Building Web-based Decision Support Systems

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Abstract: A wide variety of specific Decision Support Systems have been and can be built using Internet and Web technologies. This survey article is a focused and updated version of Power (2002) Chapter 11 "Building Web-based and Interorganizational Decision Support Systems". The survey emphasizes the what, how and why of building Web-based DSS. Also, Web-based examples of all five major categories of DSS, communications-driven, data-driven, document-driven, knowledge-driven and model-driven, are summarized and analyzed.

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1. Introduction

A few years ago, decision support applications built using Internet and Web technologies like HTML, CGI scripts, and JavaScript were interesting, but the user interface was substandard compared to client-server decision support applications and integration of the applications with databases and sophisticated modeling software was limited. Those problems have been overcome and now the Internet and Web technologies are the platform of choice for building most types of Decision Support Systems (DSS). DSS are a specific class of computerized information system that support decision-making activities. In general, DSS are interactive computer-based systems and subsystems intended to help decision makers use communications technologies, data, documents, knowledge and/or models to identify and solve problems and make decisions. (cf., Power, 2002). This survey examines decision support and web technologies in the context of a broad framework that classifies DSS into five categories: communications-driven, data-driven, document-driven, knowledge-driven and model-driven DSS.

This article is a more focused and updated version of Chapter 11 titled "Building Web-based and Interorganizational Decision Support Systems" in Daniel J. Power's (2002) book about decision support systems. This survey article emphasizes the what, how and why of building Web-based DSS.

For many reasons, the logical architecture to use for building contemporary decision support applications 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 (cf., Power and Kaparthi, 1998). 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 any size group of internal and external stakeholders.

The range and variety of decision support information and tools that can be developed, delivered, and shared is also becoming much larger. Today, innovative Web-based examples of all five categories of DSS can be found, and more innovative DSS of each type will certainly 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. More recent information indicates most large firms have created intranets, established extranets, and made company-wide data warehouses accessible on their intranets and extranets. Some evidence indicates that Web technologies can reduce the cost of building and delivering decision support.

This article focuses on Web technologies for building DSS and especially designing and developing Web-based systems; the survey also includes examples of Web-based DSS software; examples of Web-based DSS implementations; and it discusses advantages and disadvantages of Web-based DSS.

2. Types of DSS and Key Web Technologies

The World Wide Web is where the action is in developing decision support systems. 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 (cf., Power, 1998). 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 much too narrow; Web technologies can be used to implement any category of DSS. Web-based means the entire application is implemented using Web technologies; 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.

A communications-driven DSS supports more than one person working on a shared task, examples include integrated tools like Microsoft’s NetMeeting™. Communications-driven DSS support communication, collaboration, and coordination. A Group DSS is a hybrid that includes decision models like rating or brainstorming and support for communication, collaboration, and coordination. Data-driven DSS emphasize access to and manipulation of a time-series of internal company data and sometimes, external data. Document-driven DSS manage, retrieve, summarize and manipulate unstructured information in a variety of electronic formats. In general, they support a decision maker by electronically keeping track of textually represented knowledge that could have a bearing on decisions (cf., Holsapple and Whinston, 1996). Knowledge-driven DSS have specialized problem-solving expertise stored as facts, rules, and procedures or in similar structures. The "expertise" consists of knowledge about a particular domain, understanding of problems within that domain, and "skill" at solving some specific problems. A model-driven DSS emphasizes access to and manipulation of statistical, financial, optimization or simulation models. Model-driven DSS use data and parameters provided by decision makers to aid them in analyzing a situation. Model-driven DSS are not usually data intensive; that is very large databases are not needed for most model-driven DSS. The initial Decision Support Systems discussed in the 1970s by Scott-Morton (1971), Gerrity (1971) and Little (1970) are best classified as model-driven Decision Support Systems (cf., Power, D., “A Brief History of DSS”, 2002).

Some companies have created decision support applications for extranets as well as for intranets. 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 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, model-driven 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.

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 categories of DSS into a more complete management support system than any such system built in mainframe or client/server environments. The above terms are evolving as quickly as the Web itself, and all authors do not use them consistently. There will be some conceptual ambiguity and inconsistency in terminology associated with Internet and Web technologies for the foreseeable future.

3. Designing and Developing Web – based DSS

A decision-oriented diagnosis approach is important for Web-based 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 rather than a Web-based 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 a large-scale, 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-tier 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 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.

