generation, expansion, and linking of ideas tends to be disrupted when ideas are evaluated during or before convergence or organizing activities. However, once a group has converged on a set of ideas, this new found shared understanding must be leveraged to identify optimal options.

Two primary methods are used to evaluate the merit of ideas. First, ideas can be compared head-to-head using a rank-order or single criterion voting system. Second, a multi-criteria decision-making system can be utilized to develop a better understanding of the strengths and weaknesses of each idea. Dean et al. (2006) provide a thorough review of various criteria used to
evaluate problem solutions in research studies conducted from 1990 to 2005. This study supports findings from MacCrimmon and Wagner (1994) that suggest that most decision-making criteria used in previous research tend to fall under one of four categories: novelty, workability, relevance, and specificity. Further, Dean et al. emphasized that when assessing the creativity of ideas, the constructs originality and quality succinctly embody the essential characteristics of creativity, as defined by Amabile (1996). Interestingly, Dean et al. conveyed that more accurate assessments of ideas occur when multi-criteria evaluations are kept separate, rather than combined into a summated or multiplicative unidimensional rating.

In all, ideas are relatively easy to compare head-to-head, but multi-criteria evaluations provide richer data. Further, many criteria have been utilized in previous research to effectively assess collaboratively generated and distilled ideas, but criteria need not be limited to these recommendations. Depending on the purpose or goal of collaborative decision making, criteria should be adjusted to assess customized considerations such as ease of implementation, cost, and anticipated impact.

### 44.4.5 Build Commitment

The fifth and final pattern of collaboration is building commitment. In the research literature, the terms building commitment and building consensus are often used interchangeably. Building commitment or consensus typically wraps up group decision-making efforts. For collaborative efforts to succeed, groups must find solutions that balance the differing requirements or needs of stakeholders, while acknowledging that it may not be possible to satisfy all needs of all stakeholders (Simon, 1996). Otherwise, individual stakeholders whose interests are thwarted by group processes may themselves be in a position to thwart the group’s success. Thus, building consensus is a critical aspect of collaborative efforts.

To support decision making by teams and groups in consensus building, both rational (see, e.g., Yu and Lai, 2011) and social preferences (see e.g., Dong et al., 2010) should be considered. While some GSS have been developed to calculate optimal solutions with inclusion of both rational and social perspectives, these calculations are often complex and therefore less transparent. Thus, there is a possibility that the users may not trust them to represent team consensus. Even more importantly, GSSs aid in decision making, but to build consensus, groups also need to debate varying perspectives and overcome differences to arrive at a mutually agreeable decision (Er, 1988). Accordingly, one of the foci of GSS research has been to create the optimal conditions to achieve consensus. For example, Chen et al. (2012) suggested an adaptive consensus support model for group decision-making systems. Using this model, GSS can evaluate the comments of the contributors and provide suggestions for modification in order to enable progression toward consensus. Moreover, the system is also interactive so that the contributors can further modify these suggestions allowing the GSS to create an increasingly accurate model of consensus.

In addition to improving consensus building models, GSS research has also been extended to accommodate distributed decision making through the use of analytical algorithms to facilitate consensus. For example, Tavana and Kennedy (2006) used a strategic assessment model of consensus to enable distributed teams identify strengths, weaknesses, opportunities, and threats of the Cuban missile crisis situation. This model enabled consensus using various intuitive processes including subjective probabilities, an analytical hierarchy process, and environmental scanning to achieve consensus through focused interaction and negotiations among an international group of participants. However, it has been argued that these and other decision conferencing systems need to consider the cultural differences among international participants and adjust for it in order to achieve greater success (Quaddus and Tung, 2002).

Groups that use GSS tend to outperform their face-to-face counterparts on the aspects of information exchange and quality. In their study, Lam and Schaubroeck (2000) compared groups that were using GSS to groups that were involved in face-to-face decision making. They found that, in the absence of a pre-discussion consensus, the GSS groups were significantly more efficient in reaching a
Using Information Systems and Technology to Support Individual and Group Tasks

consensus about the superior hidden profile candidate than the face-to-face groups. In addition, being in a GSS facilitated group tended to shift the individual preferences toward group consensus more strongly.

