Understanding Data-Driven Decision Support Systems

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Abstract  It is important for managers and Information Technology professionals to understand data-driven decision support systems and how such systems can provide business intelligence and performance monitoring. Data-driven DSS is one of five major types of computerized decision support systems and the features of such systems vary across specific implementations. Different development packages also impact the capabilities of data-driven DSS and hence criteria for evaluating data-driven DSS development software are important to understand. Overall, this article builds on an historic foundation of prior decision support systems theory.

Keywords  decision support, DSS framework, systems features

For almost 50 years, data-driven decision support has been used for a wide variety of purposes. The U.S. Semi-Automatic Ground Environment (SAGE) air-defense command and control system became operational in 1963 and it provided real-time decision support for more than 20 years. Operators accessed the SAGE system through cathode ray tube displays and used a light pen to select “tracks” of potential incoming hostile aircraft and manage their status (cf., Power, 2006, 2007b). One of the first business-oriented, data-driven DSS was built using an APL-based software package called AAIMS, for An Analytical Information Management System. The system was developed from 1970–1974 by Richard Klaas and Charles Weiss at American Airlines (cf., Alter, 1980).

As technology has evolved, data-driven decision support systems have become more sophisticated. According to Watson, Wixom, Hoffer, Anderson-Lehman, and Reynolds (2006), “Data management for decision support has moved through three generations, with the latest being real-time data warehousing”. Today data-driven decision support is used for a variety of purposes including operational and strategic business intelligence queries, static and real-time performance monitoring, and customer relationship management.

Most of us have a general understanding of data-driven decision support and recognize how important it is in organizations. The purpose of this article is to clarify the basic concepts and stimulate further research and innovation related to this type of computerized support. The next section examines key terminology especially the terms data-driven DSS and business intelligence, then the major features of data-driven DSS are summarized, section 4 suggests some criteria for evaluating software for developing data-driven DSS, the concluding section draws some conclusions about the current state-of-the-art related to data-driven decision support.

Business Intelligence and Data-Driven DSS

Managers can use systems that access current and historical data to support many decision tasks. When the tasks are performed regularly then a computerized decision support system can potentially increase access to the data and help managers gain insights into organization processes, customer activities, employee performance, and organization-wide performance metrics.

DSSResources.com defines a decision support system (DSS) as “an interactive computer-based system or subsystem intended to help decision makers use communications technologies, data, documents, knowledge, and/or models to identify and solve problems, complete decision process tasks, and make decisions. Decision Support System is a general term for any computer application that enhances a person or group’s ability to make decisions. In addition, Decision Support Systems refers to an academic field of research that involves designing and studying Decision Support Systems in their context of use. In general, Decision Support Systems are a class of computerized information system that supports decision-making...”
activities. Five more specific Decision Support System types include: communications-driven DSS, data-driven DSS, document-driven DSS, knowledge-driven DSS, and model-driven DSS” (cf., Power, 2002a).

Business Intelligence, often referred to as BI, is a popularized, umbrella term introduced by Howard Dresner of the Gartner Group in 1989 to describe a set of concepts and methods to improve business decision making by using fact-based computerized support systems (cf., Nylund, 1999). The term is sometimes used interchangeably with briefing books and executive information systems. A business intelligence system is a data-driven DSS that primarily supports querying of an historical database and production of periodic summary reports. Data-driven DSS have been called various names over the years including data-oriented DSS (Alter, 1980), retrieval-only DSS by Bonczek, Holsapple and Whinston (1981), Executive Information Systems, OLAP systems and Business Intelligence systems. My preference is to use the term data-driven DSS or data-driven decision support. Business intelligence refers to a specific purpose for some data-driven DSS.

Data-driven DSS refers to a category or type of Decision Support System that emphasizes access to and manipulation of a time-series of internal company data and sometimes external data. Simple file systems accessed by query and retrieval tools provide the most elementary level of functionality. Data warehouse systems that allow the manipulation of data by computerized tools tailored to a specific task and setting or by more general tools and operators provide additional functionality. Data-driven DSS with On-line Analytical Processing (OLAP) provide the highest level of functionality and decision support that is linked to analysis of large collections of historical data (cf., Power, 2002a).

Emphasizing the broad purpose of providing data-driven decision support may reduce the current confusion surrounding the term business intelligence. Some think of Artificial Intelligence as the primary source of tools for business intelligence and focus on special studies using data mining. The results of data mining can be used for decision automation and if data is changing quickly some data mining tools can be incorporated in data-driven DSS, for example, in fraud detection or monitoring stock prices (cf., Hormozi & Giles, 2004). Other researchers emphasize performance monitoring and business reporting as the focus of business intelligence. Dhar and Stein in their 1997 book “Seven Methods for Transforming Corporate Data into Business Intelligence” discuss data warehousing and OLAP in Chapter 4 titled “Data-Driven Decision Support.” Their perspective has certainly influenced the expanded framework for identifying various types of DSS.

