Chapter 11

Building Web-Based and Interorganizational Decision Support Systems

INTRODUCTION

In his 1995 book *The Road Ahead*, Microsoft Chairman Bill Gates argued the "information highway will extend the electronic marketplace and make it the ultimate go-between, the universal middleman. …This will carry us into a new world of low-friction, low-overhead capitalism, in which market information will be plentiful and transaction costs low. It will be a shopper's heaven. (p. 158)" To exploit the plentiful market information and generate profits, companies will need to create and use sophisticated Decision Support Systems (DSS). These DSS will need to be available to both internal and external stakeholders. For many reasons, the logical technology to use for building these new DSS is the Internet or a corporate intranet built using Web technologies.

The dominant information technology platform in companies is changing from mainframes and LAN-based, client-server systems to Web and Internet technologies. This technology change is expanding what Peter Keen (1991) called "information reach" and "information range." The reach of information and decision support systems has expanded significantly to serve a very large group of internal and external stakeholders. The range and variety of decision support information that can be developed, delivered, and shared is also becoming much larger. Today, innovative Web-based examples of all five categories of DSS, including communications-driven, data-driven, document-driven, knowledge-driven, and model-driven DSS, can be found, and more innovative DSS of each type will surely be developed.

Data from various sources, including DSS vendors, The Conference Board, and PricewaterhouseCoopers, indicate that a technological shift to Web technologies is occurring in many corporations. In 1999, 58 percent of large

corporations had intranets and 10 percent had extranets for business partners. A large majority had Web sites (72 percent) and used e-mail (92 percent). The growth of Web-based DSS was just beginning in 1999; only 8 percent of firms had Web-enabled company data warehouses. Surveys indicate most large firms are planning to create intranets, establish extranets, and make company-wide data warehouses accessible on their intranets and extranets.

With Web technologies being rapidly implemented, it is important to monitor and explore the possibilities of Web-based DSS. Some evidence indicates that Web technologies can reduce the cost of building and delivering decision support. Managers need to know more about how to build Web-based and interorganizational DSS. Also, managers need to know how to create DSS that support customers and suppliers. In most companies it is important to explore the advantages of changing the technology of DSS to Web technologies. From a practical standpoint there are limits to the amount of knowledge of Web technologies most managers need. Managers should probably not be maintaining Web sites, but they often will be content providers. Finally, managers and MIS personnel need to "surf" the Web and try a variety of examples of Web-based and interorganizational DSS.

This chapter focuses on Web technologies and interorganizational DSS, especially topics like designing and managing Web-based systems; examples of Web-based DSS software; examples of Web-based and interorganizational DSS implementations; and advantages and disadvantages of Web-based and interorganizational DSS.

KEY TERMS

The World Wide Web is where the action is in developing enterprise-wide and interorganizational DSS. When vendors propose a Web-based DSS, they are referring to a computerized system that delivers decision support information or decision support tools to a manager, business analyst, or customer using a "thin-client" Web browser like Netscape Navigator or Internet Explorer. The computer server that is hosting the DSS application is linked to the user's computer by a network using the Transmission Control Protocol/Internet Protocol (TCP/IP). In many companies, a Web-based DSS is synonymous with an intranet and an enterprise-wide DSS that is supporting large groups of managers in a networked environment with a specialized data warehouse as part of the DSS architecture. This view is too narrow; Web technologies can be used to implement any category of DSS. Web-based means the entire application is implemented using Web technologies including a Web server; Web-enabled means key parts of an application like a database remain on a legacy system, but the application can be accessed from a Web-based component and displayed in a browser.

Some companies have created extranets for decision support as well as intranets. Interorganizational DSS serve a company's stockholders, bankers, customers, or suppliers. An interorganizational DSS may provide stakeholders with access to a company's extranet and authority or privileges to use specific decision support intranet capabilities. For example, Artesyn Technologies

(www.artesyn.com) has virtual design decision support tools to provide customers of its power supply products with pre-sales technical support. Wal-Mart Retail Link provides some suppliers with Web access to sales forecasts and decision support capabilities. Companies are creating Web-based, interorganizational DSS that customers can use to evaluate products or that suppliers can use to control costs or reduce inventories. These DSS may be data-driven or document-driven DSS, communications-driven or Group DSS (GDSS), model-driven DSS, or knowledge-driven DSS. The target users are managers and knowledge workers in a customer, supplier, or partner organization and, in some cases, retail customers. Some people would say these DSS are part of a company's external intranet or extranet.

