MANAGEMENT INFORMATION SYSTEMS

Advances in technology have been occurring at an increasing rate, and the rate of technological advances is expected to continue to increase for the foreseeable future. These advances have enhanced the flow of information around the globe in a time frame that has accelerated decision processes and time frames. Now managers can influence ongoing business processes in any part of the world with competitive speed. The potential scope of business operations, markets, and competition is truly global in nature. The term "world class" has real meaning because of the application of technology. This is evident by the fact that 25% of the US economy consists of imports and exports. The global potential of business operations places a premium on the effective and efficient use of technology because the use of management information systems is nearly always required for companies to compete successfully within the global framework. Technology has permanently altered the nature of business operations and competition. Corporations not only can operate globally but can collaborate with other corporations to gain economies of scale and to capitalize on new expertise by outsourcing parts of their operations to other companies. As an example, data entry can be outsourced to locations where labor costs are lower, and systems development can be outsourced to countries like India and Ireland where there are highly skilled labor forces. The end result of all of this is that the corporate infrastructure (which includes skilled MIS people), information technology, and management information systems play a major role in the corporate world. The speed with which corporations can incorporate new technologies and adapt to the changing technological environment is a major corporate concern.

This article discusses the competitive uses of technology in business environments and how changes in technology effect a paradigm shift in management information systems; namely that companies increase their operations in the global environment as communication technology advances, such as the World Wide Web. Next, the information architectures that support the ability of companies to do business in the global environment and support commerce and decision making are discussed: complex systems such as centralized systems, LAN-based systems, client–server systems, and distributed cooperative systems. The next section outlines decision making, decision support systems architecture, group decision support systems, and advances in decision support systems. The article concludes with a discussion of the qualifications required of the MIS personnel who develop and maintain the information systems.

COMPETITIVE USE OF INFORMATION TECHNOLOGY

Corporations are very sensitive to the bottom line and the important role technology plays in achieving lower costs, higher product quality, and improved customer service. One of the models used to evaluate an organization's competitive standing is the Porter Competitive Force model (1,2), depicted in Fig. 1. The model provides a systematic way for managers to evaluate their corporation with respect to their competitors and other competitive forces. Following is a systematic discussion of the competitive forces addressed by the model.

The first force and logical starting point for assessing a corporation's use of technology is for the corporation to understand its purpose for existence and the role it can realistically play within its environment. The corporation must realistically determine its overall goal and market strategy in the context of its competition before any analysis. The corporation must also be prepared to sustain its efforts to capitalize on technology to gain competitive advantage because competitive advantage would otherwise be short term. It takes sustained improvement and innovation to sustain competitive advan-

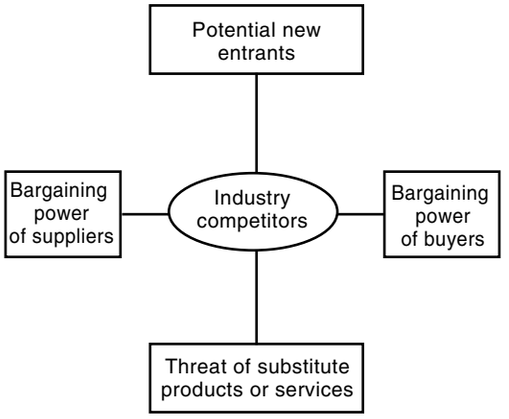

Figure 1. An analytical framework by which a company understands its relationship to its environment.

tage. Then the corporation must understand and analyze its competitors and the industry. The appropriate strategy can then be determined. Alternative strategies usually involve either achieving the status of low-cost producer or trying to differentiate its products or services from other competitors. The second consideration concerns defining its market scope which can be local, regional, national, or global. Corporations need to reassess their strategy and market scope periodically because of the dynamic changes in technology and the market they are in or are targeting for the future. Our interest concerns the role that information technology (IT) can play in corporate strategy and analysis. Some IT services that may support the initial analysis include news clipping services, government databases, commercial databases, electronic data interchange (EDI) data, and data warehousing coupled with data mining.

The second of the five major forces that must be addressed is the threat of new entrants. A new entrant into the market would certainly add new capacity and competition to the market. A new entrant is also likely to increase price pressure and may also put upward pressure on the factors of production and promotion. The question with respect to this force is whether a corporation can cover the capital cost and compete on a cost-effective basis to thwart the entry of potential competitors. A second consideration would be to address the potential of using IT to differentiate its product or to provide customer service that would be difficult to replicate or expensive to develop. The final consideration for our purposes is whether the corporate infrastructure, information architecture, and applications can be used to provide more effective market access than its competitors. The objective is to build barriers so that a competitor finds it unprofitable to enter the market. One method of achieving this is accomplished by gaining economies of scale internally or through an outsourcing arrangement. A second method is to increase the switching costs of customers to make it more difficult or expensive to switch products or services. Other methods include blocking access to distribution channels, using financial and market strength to intimidate, and eliminating competition through an outright purchase.