The use of GSS may not only make the process of decision making more efficient, but it also offers an opportunity for researchers to evaluate the data in order to analyze patterns and recommend improvements to the process on a post hoc basis. On a simple level, initial levels of consensus can be statistically evaluated following a voting process by which participants use Likert-type scales (e.g., 1 = strongly disagree to 5 = strongly agree) to assess the merit of ideas (e.g., quality, novelty, and ease of implementation). Specifically, the average rating and standard deviation of each item are calculated. Then, the team typically agrees on ideas with the highest ratings and lowest standard deviations as their preferences. Moreover, a large standard deviation suggests participants do not agree on the merit of an idea. Such ideas should be further discussed, and then voted on again, to ensure the lack of consensus is due to a true disagreement, rather than a misunderstanding of the idea.

Other, more complex, methods and algorithms can also be used to assess group consensus. For example, a study by Ngwenyama et al. (1996) showed that the data that are collected by the means of GSS allow facilitators to identify the issues that have been most contentious as well as the individual and collective positions on all the issues raised. In addition, these data can also be useful to facilitators to analyze the group preferences and the available alternatives that support consensus formation. Similarly, in another study, a GSS-based consensus building approach was utilized to analyze a group’s creative problem-solving and decision-making processes (Kato and Kunifuji, 1997). Using the GSS enabled the researchers to combine creative thinking methods with a consensus making process to solve complicated problems. The participants who used the combination of the two methods could construct the appropriate evaluation structure interactively and choose the optimal alternative in a rational manner.

Finally, the application of GSS has also moved beyond the laboratory and corporate decision making into the area of political disputes among conflicting parties. One such example can be found in the conflict resolution and consensus building effort that was successfully conducted by the water authorities in northwest Iran (Zarghami et al., 2008). In this context, a GSS was used to identify the criteria and rank the water resource projects in the area. This system guided the supervisor who was in charge of the group decision-making problem and allowed him to negotiate with the stakeholders effectively in order to resolve conflict and achieve consensus.

These studies are but a few that illustrate the significance of GSS in consensus building. The contribution of GSS to consensus building is far from saturated. With the advent of new technologies and the changing nature of groups and teams, GSSs have an opportunity to evolve and assimilate new ways of processing information and reaching consensus. For example, keeping up with the changing nature of technology, GSSs are evolving to a new level and may incorporate virtual reality and virtual interactive modeling (VIM) to assist with consensual decision making in groups (Jam et al., 2006). In their study, Jam et al. (2006) conducted a controlled experiment to evaluate the effectiveness of VIM in distributed groups. The results showed that the use of VIM leads to greater efficiency of decision making, greater satisfaction with the process, and improved group member attitude. Such visualization technologies can potentially help distributed groups integrate information easier and improve their communication.

44.5 Organizational Effects of Technology-Supported Collaboration

As the previous section shows, GSSs have been utilized in different ways and have yielded various outcomes in organizations. Early studies in university environments (e.g., Gallupe et al., 1988) were followed by studies at organizational sites (e.g., Grohowski et al., 1990). GSSs have since been commercialized and are present in an increasing number of domestic and international contexts (Briggs et al., 2003).
Interestingly, collaboration technologies such as GSS do not always render the effects that were anticipated. As suggested by adaptive structuration theorists, organizations may utilize technologies in ways that were originally not intended (DeSanctis and Poole, 1994).

Yet, field research on GSS predominantly paints a positive picture (for an overview, see Fjermestad and Hiltz, 2000). Among field studies with GSS there are comparatively few that focus on organizational groups that used GSS in their own environment, that is, the organization of which they are part. Most studies on real groups report on visits that the group made to facilities outside their organization, most often on the premise of the researchers involved. It is important (and convenient) to do such studies in university contexts where variables can be more systematically explored and sufficient sample sizes be developed under more controlled circumstances. Exceptions to this practice include the use of software aided meeting management (SAMM) by the internal revenue service (IRS) in New York City (DeSanctis et al., 1992) and GroupSystems at the U.S. Navy ThirdFleet (Briggs et al., 1998).