As noted, only about 8 percent of firms had Web-enabled company data warehouses in 1999. A company intranet based on Web technologies can provide even more extensive management information and decision support than a data warehouse. Also, an intranet can provide decision support to a wide variety of internal users. An intranet is a secure, internal organizational network that uses TCP/IP with at least one Web server. It is important that an intranet is secure and accessible by only an organization's members or others who have specific authorization. A firewall and password protection should limit access to the network. An intranet is an internal information system based on Internet technology, Web services, and Hypertext Markup Language (HTML) or portable document format (PDF) publishing.

An intranet is used to share corporate information, including DSS capabilities. Most intranets have a main page called a portal. A portal is a simple, personalized Web front end that provides access to information from the global Internet as well as a wide variety of corporate systems, including document servers, business intelligence systems, groupware databases, and enterprise resource planning systems. A Web portal provides a means to implement the different generic DSS into a more complete management support system than any built in mainframe or client/server environments.

The above terms are evolving as quickly as the Web itself, and authors do not use them consistently. There will be some conceptual ambiguity in Internet and Web technologies for the foreseeable future.

DESIGNING AND DEVELOPING WEB-BASED DSS

A decision-oriented diagnosis approach is important for Web-based and interorganizational DSS. Simply making an existing DSS accessible by using a Web browser to managers, customers or other stakeholders will often lead to unsatisfactory results. Creating a Web-enabled DSS should be considered a "quick fix" rather than as a permanent means of deploying a decision support capability. Once diagnosis is complete, a feasibility analysis is definitely needed for an enterprise-wide DSS. A systematic development approach must be explicitly chosen, and managers must be involved in the development process.

Developing the user interface, models, and data store for Web-based DSS remain major tasks. A user interface remains important in a Web development environment, and it probably becomes more important because so many users of

various levels of sophistication can potentially access some or all DSS capabilities. The representations available to user interface designers of Web-based DSS are comparable to those for stand-alone DSS, but the available operations expand enormously with the additions of hyperlinks and the availability of external data and document sources. Control and memory aids also change somewhat in a Web development environment.

The actual architecture implemented is usually simple. Most Web-based DSS are built using a three- or four-tier architecture. A person using a Web browser sends a request using the hypertext transfer protocol (HTTP) to a Web server. The Web server processes the request, using a program or script. The script may implement or link to a model, process a database request, or format a document. The results are returned to the user's Web browser for display (see Figure 11.1). Web applications are designed to allow any authorized user, with a Web browser and an Internet connection, to interact with them. The application code usually resides on a remote server and the user interface is presented at the client's Web browser.

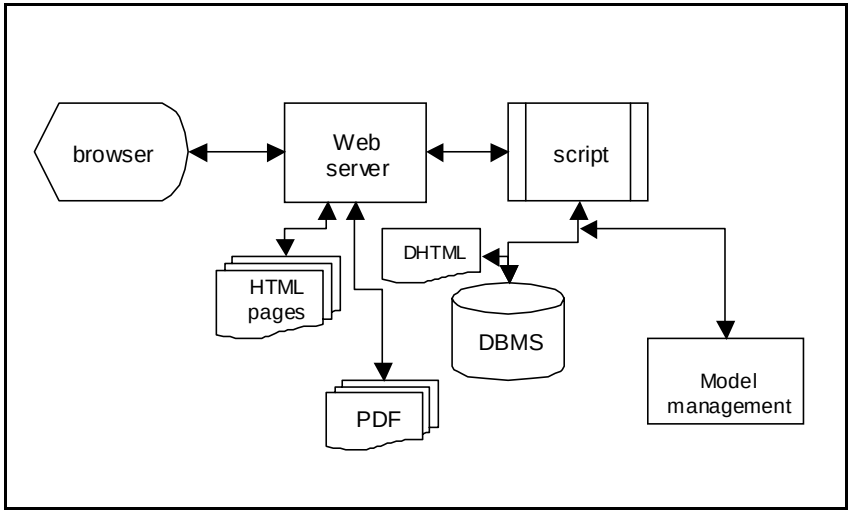

Figure 11.1 Web-Based DSS Architecture

The tools for building Web-based DSS are new and increasingly complex. Many people have heard of HTML, but it is only a small part of the development tool set. MIS staff and managers are bombarded with acronyms and terms like Extensible Markup Language (XML), Common Gateway Interface Scripts (CGI), Java applets, JavaScript code in HTML pages, and ActiveX components. The remainder of this section briefly explores some of these tools.

HyperText Markup Language (HTML) is designed to specify the logical organization of a Web document with hypertext extensions for hypertext links and user interaction. Web documents can be used for receiving input and

showing output from a decision aid programmed in a programming language, such as Java or JavaScript. The most useful tags for entering input and displaying output are the Form tags.