The third major force is the bargaining power of buyers. The power of a buyer increases with the percentage of sales. A powerful buyer has the potential to force prices down, demand higher quality, demand more services, and force competition. One obvious method is to reduce the percentage of sales to any one buyer by increasing the number of buyers. A second method is to increase the loyalty of the buyer by establishing a close relationship between the two companies. A closer relationship can be facilitated through electronic mail, point-to-point communications, and a promotional presence and linkage on the World Wide Web (WWW). This technique basically increases the switching costs. The linking of respective order, distribution, and inventory systems is widely used to achieve this objective. This approach will no doubt be less effective as more standards are established. Other approaches include blocking out the competition and differentiating products and services.

The fourth major force is supplier bargaining power. There is a relationship between the power of suppliers and the upward pressure on the cost of materials, parts, and services. Supplier power can also result in downward pressure on quality and service. One approach to reducing supplier bargaining power is in some respects similar to reducing buyer power. There is greater safety from higher prices, lower quality, and poor customer service as supplier competition is increased. In essence, there is safety in numbers. The power of buyers can be reduced by selecting and developing close relationships with multiple suppliers. The communications outages in the Chicago and New York areas caused many firms to rethink their sole dependence on a single data and voice communication system supplier. A second method of reducing supplier power is the threat of backward integration. A corporation can also combat high supplier power through backward integration. The power of the supplier is certainly diminished if the supplier knows that the corporation can and potentially would produce its products or service. These countermeasures encourage fair prices, higher quality, and better service with reasonable profits.

The fifth force is the impact of substitute products and services on the competitive stature of the corporation. The impact is similar to new entrants into the market. The availability of substitute products puts downward pressure on prices and profit margins and upward pressure on quality and service. IT can be used to assist managers in improving their price/performance, and the potential exists to allow them to differentiate their product by enhancing product features through the use of microprocessors or enhancing their customer services through communication systems.

CORPORATE MANAGEMENT INFORMATION SYSTEMS

If anything is true in the world of corporate management information systems, it is that the rate of change has increased over time and that corporations are critically dependent on computer-based management information systems. Advances have tremendously increased a corporation's capability to receive, process, store, and communicate information. Data communications has been a major facilitator for expanding corporate management information systems beyond the traditional boundaries of the firm. The focus of the application of technology and management information systems has under-

gone a transition from an internal corporate focus to a collaborative focus that uses interorganizational systems. Interorganizational systems enable the coordination of the corporation's daily operations with those of its supporting suppliers, distributors, and customers. The corporate data communications architecture has been enlarged to include one-to-one and one-to-many links to enable the integration of the supporting operations of suppliers and distributors. Interorganizational systems have greatly increased the speed of information flow which in turn increases the capability of managers to speed up decisions. The end result is faster, more accurate decisions, the minimization of physical document flows, lower inventories, less storage space, and more responsive and accurate delivery of products and services. The day of the self-sufficient corporation is a relic of the past. Computer processors provide a good illustration of a category of products produced through the cooperative efforts of multiple international suppliers. The processor chips are manufactured in the United States. Computer primary memory is manufactured in Korea, Japan, and the United States. The hard drive's secondary storage devices are manufactured for US companies in southeast Asia.

EDI systems have expanded the knowledge domain of managers through the acquisition and use of high volumes of point-of-sale data for their own and competitor products. The amount, accuracy, and timeliness of this EDI data provides a wealth of product performance knowledge with respect to geography, customer profiles, promotions, and sales patterns. This has been enabled by dramatic increases in storage, multidimensional databases, data warehouses, neural net technologies, and analytical software advances. Technology, such as Lotus Notes, has increasingly been employed to bring greater expertise, greater collaboration, and broader participation to bear on problem solving, planning, and other creative activities. This type of collaboration within the company and among interorganizational systems mentioned earlier is prevalent today, and some theorists suggest that it will lead to virtual corporations tomorrow in which a corporation may consist only of the guiding intelligence that contracts out all of the nonexecutive operations.