Another limitation of GSS field studies is that most have been executed in North American settings, making it difficult to draw generalizations. Exceptions are reported in overviews in Nunamaker et al. (1997) and de Vreede et al. (1998). An interesting cross-cultural comparison of in situ GSS experiences was reported by de Vreede et al. (2003). Their work compared the experiences from four case studies, two in the United States and two in the Netherlands. Each case study used a GSS called GroupSystems:

1. **International Business Machines**: GroupSystems was introduced at IBM in 1987. A series of studies at this site followed that demonstrated that GSS technology could be effectively introduced in organizational environments (Grohowski et al., 1990; Vogel et al., 1990). Based on success at the first facility, IBM installed the technology at six more sites over the following year and similarly expanded their internal facilitation support capabilities (Grohowski et al., 1990; Martz et al., 1992; Vogel et al., 1990). IBM continued expanding internally to 24 sites and beyond with the same format of use, that is, preplanned session agendas with facilitation support throughout the meeting process. The facilitation role was institutionalized with several generations of facilitators emerging from a wide variety of backgrounds and levels of experience with group and organizational dynamics.

2. **Boeing Aircraft Corporation**: Encouraged by reports of IBM’s success, Boeing Aircraft Corporation decided in 1990 to conduct a carefully controlled pilot test of GroupSystems in their organization. Boeing collected data so that a business case could be developed either in favor of or against the widespread use of GSS to support their projects. After 64 sessions, costs were evaluated. The project time, or number of calendar days required to produce the deliverables, was reduced by an average of 91%. The man-hour cost savings averaged 71%, or an average of $7,242 per session, for a total savings of $463,488 over the 64 sessions (Post, 1993). This was despite the fact that expense figures included the initial start-up of installing the meeting room technology, training facilitators, and collecting the measurement data.

3. **Nationale-Nederlanden (NN)**: Part of the ING Group, NN is the largest insurance firm in the Netherlands and one of the market leaders in Europe. NN was introduced to GroupSystems at Delft University of Technology in 1995. Based on early success, NN continued to use GSS and develop its own internal facilitation capabilities (de Vreede, 2001). Following the successful use at NN, other parts of the ING Group also adopted to use the technology.

4. **European Aeronautic Defense and Space Company, Military division (EADS-M)**: EADS-M is a cooperation of four European companies in producing the Eurofighter and other military aircrafts. EADS-M was first introduced to GSS by Delft University of Technology in 2001. Based on a successful pilot study on GSS, the company acquired a GroupSystems license and had a number of internal facilitators trained.

The cross-case findings from these four organizations are presented in Table 44.2 (all aspects, except savings, on a 5-point Likert scale, 5 being most positive). Overall, the results show that the application of GSS in each of the organizations can be considered successful, both in terms of the actual results that were...
achieved (e.g., time savings) and in terms of the participants’ perceptions (e.g., meeting satisfaction). In each of the organizations, the expected savings would significantly outweigh the expenses for running the technology and hiring (technology) support staff (e.g., facilitators). These findings were particularly interesting given that the individual cases were conducted over a time span of 16 years in four very different organizations in terms of business focus and national/corporate culture.

What is even more interesting than the positive findings in the individual case studies is that although the results in each situation led to management decisions to implement the technology in the organization, the use of the GSS facilities slowed down over time and in three of the four cases the facilities were disbanded. This illustrates that the technology by itself may appear to represent a positive business proposition, but its actual sustained use over time is influenced by other factors. A stream of research in the area of Collaboration Engineering identified that the root cause behind the abandonment of seemingly successful GSS facilities concerned the need to use professional facilitators to let teams get value out of the technology. That is, the technology itself is too complex to configure and align with the team process for groups to do by themselves. Facilitators can be a costly option for an organization. Thus, many groups that could benefit from their services do not have access to them. Further, it turned out that it can be challenging for an organization to retain its facilitators because they are often either promoted to new positions or they leave the organization to establish consulting practices (see, e.g., Agres et al., 2005). Since then, researchers have pursued ways to reduce the reliance on professional facilitators to benefit from GSS-enabled collaboration. One particularly promising avenue has been to codify facilitator expertise in a collaboration design pattern language called ThinkLets (de Vreede et al., 2006, 2009). ThinkLets are like a Lego™ toolkit that allows collaboration engineers click together processes that can be easily transferred to domain experts in organizations to execute by themselves. A number of successful thinkLet-based interventions are described in de Vreede et al. (2009).