Extensible Markup Language (XML) is a general syntax for describing data elements of a Web page. It is applicable to a wide range of DSS, including applications with databases and Web documents. It is similar to HTML; however, in XML one can create custom tags to show a document's structure. XML tags transform each Web page into a more structured document. For example, in a document consisting of employee information, there could be tags like < name> < /name> , < position> < /position> , and < streetaddress> < /streetaddress> . In HTML, the information could only be separated with < br> or < p> < /p> tags. XML allows DSS to process documents, data, and information faster and more efficiently.

Common Gateway Interface (CGI) applications are server-executed programs used to dynamically create HTML documents. Many World Wide Web sites use CGI applications for dynamic Web page creation, for taking values from Web forms, and for providing a Web-based interface to other applications, such as databases. CGI programs provide the back-end processing for many Web-based decision aids and DSS.

Java is a general-purpose programming language. In "The Java Language: A White Paper" (Sun Microsystems, 1996), Sun developers describe Java as "a simple, object-oriented, distributed, interpreted, robust, secure, architecture neutral, portable, high-performance, multithreaded, and dynamic language." It is related to C and C+ + , but some capabilities are omitted and a few ideas from other languages are included. Java is categorized as a high-level programming language. Compiled Java code is computer architecture neutral, so Java applications can be used in a diverse operating system environment like the Internet. The Java language provides a powerful addition to the DSS development tools available for programmers. The official Java Web site is http://java.sun.com/. The largest directory of Java applets and Java-related Web sites is http://www.gamelan.com/.

JavaScript is a programming language that is highly integrated with Web browser objects. JavaScript is downloaded as part of an HTML page, and the Web browser processes it after it is received. JavaScript programs consist of functions that are called as a result of Web browser events like a mouse click. Some examples of JavaScript decision aids are at DSSResources.COM.

ActiveX controls are reusable software components developed by Microsoft. These controls can be used to add specialized functionality quickly to Web sites, desktop applications, and development tools. According to Webopedia, ActiveX is an "outgrowth of two other Microsoft technologies called OLE (Object Linking and Embedding) and COM (Component Object Model)." Most developers focus on ActiveX controls. An ActiveX control is similar to a Java applet. Related to ActiveX is VBScript. It enables one to embed interactive elements in HTML documents. Microsoft's Internet Explorer supports Java, JavaScript, and ActiveX, and Netscape's Navigator supports only Java and JavaScript, although plug-ins can provide support of VBScript and ActiveX.

Many desktop productivity tools like Microsoft Access, Excel, and PowerPoint have the capability to create Web documents. These HTML generator tools can let managers and analysts share decision support materials prepared on their personal PCs with others in their company. Web documents created with Microsoft applications often work best when viewed using Microsoft's Internet Explorer browser. In general, managers need to become more involved in working with desktop tools that can provide content for decision support intranets and extranets.

A number of specialized developer tools can help implement Web-based DSS including Microsoft Front Page, Cold Fusion from Allaire (www.allaire.com) and Web DSS development software like dbProbe (internetivity.com). These tools can assist some experienced developers, but they can actually result in poorly developed DSS when used by people inexperienced in building DSS. End-users are building Web-based DSS using Front Page or even Cold Fusion, but these DSS often have more detractors than advocates.

When a company embarks on building Web-based DSS, some problems can be anticipated and minimized. First, Web-based DSS applications will probably encounter some peak load problems. During the business day, many managers will want to access the corporate intranet and so a "high performance" hardware architecture that can expand to serve a large number of concurrent users is needed. This load problem is associated with the "scalability" of the hardware and software and the planning of the developers.

Second, the Web is a "stateless" environment that does not automatically keep track of configuration settings, transaction information, or any other data for the next page request. To avoid requiring users to reenter information such as user name and password, Web-based DSS applications must keep state information from one Web page to another. This creates new security issues for companies wishing to make sensitive, internal data accessible to users. User authorization and authentication are challenging in the Web environment because of the large number of potential users.

Third, it is difficult to keep up with changing Web technologies. To cope, one must be selective in scanning and reading technical materials, and it is a plus to learn rapidly in such an environment. Both managers and technical staff need to learn about Web technologies and then be prepared to keep up with new developments as they occur. Despite these problems and challenges, the Web is and should be the platform of choice for new DSS.