The New Management Information Systems Paradigm

Corporate management information systems are constrained by the human ability to understand, apply, and adapt new developments in technology. Corporate information technology is typically available for several years before corporations can put it into general use. The delay is also caused by the higher expense associated with new technology, early defects, and the higher risks associated with using a new technology before standards are established. The differing characteristics of information at the operational, middle management, and executive levels are fairly well known. Information at the operational level is detailed, and the scope of the data is usually a subfunction. As we move to the middle management level, the information represents the whole functional area, and at the executive level it encompasses the corporation in an integrated, summarized manner. MIS professionals can design very fine operational systems that have user-friendly graphical user interfaces. Systems design is much easier when the functionality is well defined and decisions are repetitive in nature. Systems design is much more difficult at the executive level because the decisions are frequently unstructured and nonrepetitive. The decision time frame is very short at the operational level and quite long at the executive level. The complexity of the decision is much simpler at the operational level and usually very complex at the executive level. We know that as we move from the operational to the executive level, the information mix changes from predominantly internal to predominantly external.

Transaction Processing Systems (TPS). As depicted in Fig. 2, operational applications are often called transaction processing systems. Transaction processing systems support the normal business activities of an organization by supporting the operational level activities of an organization. They provide fast and efficient processing of large volumes of data that are input or output by the organization. For example, flight reservations for an airline is an example of a transaction processing system. When data are input and output, the system verifies that the data is accurate, free from errors, and ensures that the data are kept up to date. Transaction processing systems form the basis for most of the organizational data.

Applications, such as accounts receivable, accounts payable, payroll, and inventory, were typically the first business applications. TPS applications shared common characteristics. The applications were event-driven, human-intensive, high-volume, highly structured, dealt with internal data, and were used at the operational level of the corporation. They were also designed for one subfunction within a functional area and were used as stand-alone systems. The result was a one-to-one relationship between the application program and the data file. A reduction in labor was frequently used as justification for implementation, and these systems did in fact eliminate significant numbers of employees. Transaction processing systems also greatly improved the accuracy of processing and greatly facilitated the generation of periodic reports. Early computers were often housed in the accounting area and usually relied on batch processing. Transaction data were stored primarily in tape files because disk capacity was severely limited and expensive. The data were merged and summarized for daily, weekly, monthly, quarterly, and annual reports. The reports were most suitable for operational and second level managers to use for control purposes internally within the firm. As technology decreased in cost and

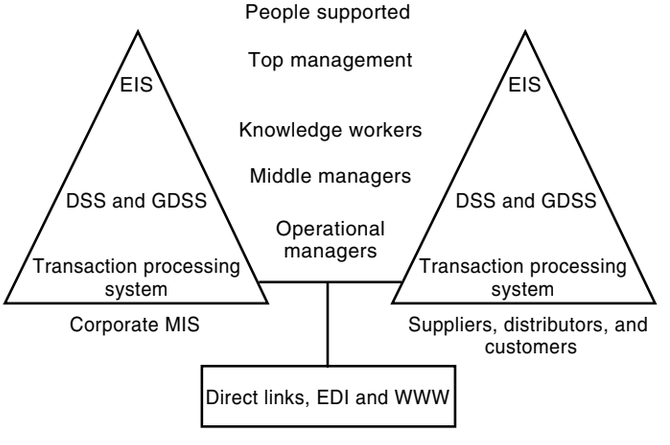

Figure 2. Advances in IT such as EDI and the WWW have dramatically changed the IS organizational boundaries and architecture.

increased in capability, the benefit of additional applications was greater than their marginal cost, and they were implemented in functional areas across corporations at the operational level. TPS generate much of the internal data stored in the corporate database.

Management information systems use the data from transaction processing systems and provide reports to business managers to enable them to gain insight into the company's operations. This helps managers plan, organize, and control their business activities more effectively and efficiently. The reports may be generated periodically or on the demand of managers. These reports may also provide for exception-based reporting (when a situation is unusual) and allow for drill-down when the reports are on-line. MIS reports can support managerial decision making and support managers at more levels of the organization than those supported by transaction processing systems. The input data for an MIS system are primarily internal and are generated by the various transaction processing systems within an organization. The traditional management information system in the past had an inward focus. Textbooks often represented MIS by a single pyramid in which a varying taxonomy of information systems was used to characterize the various levels and types of information systems. The management information of past years usually respected the boundaries of the corporation. Today, the management information system no longer has neatly defined boundaries. State of the art database, client server, and communications technologies have dramatically changed the focus of MIS to be more process oriented, collaborative, and interorganizational. The high-capacity, direct communication links, switched networks, EDI, and the WWW have facilitated the development of a more complex management information system that links transaction level application systems between different corporate management information systems. The effective operation of these interorganizational systems requires interorganizational associations to coordinate, standardize, and control these interfaces. Now corporations have integrated parts of the management information systems, allowing routine daily access so as to become more competitive within their markets.