### 44.6 Future Directions for Research on Technology-Supported Collaboration

This final section presents three important directions for future research on technology-supported collaboration. The overview that has been presented in this chapter shows that, under the right circumstances, teams can dramatically benefit from the use of collaboration technology to support their problem-solving and decision-making activities. To unlock this potential, the key challenge for teams is twofold: First, they must purposefully align the people, process, information, and leadership specifics

<table>
<thead>
<tr>
<th>Aspect</th>
<th>IBM</th>
<th>Boeing</th>
<th>NN</th>
<th>EADS-M</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Session is efficient</td>
<td>3.9</td>
<td>4.0</td>
<td>4.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Person-hours savings</td>
<td>55.5%</td>
<td>71.0%</td>
<td>53.0%</td>
<td>49.7%</td>
</tr>
<tr>
<td>Calendar time savings</td>
<td>92%/89%*</td>
<td>91.0%</td>
<td>57.7%</td>
<td>33.3%</td>
</tr>
<tr>
<td><strong>Effectiveness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSS more effective than manual</td>
<td>4.2</td>
<td>—</td>
<td>4.0</td>
<td>4.1</td>
</tr>
<tr>
<td>GSS helps to achieve goals</td>
<td>4.1</td>
<td>4.0</td>
<td>3.9</td>
<td>4.0</td>
</tr>
<tr>
<td>Initiator’s evaluation of</td>
<td>4.4</td>
<td>4.1</td>
<td>3.9</td>
<td>4.3</td>
</tr>
<tr>
<td>outcome quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>User satisfaction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction with GSS process</td>
<td>4.1</td>
<td>—</td>
<td>4.1</td>
<td>4.3</td>
</tr>
<tr>
<td>Willingness to use GSS in</td>
<td>4.2b</td>
<td>4.4</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>similar projects/activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Based on 11 and 59 sessions, respectively.
* For brainstorming activities.
of a collaborative effort with the capabilities that the technology provides. Second, to keep reaping the
benefits from the technology, they must find ways to create self-sustaining routines that they can use
repeatedly to execute a technology-supported collaborative work practice.

The first of the future directions described addresses this challenge. The other two future directions
illustrate that this challenge is even more important to address as team collaboration is moving into new
technological environments that bring about a renewed focus on designing and sustaining productive
technology-supported team efforts.

44.6.1 Task-Specific Collaboration Applications
with Build-In Facilitation Guidance

To reduce the need to rely on professional facilitators to guide team efforts, researchers have
begun to explore and prototype ways to build facilitation expertise into collaboration technology.
The guiding research question is, How can collaboration expertise be packaged with collaboration
technology in a form that nonexperts can reuse with no training on either the collaboration tools
or techniques? To answer this question, researchers are developing a new class of software called
Computer Assisted Collaboration Engineering system (CACE). CACE supports the design, develop-
ment, and deployment of technology-supported collaborative work practices. An example of a
CACE is the ActionCenters system (Briggs et al., 2010; Buttler et al., 2011; Mametjanov et al., 2011).
ActionCenters supports the rapid design, configuration, and deployment of software applications
custom tailored to support specific collaborative work practices. Each application presents the users
with a series of activities for achieving their task. Each activity provides the users with just the tools,
data, communication channels, and guidance they require for that activity, and nothing else. The
applications can therefore appear very simple and obvious to the users, while providing powerful
capabilities. The core of the ActionCenters environment is a collection of loosely coupled, highly
configurable collaborative components like shared lists and outlines, shared graphics, polling tools,
audio and video channels, and shared document repositories. In the ActionCenters CACE environ-
ment, the collaboration engineer snaps these elementary components together and configures them
to behave as if they were a tightly integrated, task-specific system without having to write a new
code. A CACE is fundamentally different from a GSS in that the GSS provides a generic, configu-
rable toolkit for a plethora of collaboration processes whereas the system built in a CACE is a task-
specific application that has all required configurations predefined and guides the users through
each step in their process.