MANAGING WEB-BASED AND INTERORGANIZATIONAL DSS

Companies are using both traditional Electronic Data Interchange (EDI) and newer Web-based extranet technologies to build "trading communities." These interorganizational systems can support both transaction processing and cooperative or shared decision making. Despite the possibilities, a number of real-world issues like reengineering or redesigning business processes and encouraging trading partners to participate in e-business relationships remain major challenges. Managers in interdependent organizations need to cooperate

to build shared DSS, and suppliers need to consider what types of DSS can assist their customers. Also, managers must confront a variety of business, technical, and legal issues and impediments if they want to build effective interorganizational DSS.

The first major business issue that must be confronted is who will use the system: customers, suppliers or both? Then, managers need to ask a number of more specific questions: What is the cost of the proposed Web-based, interorganizational DSS, and who will pay the cost? Then managers need to ask: "Do we need to reengineer or redesign our processes? Does the Internet increase the speed of decisions and transactions and create efficiencies for our business? Will the use of networks, Web-based DSS and the Internet create new value for customers?" Too many "No" answers to the above questions, and proposed DSS projects will certainly fail.

In terms of technical issues, managers need to ask if the initiating company has the staff and technology in place to build the proposed interorganizational systems. Someone needs to determine what hardware and software the partners and participants will need to acquire. Technical issues can be overcome if potential problems and needs are identified early in the development process.

Finally, from a legal perspective, managers need to determine what material can be made available to external users, especially customers and suppliers, to support their decision making. And managers should ask: Do we have privacy or liability issues or copyright issues associated with the proposed DSS project?

Implementation can be especially difficult because a DSS project team needs the support of at least two sets of senior executives. Also, the team needs to address all of the above issues in terms of two or more different business and information technology cultures.

Advanced Interorganizational Systems

The most advanced interorganizational systems (IOS) use the public Internet to create communication links. The systems may involve any stakeholder with access to the Internet and authority or privileges to use specific capabilities. These advanced systems are associated with electronic commerce, DSS, and extranets. The increasing importance of easy and efficient access to information has lead many companies, especially large ones, to move toward more advanced Interorganizational systems. The increasing use of the Internet is significantly decreasing the costs of complex networks between suppliers, customers and manufacturers/retailers. The networked economy is creating electronic business communities—networks of suppliers, distributors, commerce providers, customers, and even competitors, according to the Alliance for Converging Technologies. The mission of the Alliance is to help companies collectively produce products and services by exchanging information online (see Tapscott, 1998).

Web technologies offer firms the opportunity to gather market intelligence and monitor consumer choices through customers' revealed preferences in navigational and purchasing behavior on the Web. Interorganizational DSS reduce costs to suppliers by letting them electronically access on-line databases

of bid opportunities, online abilities to submit bids, and online review of awards. The Web facilitates cooperative processes and can include buyers, suppliers, and partners in redesigned business processes.

With Web-based DSS supporting value chains, the supply-chain management system and the customer support system can be integrated. Integration can provide sharing of manufacturing, inventory, and sales data. With such a system, suppliers build to order and do not stock inventory based on projections. A collaborative extranet supports relationships with key accounts. With an extranet, departmental peers in customer and supplier organizations are connected for real-time collaboration. A well-designed extranet with Web-based DSS should reduce cycle time and promote greater creativity in solving shared business problems.

Some Examples

According to John Webster (2000), PCS Health Systems, a prescription management company, issues plastic information cards to health-plan members. He notes, "When a patient fills a prescription, the pharmacist inputs patient information from the card, and PCS provides information such as eligibility, drug interactions and whether other drugs are preferred. Then the prescription can be dispensed, and PCS records the transaction and bills the health plan." Also, PCS provides analytical tools to its clients, the health plan managers, to help them understand how well their plan is performing. Clients use Web browsers to connect to the PCS network. Ron Merlino, senior vice president of technology infrastructure at PCS, said in Fall 2000 that PCS is giving more managers in client organizations access to data mining and analytical tools. A competing company, NDC Health Information Services, has a Web-enabled prescription data warehouse that it markets to pharmaceutical manufacturers.

Retailer Dayton Hudson has spent several years working to move its suppliers to EDI-based supply chains. It has standardized transactions on the delivery of Advanced Ship/Manifest documents based on Universal Product Codes (UPCs) to enable the retailer to keep track of its shipments and inventory. The retailer's EDI purchase order rollout began in January 1998, and the system currently supports 3,800 vendors with over one million UPCs cross-referenced. (Check http://www.internetwk.com) This large database provides extensive DSS possibilities similar to those in place at Wal-Mart and other retailers.

EXAMPLES OF WEB-BASED DSS DEVELOPMENT SOFTWARE

The DSS Vendor pages at DSSResources.COM include more than 75 companies that market decision support products. Many of these vendors have Web-based DSS products. The following paragraphs discuss a few vendors that have on-line examples or demonstrations of Web-based DSS development software. This information is quickly outdated so it will probably be necessary to explore the referenced sites to obtain current product information.