Decision Support Systems (DSSs). Decision support systems are used primarily by managers or professionals [or groups of managers (GDSS)] at middle management levels to make operational and planning decisions. The decisions are semi-structured, the problems are less repetitive, and the user–interface is graphical and intuitive. Decision support systems are used to resolve operational problems, interorganizational system problems, and problems assigned by higher levels of management. The problems may address decisions that are solely internal or relate to external relationships. The internal and external mix of data varies with the nature of the decision at hand. A GDSS/DSS is typically capable of accessing both internal and external databases. The DSS typically can easily enter data for analytical purposes, create graphics, and generate custom reports. The tools may include spreadsheets, mathematical models, expert systems, neural net systems, financial models, high-level programming languages, and a wide variety of other tools. DSSs are discussed in further detail in a later section.

Executive Information Systems (EISs). EISs are used by high-level executives for planning and control. The executive makes decisions that have a longer term impact than middle or operational managers. These executives make the strategic directional decisions that guide the corporation in terms of people, products, and markets. The decisions are unstructured and based on substantial amounts of external data. Executives must have access to data covering longer historical and projected future time periods. Top executives are interested in issues critical to the success of the corporation. The concept of management by exception is important to the effective use of their time. They often need to access information by product line, vendor, geographic location, competitor, and other similar categories. The ad hoc ability to look at overall corporate performance indicators and drill down into more detail is an important capability within the EIS. EISs are very difficult to design and relatively expensive to operate because of their dynamic nature.

EISs reduce information overload on the executive and include user-friendly versions of the DSS used by middle level managers. In general, the interface is graphical and easy to use. Executives do not enter queries, but rather use preselected models with options that enable them to customize the information needed to respond to their request. The information is provided in a summary format so that the executive can get a broad picture. Then the executive can choose to drill down for the details or do a pivot to view the data from a different perspective so as to identify problems and seek solutions. The internal databases that an EIS uses often are in the form of data warehouses. EISs also link to external databases and must provide access to both qualitative and quantitative information.

THE GLOBAL MARKET

The international nature of the corporation and its management information systems are currently going through a paradigm shift with the advent of the WWW which is making a dramatic impact on businesses worldwide. In 1996 sales reached $2.6 billion and were estimated to be more than $220 billion in 2002. Although the Web is still essentially unregulated, has security deficiencies, and lacks standards, the information available is doubling on a yearly basis. The WWW has dramatically increased the access of even small businesses to local, regional, national, and international markets. The use of the WWW is widely accepted for providing information about companies, products, services, and employment opportunities. The Web's rapid acceptance is driven by the potential for increasing profit through electronic commerce and also by the danger that a given firm will become less competitive because of its failure to stay current with the electronic marketplace. The WWW increases competition by equally facilitating the access of other foreign and domestic corporations into US markets. The price of technological obsolescence can be high and might be life-threatening. The increased competition puts pressure on corporations to improve product quality, improve customer service, and decrease price, while simultaneously improving efficiency. To succeed in this increasingly competitive environment, corporations must effectively use information technology to create, promote, distribute, and support products and services which are truly "world class." Companies operating in this environment must marshal the resources necessary to create and maintain

the infrastructure and corporate IT architecture that enables these operations.

INFORMATION ARCHITECTURE

The decreasing cost and increasing power of IT have continually reduced the marginal cost of employing IT in an increasing range and intensity of business applications. Over the years the use of the technology has steadily increased and the computer-based applications have permeated competitively critical operations. In most cases, corporations could not function for any significant period of time without their data and application portfolio. Corporations have had to invest consistently in MIS to remain competitive in products, services, and distribution. Information architecture has evolved with advances in technology.

Information architecture is the form that information technology takes in an organization so as to achieve organizational goals. The organization's architecture consists of the way the components, hardware, software, networks, and databases are organized. The manner in which these components are organized for many organizations has changed from pure centralized systems, to client-server systems, and to distributed cooperative processing systems. Much of this changeover has taken place because of the emergence of powerful personal computers and the growth of sophisticated knowledge users who demand easy-to-navigate graphical interfaces and use powerful software to accomplish their work. The cost of these systems has also meant that organizations have pushed more of their processing to personal computers and networks of personal computers, as opposed to handling the processing centrally. In addition, when connected cooperatively, new organizational structures, such as teams and work groups, can be supported effectively, and they provide organizational flexibility.

Centralized Systems. Traditionally, prior to the mid-1980s, almost all processing was done centrally in a mainframe, and users were provided with terminals and sharing access to the mainframe. This architecture provided control and security to organizational data. Centralized systems started with standalone systems and later evolved to integrated functional systems.

Stand-Alone Systems. These systems were developed for well-defined applications, for example, accounts payable, accounts receivable, payroll, and inventory processing. Being transaction-based systems, they usually processed large volumes of data. The outputs of these systems were periodic, printed reports responding to predefined queries usually written in a low-level language. These systems were under the control of centralized management, predominantly batch processed, and with relatively little end user access. Hence, they were not very useful for executive decision making. These centralized systems gave way to integrated systems.