A CACE system can be seen as a design studio for creating technology support for repeatable group
processes without writing any new code (see Figure 44.1). With a CACE system, collaboration engineers
can embed different types of collaboration expertise into the collaborative tools in a format that enables
practitioners to execute the technology-supported work practice with no training on either the tools or
the collaboration techniques. The resulting collaborative application provides end users with a sequence
of screens that represent the activities that together make up the team task. Each screen provides users
only with the functionality that they require for that activity in the sequence. For example, Figure 44.2
depicts a screen at runtime in a requirements negotiation process. The banner heading at the top is
implemented with an HTML control. The numbered list in the middle with its input panel is a config-
ured outliner component. The caption-balloon icons to the right of each outline heading are links to a
subordinate outliner component. When a caption balloon is clicked, the subordinate outline component
pops up configured to appear and behave as a comment window, so users can comment on any heading
in the main outline.

Pilot studies with ActionCenters for five technology-supported collaborative work practices have
demonstrated that collaboration engineers could create complete, task-specific collaboration sys-
tems in hours or days that would have required several person-years of effort using conventional
approaches. In a pilot study of a domain-specific creative problem-solving application, eight groups
of practitioners with no prior experience on collaboration technology and no knowledge of the collaboration techniques embedded in the work practice nonetheless executed successfully a sequence of five techniques under the guidance of the ActionCenters application. Each group achieved its goals. Current efforts are under way to test the ActionCenters more rigorously in a program of laboratory experiments, which will be followed by a series of field trials.
44.6.2 Virtual Worlds

In the recent years, much excitement has built up around a new concept of work spaces called meta-verses or virtual three-dimensional (3-D) spaces. Metaverses are usually used for sharing information, creating personal virtual images (avatars), and manipulating virtual objects. They are immersive virtual worlds (VWs) where avatars interact with each other and with software agents, using the metaphor of the real world but without its physical limitations (Davis et al., 2009). VWs allow teams to move beyond simple electronic conversation and document distribution by providing an environment where people can also share a communal space with others.

Extrapolating from Media Richness Theory (Daft and Lengel, 1986) and Media Synchronicity Theory (Dennis et al., 2008), researchers suggest that users of VWs may be more engaged during VW collaboration than low-tech distributed collaboration because VW users experience co-presence—a feeling of shared social and physical space that adds an element of interpersonal realism to collaborative interactions. Further, the accessibility and multiple means of communication inherent to VWs makes it a powerful platform for supporting collaboration. Specifically, in VWs, users have many communication tools to their disposal, such as text-based messaging, video conferencing, object creation/sharing, audio, and even GSS. Research to date has shown that collaboration in VWs can be a motivating, engaging, productive, and satisfying experience for team members. Yet, teams face various challenges at the same time, including but not limited to the need to master the skills to smoothly operate their avatars, the risk of social loafing from team members, and the difficulty for team leaders to monitor participants’ emotional states and establish rapport. For an overview of VW collaboration research to date, see Boughzala et al. (2012).

VWs are currently facing some major challenges to become a broadly accepted environment for team collaboration. In fact, VWs appear to be losing some popularity, especially as society is moving toward mobile technology that does not yet suitably supports VWs, such as cell phones and tablets. Also, researchers found that despite richer communication tools, the absence of face-to-face interaction makes convergence and consensus processes difficult as the body language, perceptions, and feelings of participants are difficult to assess in VWs (Wigert et al., 2012). Notably, much of the challenge of using VWs can be attributed to the difficulty faced when trying to effectively manipulate avatars to display appropriate body language. As such, future research is needed to determine how VW collaboration can be further enriched through advances that focus both on the technology itself and the processes that teams execute.