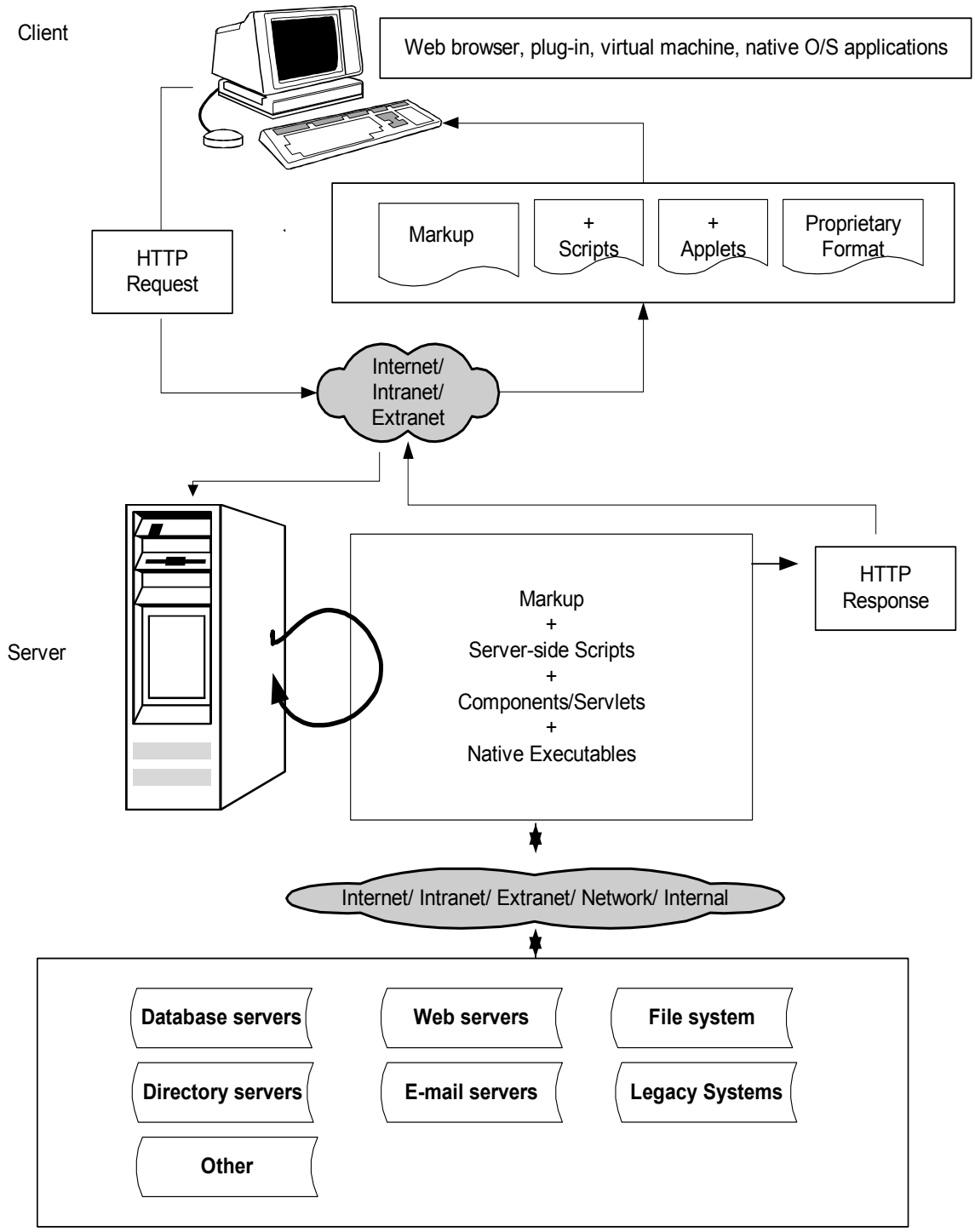

Figure 1: Web-based DSS Architecture

The tools for building Web-based DSS are still new and are 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), Web Server API (Application Programming Interface), Java applets and servlets, JavaScript code in HTML pages, ActiveX components and Plugins. 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
 or 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

To design systems without requiring sophisticated programming in languages such as C, C++, or Visual Basic, vendors designed embedded scripting languages that function on Web server API standards. Two well-known embedded scripting languages are Microsoft's Active Server Pages (ASP), which includes VBScript and JScript, and Macromedia ColdFusion, which processes embedded ColdFusion Markup Language (CFML). Both of these embedded scripting languages allow developers to build interactive Web-based systems that provide dynamic output (Kaparthi and Kaparthi, 2001).

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 Macromedia (www.macromedia.com) and Web DSS development software (cf., databeacon.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. Decision support users are building Web-based DSS using Front Page or even Cold Fusion, but these end-user built DSS usually 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. 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 decision support systems.

4. 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 online 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.

RetrievalWare from Convera (http://www.convera.com/Products/rw_arch.asp) offers an approach to document retrieval that uses semantic networks and adaptive pattern recognition. According to their product literature, these tools free people from the need to learn arcane and specialized search languages and give them the ability to locate and retrieve information based on its meaningful content. It provides unified access to data from file systems, office documents, groupware servers, document management systems, Web servers, scanned documents, news feeds, experts and relational database management systems.