Integrated functional systems are what we might today call "suites," for example, an accounting, marketing, or production suite. These functional suites were predominantly transaction-based and stored data in early database management formats that supported more summarized reports and presented somewhat integrated data reports to middle and upper management. These suites were more customizable and allowed for ad hoc queries and on demand reports. However, these systems were all centralized, and users were clamoring for additional functionality in applications that was often not provided by the information systems staff.

LAN-Based Systems. Because of the time lag for applications to be developed on mainframe systems, many departments purchased personal computers and connected them via local area networks (LANs) to meet their needs. These systems were characterized by network servers, to which users connected by using LANs. The network file server stored common office productivity applications, such as spreadsheets and word processing, and provided other services, such as print and email services. Users connected to the server and could use these applications and communicate with other members of the network via email.

Client-Server Computers. A logical extension of the LAN occurred when users were connected to the network server and also to the centralized mainframe where corporate data existed. Users could use their computers as dumb terminals to the mainframe and also use their personal computers to do additional processing, such as formatting the presentation of data and error checking. This led to client-server processing. In client-server applications, the processing is done on more than one computer. Typically the applications are broken down into presentation, business logic, and data. The data layer is typically a database management system stored on the main-frame that allows the user to query and perform functions on the centralized database. The business logic layer checks and makes sure that integrity considerations for the application are not violated. For example, salary raises in a particular year may not be greater than 5% is an integrity rule that may be stored separately in the business layer. The presentation layer formats the data for the user. When all these three layers are in separate computers, as in Fig. 3, then we have a three-tier, client-server system. More commonly, two of these, such as the business layer and presentation layer, may be in the client system leading to the two-tier, client-server system. Three-tier, client-server systems are better because they provide more flexibility and scalability (i.e., we can add additional clients without lowering performance), and changes made in one layer do not affect other layers.

Distributed Cooperative Systems. When client-server systems first came into use, they were generally constrained by proprietary interfaces. These have slowly given way to open or industry standard interfaces allowing organizations to mix and match computers and software more easily. The emer-

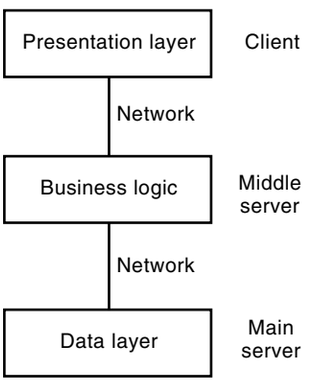

Figure 3. An overview of a common architecture used to design client–server applications.

gence of the Web browser as a universal client and the internet as the underlying networking mechanism has helped to promote open systems. Cooperative systems take client-server processing to its logical end, wherein different (n-tier as opposed to two- or three-tier) computers work together to solve a common problem. These computers can be connected via a LAN or a wide area network. For example, in a cooperative processing system, the order processing system may log into a supplier's information system to check the status of an order. Standards are developing wherein users would not have to know where on the network of computers a service is being performed, and all cooperative processing takes place transparently to the user.

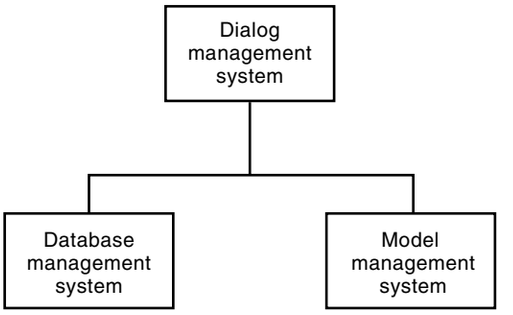

Figure 4. An illustration of the main components in a decision support system.

DECISION SUPPORT SYSTEMS

As discussed previously, a DSS supports the decision making activities of managers. DSSs help managers identify and study alternative solutions to problems and choose among them.

Decision Making

Managers make decisions on a variety of problems. Simon stated that managers make decisions that are either programmed or nonprogrammed (3). Programmed decisions are fairly structured and can be made via rules or standard procedures. For example, the decision to reorder products in an inventory can probably be automated based on the product concerned. Nonprogrammed decisions are more difficult to quantify and inherently lend less structure to the problem. For example, the decision to open a new plant is an unstructured problem.

Simon also described the following three phases that managers go through when making a decision or solving a problem:

- *Intelligence.* In this phase the manager scans the environment for problems calling for a solution. This is akin to the intelligence activities undertaken by the military. The problem is identified, constraints specified, and the problem formulated.
- *Design.* The manager designs, develops, and analyzes alternative courses of action. Here the manager identifies and evaluates alternatives for feasibility.
- *Choice.* In the choice phase the manager decides on one of the alternative courses of action and then implements the decision. Then a continuous review of choice activities takes place.