44.6.3 Crowdsourcing

The third and final direction for future research relates to collaboration through social media. Social media have expanded the capability of collaborative problem solving into social levels including online crowds of employees, professionals, amateurs, producers, and consumers. This has given rise to a new phenomenon, which is commonly known as crowdsourcing (Howe, 2008) that can be defined as a collaboration model enabled by social web technologies to solve organizational problems in partnership with online communities (Oh et al., 2012). Other popular terms include “mass collaboration” (Tapscott and Williams, 2006), “open collaboration,” “collective intelligence” (Surowiecki, 2005), and “co-creation” (Kazman and Chen, 2009). All these terms put online users in the center of collaboration processes, while they have not been considered as important actors in traditional collaboration models.

In crowdsourcing, there are two modes of collaboration (closed collaboration versus open collaboration), which have distinctively different collaboration processes. Table 44.1 illustrates that “closed collaboration” focuses on finding the best solution out of many submitted ones, whereas “open collaboration” focuses on facilitating collaboration among undefined large number of online community members to solve problems (Table 44.3).
Crowdsourcing is based on two underlying assumptions: (1) a larger number of people can solve difficult or complex problems better than a small number of people and (2) a team or group that has high collective intelligence is more likely to excel in complex problem solving. Compared to traditional settings such as GSS, a distinctive feature of social media–driven collaboration is that it highlights the potential that a large online \textit{amateur crowd} can be smarter than a handful of \textit{organizational professional experts} in problem solving. To this end, Surowieck (2005, p. 10) suggests four conditions that need to be met for online crowds to make wise decisions to solve problems collectively: (1) creating sufficient diversity of opinion, by which each individual involved has some private information, even if it is just an eccentric opinion; (2) maintaining independence, wherein each person’s opinion or decision is not influenced by those around them; (3) enabling decentralization, through which individuals can specialize and tap into local sources of knowledge; and (4) facilitating aggregation, which stresses the importance of mechanisms for translating many private opinions or decisions into a collective decision. These notions are not entirely new. Apart from the fourth condition (“aggregation”), the first three conditions have been repeated research questions in collaboration science research in general and GSS research in particular. Although it is still an under-researched area, recent studies have begun to pursue the notion of “convergence,” which is comparable to Surowiecki’s notion of “aggregation.” Finding ways to effectively create and sustain the conditions that Surowiecki outlines provides an exciting opportunity for collaboration technology researchers in general and GSS researchers in particular.

\begin{table}[h]
\centering
\caption{Different Modes of Collaboration in Crowdsourcing}
\begin{tabular}{|l|l|}
\hline
\textbf{Types of problem} & \textbf{Closed Collaboration} \hspace{4cm} \textbf{Open Collaboration} \\
\hline
\textbullet Structured problem & \textbullet Unstructured problem \\
\textbullet Organizations define a problem and broadcast the defined problem to an online community so that community members can submit solutions to the organization & \textbullet Organizations broadcast an unstructured question to an online community so that the community can (1) identify and define specific problems in parallel (“brainstorming”) and (2) clarify and evaluate each problem by commenting or voting to reduce the large number of suggested problems into a selection of the best few ideas worthy of more focused attention (“convergence”) \\
Exemplary Problem: “A one-part adhesive is required that is activated at room temperature. The adhesive should have a minimum set-strength upon activation for gluing a fixed substrate on metals and synthetics (polymers) which can then be fully cured by other methods … Theoretical proposals (no verified method data) will be considered for a lesser reward.” \textit{(taken from InnoCentive.com)} & Exemplary Problem: “We’ve received many suggestions about closing select streets temporarily to create more opportunities for bicycling, walking, and events such as farmers markets and art walks. How often should we close streets for these types of activities?” \textit{(taken from ideas.LA2B.org)} \\
\hline
\textbf{Way of finding solution} & The organization selects the best solution from a large number of solutions submitted by the online community. Collaboration between online community members is not allowed. Therefore, collaboration features such as voting, commenting, rating, and sharing in the web interface design are not important & The organization facilitates collaboration between online community members. The organization determines the best solution considering the results of both brainstorming and convergence activities. Therefore, collaboration features such as voting, commenting, rating, and sharing in the web interface design are important \\
\hline
\hline
\end{tabular}
\end{table}
44.7 Summary