Arcplan, Inc. (http://www.arcplan.com) products include insight and dynaSight. The company Website claims dynaSight is the basis of a "New

Generation Corporate Information System that combines internal data sources and the Internet." It has a Java-based user interface and is able to analyze and structure the Internet dynamically, determine changes in information contents, and compress and store data in a database.

Business Objects (http://www.businessobjects.com/) has a number of Web-based decision support and business intelligence solutions. Its integrated query, reporting, and analysis tools are called WebIntelligence and BusinessObjects. WebIntelligence, Extranet edition, has "added security and audit features specific to extranets allowing organizations to share their data with their customers, partners, and suppliers."

Cognos (http://www.cognos.com/) DecisionStream is an application designed to build dimensional data marts. It integrates with Cognos Business Intelligence Web tools like Impromptu Web Query. There are two main parts to the DecisionStream architecture: a design client running on Windows or NT, and a Server Engine running on UNIX or NT.

Comshare MPC (http://www.comshare.com) is a Web-based application that provides management planning and control decision support. It has four modules for planning, budgeting, financial consolidation, and management reporting and analysis. All four modules share a common database.

Databeacon (http://www.databeacon.com) has a product called Databeacon 5.1. Written in Java, it is a cross-platform, corporate-wide tool for developing sales analysis, statistical analysis, financial analysis, inventory analysis, or data warehouse applications that needs multidimensional data analysis. This product is an excellent example of what is possible with Java applets.

Dimensional Insight has a dynamic Web-based, On-Line Analytical Processing (OLAP) tool based on Java applets. Web-enabled products include DI-WebDiver, DI-Discovery and DI-ReportDiver. With DI-ReportDiver, a user's password opens a Web page with a pop-down menu. The user selects a report that has been customized to answer his or her specific questions. The request is made to the server and the report is generated and sent back in compressed streams. Reports are generated in real-time.

Gentia (http://www.gentia.com/) markets a Web-based Enterprise Performance Management Suite based on the balanced scorecard concept and activity-based costing.

Hyperion (http://www.hyperion.com/) Web Gateway is a development platform for building Web-based analytic applications. It enables high-speed, interactive read-write access to Hyperion Essbase OLAP server across the World Wide Web. According to materials at the website, "The more than 800 licensees of Hyperion Web Gateway have built applications ranging from performance measurement to risk analysis to preparing the Federal Budget."

Hummingbird, Inc. (http://www.hummingbird.com) specializes in the development of decision-enabling Web-based work environments. Hummingbird's enterprise software solutions provide access to structured and unstructured data.

MicroStrategy (http://www.microstrategy.com) provides business intelligence technology. It's e-business decision support platform is called

MicroStrategy 7™. The primary application development capability is Web-based query and reporting.

Speedware (http://www.speedware.com) creates and markets client/server and Web solutions for application development and business intelligence systems. Speedware software products include Esperant, Speedware Autobahn.

The market for Web-based DSS development software is very competitive, highly fragmented, and rapidly changing. Vendors of packaged analytic applications include Informatica, Broadbase, e.Piphany, and Hyperion. Vendors of business intelligence software include Cognos, Business Objects, Brio, MicroStrategy, and Hummingbird. Vendors of tools for building Model-Driven Web-based applications include SAS and SPSS. Vendors of Web-based Groupware include Microsoft, Ventana and Netscape.

EXAMPLES OF WEB-BASED DSS

Many Web sites have decision support for customers or suppliers. Microsoft Carpoint at URL http://carpoint.msn.com demonstrates both data and model-driven DSS. Users can use a "Compare" feature to make pair-wise comparisons of car models across prespecified attributes.

A prototype Web-based, communications-driven DSS called TCB Works was developed by Dennis and Pootheri at the University of Georgia (cf., Dennis, Quek and Pootheri, 1996). TCBWorks is different from the typical discussion-oriented tools available on the Web. It is designed to enable people to interact, discuss issues, and make decisions. It can support both structured discussions and multicriteria decision making. When a user connects to TCBWorks a login screen requests the user's name and password. Once logged on, the user starts with a project screen. GroupSystems and other companies are developing similar Web-based GDSS.