Decision makers do not necessarily always optimize and find the best solution. They may find a solution that is good but not necessarily optimal. This is reasonable in situations where finding the optimal solution proves too costly or is time consuming. Information systems, such as a decision support system, can help the manager make programmed or nonprogrammed decisions, provide support in all three phases of decision making, and help in identifying either optimal or satisficing solutions.

DSS Architecture

A DSS architecture, shown in Fig. 4, consists of a database management system, model management system, and a dialog management system. A DSS uses a database system that provides access to data. These allow the manager to query data. These data may reside in a traditional database system, client-server environment, or in a data warehouse. In addition to traditional data, DSS typically contain links to external databases, such as those available from different sources on the Web.

Models are built using model base systems. These help the manager analyze the data. A model base includes (1) formulas and equations, (2) simulation models, (3) linear integral programming models, (4) statistical models, and (5) financial formulas, such as cash flow. Typically these models may be created using spreadsheets or other special purpose software. For example, Taco Bell combines three models—a forecasting model, a simulation model, and an integer model—to schedule its employees. The *forecasting model* is used to predict customer arrival so that managers can predict the sales in fifteen-minute intervals. A discrete event *simulation model* then helps the manager develop labor or staffing tables. These are then fed to an *integer-programming model* that allows the manager to decide what the exact employee schedule should look like. The output specifies how many people are needed, their positions throughout the day, and what their shifts would look like including breaks. These are provided in both graphical and tabular formats to the manager. For engineering purposes, a model might contain a simulation of an integrated chip, before it is physically produced. The simulation may provide valuable information on layout, thermal considerations, performance, and other factors. Then these simulations enable the design engineers to arrive at a suitable design before spending large amounts of money to produce a chip.

The dialog management system provides the user interface to the DSS. Using the dialog management system the user interacts with both the database and the model base. Interactions include performing queries and entering parameters into the system. The dialog management system also returns the results in a format selected by the user, such as tabular, graphical, or animation. The dialog management system allows the user to switch views easily between a tabular or graphical display.

Group Decision Support Systems

Businesses are now moving toward an environment where teams and groups work together to complete projects. Group

decision support systems (GDSSs) support the decision making activities of groups of managers or teams. GDSS enhance decisions by removing group process impediments, such as groupthink or pressures to conform in making a decision. Typically, a GDSS is installed in a conference room and contains hardware and software that facilitate meetings.

Some types of software that are installed include brainstorming and idea generation software, wherein members of the group enter ideas anonymously. Others can comment on these ideas and participants can rank, consolidate, and vote on these ideas. Alternatives can be evaluated based on these ideas, and they can be ranked using different weighting factors. In addition, software for stakeholder analysis, problem formulation, and contingency planning aids are included. Collaborative tools, such as a private scratchpad and a group scratchpad, are typically included.

GDSSs are typically run by using a meeting facilitator and giving anonymity to all participant actions. This provides the advantage that some users do not dominate meetings and improves the decision making capacity of the group as a whole. In addition, GDSSs provide group memory facilities by keeping records of the meeting.

Groupware. In contrast to GDSSs that provide support for decision making, groupware, such as Lotus Notes, supports more collaborative work. Groupware provides bulletin boards, e-mail, calendar facilities, etc. to support teams and groups. It facilitates the movement of messages or documents to enhance communication among team members. Groupware also provides access to shared databases, work-flow management, and conferencing. Using these, team members across the globe can keep in touch with each other and keep every other member of the group posted on their activities and the project's progress. The Internet and its discussion groups, e-mail, and browsing software provide some of the same capabilities using open standards and nonproprietary software. The discussion groups on the Internet can be limited to users within a corporation by limiting access to specified individuals.

Advances in Decision Support Systems

Organizations have started to realize a new purpose for gathering information, that is, as a measurement on which to base future action rather than as a postmortem and a record of what has already occurred. On-line analytical processing (OLAP) tries to support this new desire of organizations. OLAP refers to the dynamic enterprise analysis required to create, manipulate, and synthesize information from enterprise data models. OLAP includes the ability to discern new or unanticipated relationships among variables and the ability to

- Identify the parameters necessary to handle the large volume of data
- Create an unlimited number of dimensions (consolidation paths)
- Specify cross-dimensional conditions and expressions
- Analyze data according to these multiple dimensions

Multidimensionality is the key requirement for OLAP, which handles large volumes of data, typically resident in a data warehouse. An OLAP server typically sits between the data warehouse and the client software that the decision maker uses. The client software used for analysis can be user-driven (e.g., traditional queries and reports), system-driven as in data mining, or driven jointly by both system and user, as in multidimensional analysis. This new DSS architecture is shown in Fig. 5.