The advent of ubiquitous computing power and access to the Internet has enabled team collaboration across boundaries of time, place, institutions, and culture. Modern collaboration processes have become increasingly reliant on advanced collaboration technologies and systems. Notwithstanding the clear value that these technologies bring, their use in organizations and teams is not without challenges. Collaboration researchers and practitioners have developed and leveraged new collaboration techniques and applications to address many challenges inherent to IT-supported collaboration. The aim of this chapter was to provide an overview of how IT in general and collaboration technologies in particular support team problem solving and decision making to improve their performance.

First, a classification scheme was presented to organize the different types of collaboration technologies teams can use in various situations. Next, some underlying principles of IT-supported collaboration were introduced in the form of six patterns of collaboration: idea generation, reduction, clarification, organization, evaluation, and building commitment. An overview was provided to show how past research has offered insights on supporting groups in each of these patterns through collaboration technology, with a special focus on GSS. Next, an account was given on the organizational value that organizations can derive in terms of cost savings and productivity gains through the use of GSS-supported team processes. Finally, three important directions for future research and practice were introduced: (1) the development of a new generation of collaboration technology in the form of CACE environments that enable collaboration engineers to snap together task-specific collaborative applications with embedded facilitation guidance without having to write software code, (2) the use of virtual worlds as an environment to provide a rich online collaboration experience through the use of avatar representations of team members, and (3) the emergence of crowdsourcing as a force for superior collaborative problem solving through the active involvement of large numbers of participants. Together these directions represent both an opportunity and challenge for researchers to transfer and expand insights from past research on technology-supported group work to future research efforts.

Glossary

Audio conferencing tools provide a continuous channel for multiple users to send and receive sound while video conferencing tools allow users to send and receive sound or moving images.

Convergence is the action of moving from having many concepts to a focus on and understanding of a few concepts deemed worthy of further attention.

Conversation tools are primarily optimized to support dialog among group members. E-mail is a widely used conversation tool as well as short message service (SMS) (i.e., cell phone text messaging), which is becoming increasingly common.

Crowdsourcing is used in order for the job of a specific agent or team to be outsourced to a larger, undefined group in an open call for solutions.

Desktop sharing tools allow the events displayed on one computer to be seen on the screens of other computers.

Enterprise analysis is a collaborative design model building approach that concentrates on collaboratively built models as a goal in itself rather than as a transitional object.

Group dynamics tools are optimized for creating, sustaining, or changing patterns of collaboration among individuals making a joint effort toward a goal.

Group model building refers to a bundle of techniques used to construct system dynamics models working directly with client groups on key strategic decisions.

Group support systems integrate collections of group dynamics tools to move groups seamlessly through a series of activities toward a goal, for example, by generating ideas in one tool, organize them in another, and evaluating them in yet another (e.g., GroupSystems or MeetingWorks).
Idea generation (i.e., brainstorming) is the practice of gathering in a group and generating as many ideas for identifying or solving a problem as possible.

Polling tools are a special class of jointly authored pages, optimized for gathering, aggregating, and understanding judgments, or opinions from multiple people.

Problem structuring methods (PSM) refer to a broad variety of methods and tools that have been developed mainly in the United Kingdom to cope with complexity, uncertainty, and conflict.

Search engines use search criteria provided by users to retrieve digital objects from among vast stores of such objects (e.g., the World Wide Web, the blogosphere, and digital libraries).

Shared editor tools are typically a jointly authored page optimized for the creation of a certain kind of deliverable by multiple authors.

Shared file repositories provide mechanisms for group members to store digital files where others in the group can access them.

Social tagging allows users to affix keyword tags to digital objects in a shared repository.

Syndication tools allow a user to receive a notification when new contributions to pages or repositories they deem to be of interest (e.g., blogs, wikis, and social networks).

Virtual worlds (VWs) are online virtual environments in which users interact using 3-D avatars in a shared space.

References