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.

5. Examples of Web – based DSS

Table 1 summarizes examples of Web-based DSS and the technologies used on the client tier, server tier and the backend tier. 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. Once logged on, a user starts with a project screen. Work on TCBWorks was discontinued in 1997 when it was licensed for commercial release. It was renamed Consensus @nyWARE. The current product status is uncertain (check www.touchstone.com). GroupSystems (groupsystems.com) and other companies are developing similar Web-based GDSS. Another example of a Web-based, communications-driven DSS is the eRoom digital workplace solution. It provides a platform for global collaboration and knowledge-sharing. A case study at DSSResources.COM (eRoom, 2002) discusses how Chief Information Officers (CIOs) of the U.S. Navy's Bureau of Medicine and Surgery use the eRoom technology for decision support.

DSS Categories	Client Tier	Server Tier	Backend Tier
Communications-driven			
• TCB Works	Markup	CGI programs (written in C)	Database Servers (MiniSQL)
• U.S. Navy's Bureau of Medicine and Surgery (eRoom)	Markup + Scripts	Web Server + Scripts	Database Servers
Data-driven			
• Pfizer Manufacturing (Data Beacon)	Markup + Applets	Web Server	OLAP files created by proprietary software
• Stockpoint.com	Markup + Scripts + Applets	Web Server+ Servlets	Database Servers
• Pfizer (Alphablox)	Markup + Scripts	Web Server+ Components	Database Servers
Document-driven			
• San Francisco Department of Public Health (Documentum)	Markup + Scripts	Web Server+ Components	File system
• Fortis Bank (RetrievalWare	Markup + Scripts + Applets	Web Server+ Servlets	Most types
Knowledge-driven			
• EASE (Pennsylvania Department of Labor and Industry)	Markup	Web Server + Servlet (Exsys Web Runtime) + Component	Database Servers (MS SQL Server)
Model-driven			
• Fidelity "Retirement Planning Calculator"	Markup + Scripts	Web Server + Servlets + Components (.gi generation)	
• WATERSHEDSS	Markup	Web Server + CGI Scripts	

Table 1: Examples of Web-based DSS

Web-based, data-driven DSS are increasingly common. At DSSResources.COM one can find case examples from many vendors including Alphablox, Cognos and Teradata. Data Beacon software was used to create a decision support application for Pfizer Manufacturing in Italy. Pfizer U.S. Pharmaceuticals used the Alphablox Web-based platform to create a Sales Analysis Decision Support application. Many Web sites have examples of decision support applications 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 pre-specified attributes.

Retirement and Investment planning is facilitated by Web-based DSS at a number of Web sites. Model-driven DSS show how an investment may grow over time; and knowledge-driven DSS provide investment 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.

Stockfinder at http://investor.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.

Vendors of software for building Web-based, document-driven DSS are varied and the tools can also often be used for building communications-driven DSS. A Web search engine like Google.com demonstrates a very elementary level of Web-based, document-driven, decision support functionality. The San Francisco Department of Public Health used the Documentum 4i content management capabilities to automate its contract approval process. Fortis Bank, part of Fortis, an international financial services provider active in the fields of insurance, banking and investment, is using Convera's RetrievalWare to help employees search and retrieve over 400,000 multilingual documents archived in a password-protected section of the bank's corporate intranet.

At the Pennsylvania Department of Labor and Industry, consultants and department staff implemented a Web-based, knowledge-driven DSS (cf., Pontz and Power, 2002). The Expert Assistance System for Examiners (EASE) is a Web-based application designed to assist in resolving unemployment insurance claims. The system was built beginning in 1998 using the EXSYS expert system (www.exsys.com) and Internet technologies on a Microsoft Windows NT platform.

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.

6. More Examples of 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. DSSResources.COM has at least 10 case examples of companies with Web-based DSS. As one would expect, the vendors are reporting very 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 backend 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.

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-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.

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.

7. Advantages and Disavantages of Web –based DSS

Web-based DSS have reduced technological barriers and made it easier and less costly to make decision-relevant information and decision support tools 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 will result in hiring someone to monitor the currency of decision information.

8. 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. 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 Web-based DSS provide a broader knowledge base for decision making? Yes, in most cases, once the "knowledge" is online. 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 can be more widely available. Does a Web-based, interorganizational DSS help customers and suppliers? Yes; in many cases such a DSS will help customers and suppliers make better choices.

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. Will a Web-based DSS improve decision making? Perhaps; the optimists think so.

Along with the Web-based opportunities for building innovative DSS come new challenges. Information technology managers must choose which Web technologies to use and decide how to deploy these new technologies.

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-based 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).

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