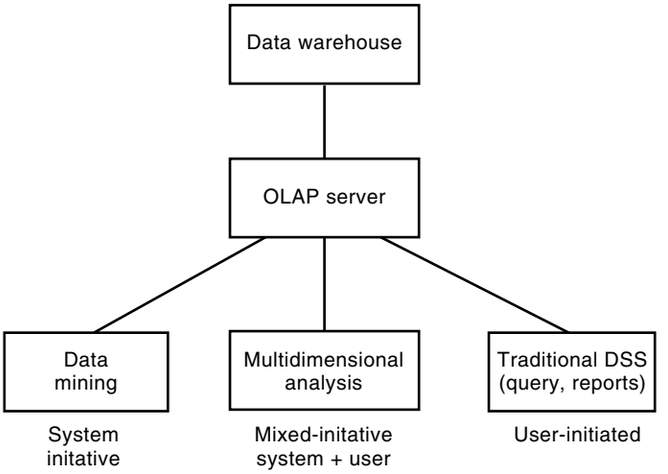

Figure 5. An illustration of the role that data warehouses, OLAP, data mining, and multidimensional analysis plays in augmenting the traditional DSS in supporting decision making.

Data Warehouse. Regular databases do not meet the needs of a DSS because they do not include historical data, in general lack some data integrity (not free from errors), and also are organized for ease of application rather than for decision making. A data warehouse is a database created specifically to support decision making. Hence, the data in a data warehouse are highly integrated (from many different databases in the organization), scrubbed (free of errors), contain time-variant data (historical data), and are organized by subject rather than by application. In general, data in a data warehouse are not deleted.

Multidimensional Database. Multidimensional databases optimize storage and manipulate output to help users investigate patterns of data in the data warehouse. The dimensions represent the user's perception of the data. For example, the set of all products or sales regions is a dimension, the quarterly year may be a dimension, etc. The objective of multidimensional analysis is to help decision makers perceive the meaning contained in the data. The user can visualize the interrelationships in the data more easily than otherwise. Multidimensional databases allow users to look at all possible combinations of entities and their interrelationships by providing the following capabilities:

Pivoting. Users can pivot or rotate across tabs by moving dimensions displayed in columns and rows. This changes the orientation of the object that is displayed allowing the user to investigate the different relationships.

Sorting and Collapsing. Users can sort by any dimension or collapse two dimensions into one.

Aggregation and Drill-Down. Users can see the data at the desired level of detail. They can receive a summary report or can choose to drill down and investigate further.

Time-Dimension. Support for time dimension is built into multidimensional analyses, as most data warehouses have historical data stored in them. Users can query for averages for last year, sales by month, etc.

Data Mining. In multidimensional analyses, users search for the patterns in the data. However, in data mining the computer system searches for patterns of information in data. Data mining is the computer-assisted process of searching through and analyzing enormous sets of data and extracting the meaning of the data. Basically two approaches are used: (1) predictive modeling and (2) automatic discovery. If the search is based on a predetermined idea of the patterns or some hypothesis about what the patterns might be, it is called predictive modeling. In the absence of any predetermined hypothesis, the search is called automatic discovery. Ideally, a combination of the two methods is used in conjunction with the user to discover the patterns. The user's role is to guide the search process, using a visualization system.

The process is usually iterative, so that the user can review the output to help refine the search process or to form a narrower or more elaborate search. Data mining software should be transparent (the system can explain why it performed certain operations), so that it can help the user understand and guide the system. Once the search process is complete, it is still the responsibility of the user to interpret the results so as to ensure that useful knowledge is derived from the data.

Generally data mining tools solve problems that

- Partition data into two sets, based on the presence or absence of data. This is useful in direct mail campaigns, fraud detection, and bankruptcy prediction.
- Partition data into multiple predetermined sets of classes. This is useful in medical diagnosis, and in establishing a credit rating and bond rating.
- Perform function reconstruction, such as time-series forecasting. This is useful in areas, such as forecasting financial data and sales data at the level of the individual.

QUALIFIED IS PERSONNEL

The information system is organized to optimize the information system services so as to meet the organizational goals and culture. In general, the structure of the IS organization reflects its informational architecture. However, it can be either centralized or decentralized. A chief information officer (CIO) typically heads the information systems organization. John Whitmarsh, editor of *CIO* magazine, defines the CIO as one who designs a "technology blueprint" and develops technology strategies that advance corporate goals.