Retirement and Investment planning is facilitated at a number of Web sites. Also, many 401K plans are supported by Web sites. Plan participants and sponsors do the work of entering data, transferring investments and researching investments. Model-driven DSS can show how an investment may grow over time; and knowledge-driven DSS provide advice. Some sites with DSS include Fidelity Investment's 401k.com, Principal Financial group at principal.com, and American Express at americanexpress.com. The Fidelity "Retirement Planning Calculator" is a model-driven DSS that helps a person decide how much to invest for retirement each month. Principal Financial has an "Investor Profile Quiz" that is a knowledge-driven DSS.

Netscape decision guides are good examples of model-driven and knowledge-driven DSS. One can find more than 25 decision guides at URL http://home.netscape.com/decisionguides. Topics of guides include choosing pets, bikes, and business schools.

Stockfinder at http://stockpoint.com has a data-driven DSS that helps investors identify stocks based on criteria like price, earnings, and type of industry. Stockpoint also has an Investment Profile knowledge-driven DSS. A user answers a short questionnaire about income constraints, personal financial goals and risk tolerance. The DSS processes the responses and provides a list of

possible investments that match the person's personal goals and budget constraints. A number of investment web sites provide their users with DSS capabilities. Document-driven DSS provide company information from many sources, charting software lets users manipulate financial comparisons of large time series databases, and search and agent software alerts users to news, stock prices and changes in stock prices.

WATERSHEDSS (Water, Soil, and Hydro- Environmental Decision Support System) at URL http://h2osparc.wq.ncsu.edu/ is a model-driven DSS used to help watershed managers and land treatment personnel identify their water quality problems and select appropriate best management practices.

Finally, a cost/benefit analysis decision aid is at DSSResources.COM. It is a simple calculator built using JavaScript that structures information input and calculates some decision relevant information using a model. Figure 11.2 shows a screen shot. To try the application, JavaScript must be enabled and commas cannot be used in input fields. JavaScript decision aids at DSSResources.COM are provided for informational and instructional purposes only.

COMPANIES WITH WEB-BASED DSS

Many companies have implemented Web-based DSS. Universities are also making DSS available to stakeholders at Web sites. A number of DSS software companies provide case studies of successful Web-based DSS implementations at their Web sites. As one would expect, the vendors are reporting favorable results from Web-based DSS.

According to Arborsoft and Hyperion materials, Bell Canada implemented a Web-based DSS. In a press release, a Bell Canada spokesperson said that the cost of deploying traditional client/server OLAP software made it prohibitively expensive to enable the entire enterprise for OLAP. . . . "The Web dramatically alters the cost dynamics of delivering applications to users." He notes, "All users need are a Web browser and a laptop computer. There's almost no training required, very low client costs and zero infrastructure costs. The internet acts as a free wide area network." According to the release, "Hundreds of business, operation and sales managers will be able to compose their own interactive queries right from their Web browser rather than accessing static data reports prepared by financial analysts. They can navigate, analyze, and even update their sales forecasts without the need for proprietary client software."

In 1998, the Pharmaceutical Division of Bayer Corporation deployed a Web-based tool that allows managers at the company's 600+ cost centers to create yearly budget plans. Users access their planning information via Bayer's corporate intranet from any of the company's North American locations or its German headquarters. The planning tool was developed using arcplan's inSight interface development software with a back-end system based on an IBM RS 6000 server running Oracle® 7.4. The system also incorporates a firewall-protected intranet server, which subsequently feeds information to the Oracle server/data warehouse and then on to a Hyperion system for further reporting. The Web-based implementation was chosen due to the ease of distribution of applications over the Internet.

