positions, and the U.S. federal government meets periodically to set the short-term interest rate. Some of these decisions are complex; others can be controversial, as in resource allocation by a city government. Process dysfunctions can be significantly large in such situations; therefore, computerized support has often been suggested to mitigate these controversies. These computer-based support systems have appeared in the literature under different names, including *group decision support systems* (GDSS), *group support systems* (GSS), *computer-supported collaborative work* (CSCW), and *electronic meeting systems* (EMS). These systems are the subject of this section. In addition to supporting entire processes, there are tools that support one or several activities in the group decision-making process (e.g., brainstorming).

Group Decision Support Systems (GDSS)

During the 1980s, researchers realized that computerized support to managerial decision making needed to be expanded to groups, because major organizational decisions are made by groups, such as executive committees and special task forces. The result was the creation of the *group decision support systems* methodology.

A **group decision support system (GDSS)** is an interactive computer-based system that facilitates the solution of semistructured or unstructured problems by a group of decision makers. The goals of GDSS are to improve the productivity of decision-making meetings by speeding up the decision-making *process* and/or to increase the quality of the resulting decisions.

MAJOR CHARACTERISTICS AND CAPABILITIES OF A GDSS GDSS characteristics follow:

- It supports the *process* of group decision makers mainly by providing automation of subprocesses (e.g., brainstorming) and using information technology tools.
- It is a specially designed information system, not merely a configuration of already existing system components. It can be designed to address one type of problem or make a variety of group-level organizational decisions.
- It encourages generation of ideas, resolution of conflicts, and freedom of expression. It contains built-in mechanisms that discourage development of negative group behaviors, such as destructive conflict, miscommunication, and groupthink.

The first generation of GDSS was designed to support face-to-face meetings in a *decision room*. Today, support is provided mostly over the Web to virtual teams. A group can meet at the same time or at different times. GDSS is especially useful when controversial decisions have to be made (e.g., resource allocation, determining which individuals to lay off). GDSS applications require a facilitator for one physical place or a coordinator or leader for online virtual meetings.

GDSS can improve the decision-making process in various ways. For one, GDSS generally provides structure to the meeting planning process, which keeps a group meeting on track, although some applications permit the group to use unstructured techniques and methods for **idea generation**. In addition, GDSS offers rapid and easy access to external and stored information needed for decision making. It also supports parallel processing of information and idea generation by participants and allows asynchronous computer discussion. GDSS makes possible larger group meetings that would otherwise be unmanageable; having a larger group means that more complete information, knowledge, and skills can be represented in the meeting. Finally, voting can be anonymous with instant results, and all information that passes through the system can be recorded for future analysis (producing *organizational memory*).

Over time, it became clear that supporting teams needed to be broader than GDSS has beed supported in a decision room. Furthermore, it became clear that what was really

needed was support for *virtual teams*, both in different place/same time and different place/different time situations. Also, it became clear that teams needed indirect support in most decision-making cases (e.g., help in searching for information or in collaboration) rather than direct support for the decision-making process. Although GDSS expanded to virtual team support, it was unable to meet all the other needs. In addition, the traditional GDSS was designed to deal with contradictory decisions when conflicts were likely to arise. Thus, a new generation of GDSS that supports collaboration work was needed. As we will see later, products such as Stormboard provide those needs.

Characteristics of GDSS

There are two options for deploying GDSS technology: (1) in a special-purpose decision room and (2) as Internet-based groupware with client programs running wherever the group members are.

DECISION ROOMS The earliest GDSS was installed in expensive, customized, special-purpose facilities called **decision rooms** (or electronic meeting rooms) that had PCs and a large public screen at the front of each room. The original idea was that only executives and high-level managers would use the expensive facility. The software in an electronic meeting room usually ran over a local area network (LAN), and these rooms were fairly plush in their furnishings. Electronic meeting rooms were structured in different shapes and sizes. A common design was a room equipped with 12 to 30 networked PCs, usually recessed into the desktop (for better participant viewing). A server PC was attached to a large screen projection system and connected to the network to display the work at individual workstations and aggregated information from the facilitator's workstation. Breakout rooms equipped with PCs connected to the server, in which small subgroups could consult, were sometimes located adjacent to the decision room. The output from the subgroups was able to be displayed on the large public screen. A few companies offered such rooms for a daily rent. Only a few upgraded rooms are still available today, usually for high rent.

INTERNET-BASED GROUPWARE Since the late 1990s, the most common approach to GSS and GDSS delivery has been to use an Internet-based groupware that allows group members to work from any location at any time (e.g., WebEx, GoToMeeting, Adobe Connect, IBM Connections, Microsoft Teams). This groupware often includes audio conferencing and videoconferencing. The availability of relatively inexpensive groupware, as described in Section 11.4, combined with the power and low cost of computers and the availability of mobile devices, makes this type of system very attractive.

Supporting the Entire Decision-Making Process

The process that was illustrated in Figure 11.1 can be supported by a variety of software products. In this section, we provide an example of one product, Stormboard, that supports several aspects of that process.