A CIO's role is to

- Guide and unify the entire IT resources
- Coordinate all resources
- Be business oriented, not technology oriented
- See the advantage of technology and where to apply it broadly in the business
- Engineer technology organizations and infrastructure

A growing role for the CIO is to add value to their customers and also make sure that their customers recognize the value added. In general, the CIO has to ensure that the right things are done and is responsible for management of information technology and technical issues in information systems. In a centralized organization, the CIO supervises all IS professionals. In a decentralized setup, the CIO supervises the corporate unit. Each division has its own divisional information leader. The CIO relies on database administrators (DBAs), a telecommunications manager, programmers, and systems analysts to help in carrying out the various information system tasks. Figure 6 shows a typical organization chart for the information systems group.

Programmers and Systems Analysts. Most IS professionals start their careers either as programmers or systems analysts. They analyze the needs of the users and design and write codes to develop custom solutions. They also help maintain and update existing systems. To succeed, these professionals must have a technical background and also must also understand the business functions and possess excellent communication skills. They advance to become project leaders and are in charge of other analysts, allocate resources, such as hardware and software used in the development process, and use project management skills to ensure that the project is developed and delivered to the customer on time and within budget.

Database Administrator. The information stored in the corporate database is one of the most valuable resources within the organization. A separate database administrator (DBA) is responsible for managing all aspects of the database. Some responsibilities include planning, design, maintenance, and organization of the database, determining access to the database, user support and training with regard to database, maintaining a secure database environment, and providing for recovery from failures. To perform these functions, the DBA must be able to work with programmers and systems analysts and also with end users who have varying levels of computing skills. The person must be skilled in design and administration of databases while simultaneously having the

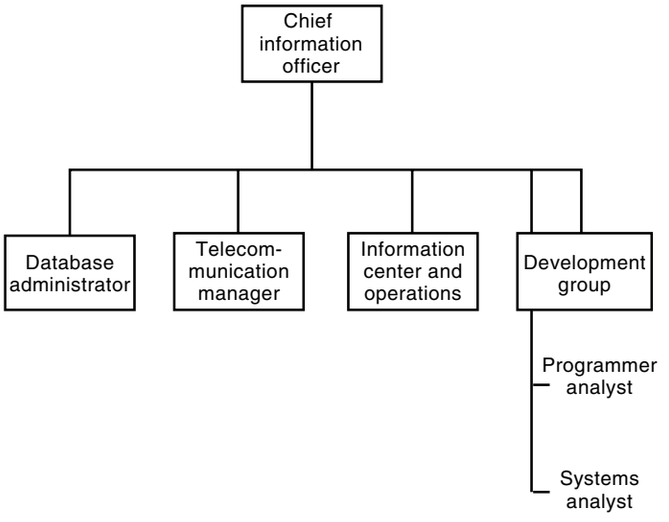

Figure 6. A typical organizational structure for an MIS department.

ability to work with end users and management. In many organizations, the data administration functions may be spread over a group of people rather than an individual.

Telecommunications Manager. The telecommunications manager is responsible for designing, implementing, and maintaining the corporate networks (both local and wide area) and ensuring that users can get to the computing resources that they need. The manager must be able to assess current and future telecommunication needs, the direction of communication technology, plan the network topologies, recommend hardware and software, design the system and implement it. In addition, the manager must implement security measures for authentication, authorization, and prevent against any unauthorized break-in and use of the corporate network. With the emergence of the Internet as a feasible commercial medium, these functions have taken on additional importance within the IS organization. Communication audits must be undertaken to check that the networks are being operated and used as intended.

Information Center. The information center is responsible for providing help to end users and assisting users with any problems that arise as they use the system. The center provides functions, such as training, documentation, equipment selection and setup, standards, and trouble shooting.

Operations. This group focuses on the efficiency of computer operations in the organization and consists of systems operators. Systems operators are responsible for ensuring that computers, networks, printers, etc., work efficiently. They generally hold certification from the industry vendors and work directly with hardware and software.

FUTURE DEVELOPMENTS

Information systems provide value to their business units by (1) allowing the organization to respond rapidly to changing market conditions or customer requests, (2) improving quality, and fostering innovation, and (3) competing and serving customers on a global basis. They also create value indirectly when they improve user interfaces and make it easier for users to respond to customer queries or when information systems are developed using different techniques to allow them to respond rapidly to competitive pressures. Advances are taking place in new user interfaces. For example, speech recognition is starting to become available for issuing commands to the computer. Systems development is changing to using components off the shelf, as opposed to developing them in-house. In addition, developments in electronic commerce are making interorganizational systems commonplace and provide organizations with another mechanism to reach their customers and end users. Videoconferencing technology and collaborative technologies are also starting to emerge. These allow organizations to support group meetings and project teams globally. They provide organizations with flexibility and the ability to compete worldwide. Technological advances make possible business reengineering using information technology. All of these advances imply that organizations, customers, and end users can expect to perform or have their work performed quicker with better quality and at low cost.

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