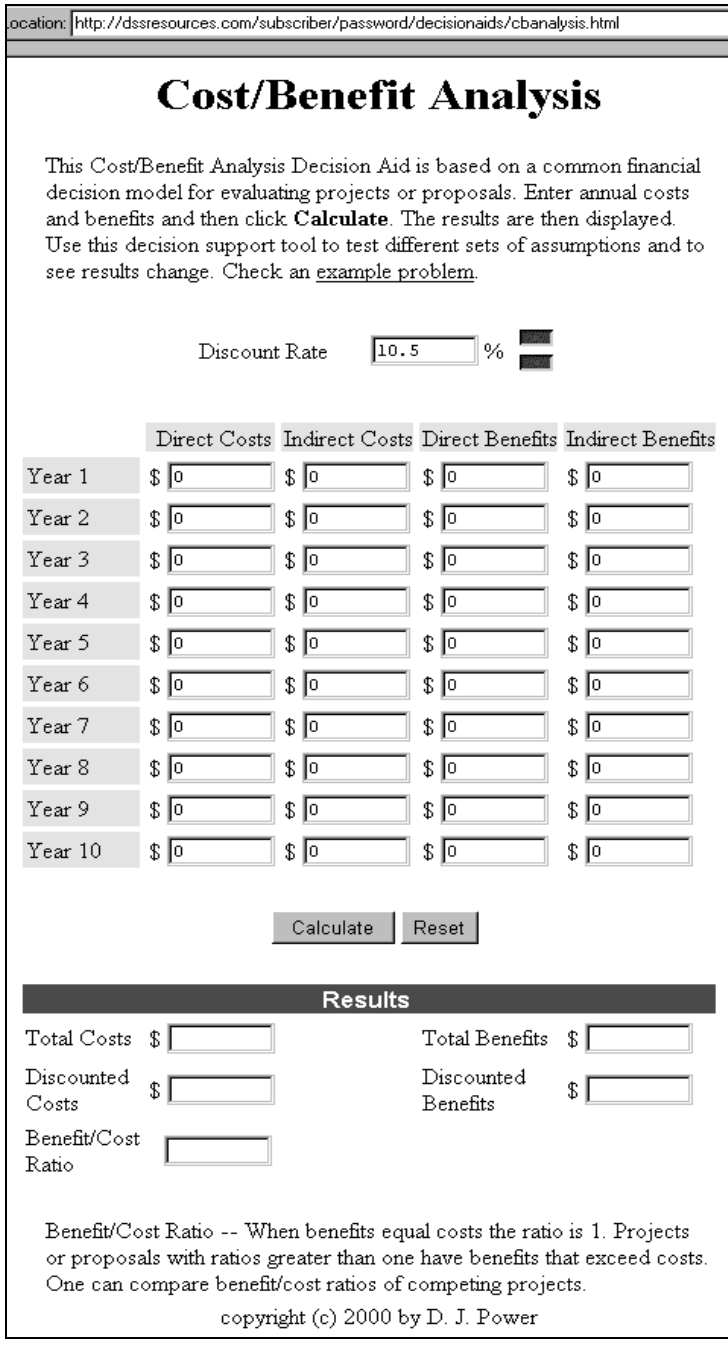

Figure 11.2 – JavaScript Decision Aid at DSSResources.COM.

Deere & Co., Inc., Waterloo Works, is using Information Discovery's (http://www.datamining.com) pattern-based approach to data analysis to forecast tractor sales. Their system is Web-browser-based, and it allows users to access historical data. Business users can access information on the corporate intranet. A case study at the Information Discovery Website, Datamining.com, claims the application has lowered Deere's inventory and marketing costs and allowed Deere to better plan sales.

In January 1998, Information Advantage announced that EDS had chosen DecisionSuite and WebOLAP(tm) to support implementation of the EDS knowledge management strategy. "EDS is rolling out DecisionSuite to several hundred users performing on-line analyses on a 50 GB database. 1998 deployment could scale up to 9000 knowledge worker desktops." Larry Ford, president and CEO of Information Advantage said in the press release, "The Web enables multinational organizations, like EDS, to provide applications that deliver content to the end-user without the traditional, costly barriers of installation, training and maintenance."

Hannaford Brothers grocery chain developed a DSS using Microstrategy's DSS Web. At Hannaford, DSS Web provides store managers with access to the same data warehouse application relied upon by corporate decision makers. Utilizing DSS Web, managers receive detailed sales, cost, inventory, and budget reports and use this information to make decisions at the store level.

According to a MicroStrategy case study, Société Générale USA chose a multi-tier architecture that enabled the support of both client server and Web computing. MicroStrategy software enabled Société Générale USA to provide support for executive and power users, running on either PCs or UNIX workstations and using a Web browser interface.

Many other cases are available at Vendor Websites and at DSSResources.COM. For example, at DSSResources.COM, decision support applications at the following companies are summarized: ShopKo, BMW, Pfizer, Shell International and Maytag International.

ADVANTAGES AND DISADVANTAGES OF WEB-BASED DSS

Web-based DSS have reduced technological barriers and made it easier and less costly to make decision-relevant information available to managers and staff users in geographically distributed locations. Because of the World Wide Web infrastructure, enterprise-wide DSS can now be implemented at a relatively low cost in geographically dispersed companies to dispersed stakeholders, including suppliers and customers. Using Web-based DSS, organizations can provide DSS capability to managers over an intranet, to customers and suppliers over an extranet, or to any stakeholder over the global Internet.

The Web has increased access to DSS, and it should increase the use of a well-designed DSS in a company. Using a Web infrastructure for building DSS improves the rapid dissemination of "best practices" analysis and decision-making frameworks, and it should promote more consistent decision making on repetitive decision tasks across a geographically distributed organization. The

Web also provides a way to manage a company's knowledge repository and to bring knowledge resources into the decision-making process. One can hope that Web-based delivery of DSS capabilities will promote and encourage ongoing improvements in decision making processes.