Example: Stormboard

Stormboard **stormboard.com** provides support for different brainstorming and group decision-making configurations. The following is the product's sequence of activities:

1. Define the problem and the users' objectives (what they are hoping to achieve).
2. Brainstorm ideas (to be discussed later).
3. Organize the ideas in groups of similar flavor, look for patterns, and select only viable ideas.

4. Collaborate, refine concepts, and evaluate (using criteria) the meeting's objectives.
5. The software enables users to prioritize proposed ideas by focusing on the selection criteria. It lets all participants express their thinking and directs the team to be cohesive.
6. It presents a short list of superior ideas.
7. The software suggests the best idea and recommends implementation.
8. It plans the project implementation.
9. It manages the project.
10. It periodically reviews progress.

For a video, see **youtube.com/watch?v=0buRzu4rhJs**.

COMPREHENSIVE GROUPWARE TOOLS INCLUDING THINKTHANK Although many capabilities that enable group decision support are embedded in common software tools for office productivity such as Microsoft Office 365, it is instructive to learn about specific software that illustrates some of groupware's unique capabilities. MeetingRoom was one of the first comprehensive, same time/same place electronic meeting packages. Its follow-up product, GroupSystems OnLine, offered similar capabilities, and it ran in asynchronous mode (anytime/anyplace) over the Web (MeetingRoom ran only over a LAN). GroupSystems' latest product is ThinkTank, a suite of tools that facilitate the various group decision-making activities. For example, it shortens cycle time for brainstorming. ThinkTank improves the collaboration of face-to-face or virtual teams through customizable processes toward the groups' goals faster and more effectively than in previous product generations. ThinkTank offers the following:

- It can provide efficient participation, workflow, prioritization, and decision analysis.
- Its anonymous brainstorming for ideas and comment generation is an ideal way to capture the participants' creativity and experience.
- The product's enhanced Web 2.0 user interface ensures that participants do not need special training to join, so they can focus 100 percent on solving problems and making decisions.
- With ThinkTank, all of the knowledge shared by participants is captured and saved in documents and spreadsheets, automatically converted to the meeting minutes, and made available to all participants at the end of the session.

Examples: ThinkTank Use (thinktank.net/case-study)

The following are two examples of ThinkTank's use.

- It enables transformational collaboration between supply chain partners. Their meeting was supported by collective intelligence tools and procedures. Partners agreed on how to cut costs, speed processes, and improve efficiencies. In the past, there had been no progress on these issues.
- The University of Nebraska and the American College of Cardiology collaborated using ThinkTank tools and procedures to rethink how electronic health records could be reorganized to help medical consultants save time. Patients' appointment times were shortened by 5 to 8 minutes. Other improvements also were achieved. Both patient care and large monetary savings were achieved.

OTHER DECISION-MAKING SUPPORT The following is a list of other types of support provided by intelligent systems:

- Using knowledge systems and a product called Expert Choice Software for dealing with multiple-criteria group decision making.

- A mediating group decision-making method for infrastructure asset management was proposed by Yoon et al. (2017).
- For a group decision-making support system in logistics and supply chain management, see Yazdani et al. (2017).

Brainstorming for Idea Generation and Problem Solving

A major activity in group decision making is idea generation. **Brainstorming** is a process for generating creative ideas. It involves freewheeling group discussions and spontaneous contribution of ideas for solving problems and making strategy and resource allocation. Contributors' ideas are discussed by the members. An attempt is made to generate as many ideas as possible, no matter how bizarre they look. Generated ideas are discussed and evaluated by the group. There is evidence that groups not only generate more ideas but also better ones (McMahon et al., 2016). Manually managed brainstorming has some of the limitations of group work described in Section 11.2. Therefore, computer support is frequently recommended.

COMPUTER-SUPPORTED BRAINSTORMING Computer programs can support the various brainstorming activities. The support is usually for online brainstorming, synchronously or asynchronously. Hopefully, electronic brainstorming eliminates many of the process dysfunctions cited in Section 11.2 and helps in the generation of many new ideas. Brainstorming software can stand alone or be a part of a general group support package. The major features of software packages follow:

- Creation of a large number of ideas.
- Large group participation.
- Real-time updates.
- Information color coding.
- Collaborative editing.
- Design of brainstorming sessions.
- Idea sharing.
- People participation.
- Idea mapping (e.g., create mind maps).
- Text, video, documents, etc. posting.
- Remote brainstorming.
- Creation of an electronic archive.
- Reduction of social loafing.

The major limitations of electronic software support are increased cognitive load, fear of using new technology, and need for technical assistance.

COMPANIES THAT PROVIDE ONLINE BRAINSTORMING SERVICES AND SUPPORT FOR GROUP WORK Some companies and the services and support they provide follow:

- **eZ Talks Meetings.** Cloud-based tool for brainstorming and idea sharing.
- **Bubbl.us.** Visual thinking machine that provides a graphical representation of ideas and concepts, helps in idea generation, and shows where ideas and thoughts overlap (visually, in colors).
- **Mindomo.** Tool for real-time collaboration that offers integrated chat capability.
- **Mural.** Tool that enables collecting and sorting of ideas in rich media files. It is designed as a Pinboard that invites participants.
- **iMindQ.** Cloud-based service that enables creating mind maps and basic diagrams.