Also, the Web can reduce some of the problems associated with the competing "thick client" enterprise-wide DSS architecture where special software needs to be installed on a manager's computer. It becomes much easier to add new users and initial training needs are often minimal. Web-based DSS reduce costs of operations, administration, support and maintenance as well as end user training costs. Web-based DSS also facilitate centralized management and maintenance of information technology resources.

With many Web-based, data-driven DSS products, managers with a browser have the same type of ad hoc reporting and interactive data analysis capability as that provided by "thick client" tools. Web technology is and will continue to change the way organizations deliver all types of documents and data.

What are the potential problems with Web-based DSS? First, user expectations may be unrealistic; especially in terms of how much information they want to be able to access from the Web. Second, there may be technical implementation problems, especially in terms of peak demand and load problems. Third, it is costly to train decision support content providers and to provide them with the necessary tools and technical assistance. Fourth, the continuing "browser wars" between Microsoft and Netscape that make some applications unreadable on one or the other browser are also a potential problem. Fifth, Web-based DSS create additional security concerns. Finally, using the Web for decision support may result in the accumulation of obsolete materials, especially management reports and documents or alternatively require hiring someone to monitor the currency of decision information.

CONCLUSIONS AND COMMENTARY

The World Wide Web has created a major opportunity to deliver more quantitative and qualitative information to decision makers. Web architectures and networks permit Information Systems professionals to centralize and control information and yet easily distribute it in a timely manner to managers who need it. Also, intranets are providing many opportunities for securely delivering information from data warehouses and external databases to a manager's desktop in a format that permits and encourages frequent use and follow-on analysis.

The Web has not resolved all problems associated with building, developing and delivering enterprise-wide DSS, and many questions about Web-based DSS remain controversial. The following questions are still being debated, but at this point the associated responses seem like reasonable answers. Can a Web-based DSS provide a company with a competitive advantage? *Sometimes*, especially in knowledge-oriented businesses. Does a Web-based DSS have significant cost advantages compared to other competing DSS technologies? *Usually*, especially in large-scale implementations where companies have multiple, geographically dispersed sites. Sometimes it is more cost advantageous to Web-enable a legacy

DSS for Internet access. Will a Web-based DSS speed application deployment and increase access to both structured and unstructured data? *Yes*, in most situations.

Will a Web-based DSS improve decision making? *Perhaps;* the optimists think so. Will Web-based DSS provide a broader knowledge base for decision making? *Yes*, in most cases, once the "knowledge" is on-line. Does Web access increase the value of a data warehouse? *Yes*, if the data is meaningfully displayed and drill-down is available to decision makers.

Does a Web-based DSS provide timely, user-friendly, and secure distribution of business information? *Yes*, if a good development product is selected and if the implementation is successful. Can a Web-based Decision Support System be managed and maintained? *Yes;* the tools for managing the Web server and Web content are maturing. Will information on a Company Web site expand in an uncontrolled manner? *No*, assuming a person manages the knowledge base. Will managers be able to locate what they need when they need it? *Probably;* staff need to organize information in meaningful ways, and search engines need to be available for unexpected information queries.

Does a Web-based DSS help mobile managers, sales staff, and customer support staff? *Yes*; information access and analysis is much easier and more widely available. Does a Web-based, interorganizational DSS help customers and suppliers? *Yes;* customers and suppliers can make better choices. Are Web-based agents and alerts useful and practical? *Yes*, if one understands what agents are and how to use them. An alert or agent can help a busy manager stay informed about more key performance indicators.

The Web makes it possible to deploy a global enterprise-wide DSS. Will Web-based DSS facilitate corporate growth? Improve productivity? Improve profitability? *Yes;* appropriately designed DSS can impact the corporate bottom-line.

Along with the Web-based opportunities for building innovative DSS come new challenges. Managers must choose which Web technologies to use and decide how to deploy these new technologies. Also, managers must learn how to use Web and Internet technologies to really gain a competitive advantage. This means that to implement Web-based and interorganizational DSS, it is essential to develop appropriate strategies and organizational structures, redesign business processes, integrate the technologies and associated information into decision-making processes, evaluate costs and benefits, and manage new types of business relationships.

The Web is the platform of choice and the new frontier for innovative DSS. All of the Web DSS development environments have strengths and weaknesses, but the capabilities are increasing rapidly, and the Web DSS user interfaces are impressive compared to those of only a few years ago. DSS built using Web technologies will take on a new importance as accessible and useful tools for improving business decisions (cf., Power, 2000).