The most common data-driven computerized decision support system is built using a data warehouse product and a report and query product. Overall, this software application category involves billions of U.S. dollars in revenues each year. Beginning with Bill Inmon’s (1991) book “Database Machines and Decision Support Systems,” managers have sought to deploy such systems. Inmon’s book provided the conceptual foundation for data-driven DSS. Both Bill Inmon and Ralph Kimball (called “Dr. DSS”) have had a major impact on what Information Technology practitioners think of when the term decision support system is used (cf., Power, 2007b). Referring to this broad category of information systems as data-driven decision support systems is both understandable and useful. This terminology also provides research continuity extending back to Gorry and Scott-Morton’s (1971) article that introduced the concept of a decision support system.

Various companies sell software that can be used to build data-driven DSS including Teradata, Business Objects, Cognos, Hyperion, and MicroStrategy. Teradata software is primarily for the processing and development of the backend data warehouse. The other vendors focus on tools for creating a web-based user interface for a data-driven DSS. Based upon recent DM Review magazine reader surveys the major companies serving the business intelligence community are IBM, Oracle, Microsoft, Business Objects, and Teradata. Most of these large vendors focus on the database component of a data-driven decision support system.

### Features of a Data-Driven DSS

Research on Executive Information Systems (Watson, Rainer, & Koh, 1991) expanded the features managers expect from data-driven DSS. In addition, a major advance in technical capabilities for data-driven DSS occurred in the early 1990s with the introduction of Online Analytical Processing (OLAP) software. The term OLAP was coined in 1993 by E. F. “Ted” Codd (Codd, Codd, & Salley, 1993).

The key to a successful data-driven DSS is having easy and rapid access to a large amount of accurate, well-organized multidimensional data. Codd et al. (1993) argued OLAP systems were characterized by:

1. multidimensional conceptual view;
2. link to a variety of data sources;
3. easy for users to access and understand;
4. multi-user support;
5. intuitive data manipulation;
6. flexible reporting; and
7. analytical capabilities.

### Power’s (2007a) Data-Driven DSS Major Features

The following is a detailed summary of major features of data-driven DSS presented from a user’s perspective from Power (2007a).
Ad Hoc Data Filtering and Retrieval

The system helps users systematically search for and retrieve computerized data, filtering is often done using drop down menus, queries are often predefined, and users have drill-down capabilities. Users can often change aggregation levels, ranging from the most summarized to the most detailed (drill-down).

Alerts and Triggers

Some systems help users establish rules for email notification and for other predefined actions.

Create Data Displays

Users can usually choose among displays like scatter diagrams, bar and pie charts, can often interactively change the displays, may be able to animate historical data on charts or other representations, and may be able to playback historical data in a time sequence.

Data Management

Users have limited “working storage” for a data subset, users can sometimes group data or change data formats. In some systems, users can request changes to master data definitions and data models.

Data Summarization

Users can view or create pivot tables and cross tabulations. Users can create custom aggregations and calculate computed fields, totals and subtotals. A pivot table summarizes selected fields and rows of data in a table format. In a pivot table, a user can view data from different perspectives and include various fields in the table. Users can view a slice of the data, or drill-down for more detailed data from a summarized value in a table.

Excel Integration

Many data-driven DSS let users extract and download data for further analysis, some systems allow users to upload data for analysis in a user’s “working storage.”

Metadata Creation and Retrieval

Users should be able to add metadata to analyses and reports they create and temporarily change labels and descriptive information stored as metadata. Metadata is an explanation of the data in a DSS data store. It provides a context for decision support and helps users understand the data in a system. Some metadata is used to label screen displays and create report heading.

Report Design, Generation, and Storage

Users can often interactively extract, design and present information in a formal report with tables, text, pie charts, bar charts, and other diagrams. Once the user has created a format for a report, it can be saved and reused with new data. Reports can often be distributed using print, Web pages and PDF documents.

Statistical Analysis

Users can calculate descriptive statistics to summarize or describe data, create trend lines and “mine” the data for relationships.

View predefined data displays

Data-driven DSS often have displays created by the DSS designer. A system for operational performance monitoring often includes a dashboard display. The term is a metaphorical reference to an automobile’s dashboard. The display integrates information from multiple sources/metrics into gauges and dials that resembles the dashboard of an automobile. A system for more long-term strategic performance monitoring may include a scorecard. A scorecard is a table displaying performance metrics and it may include indicators like arrows or a stoplight display. Bar and pie charts, scatter plots and two and three dimensional maps may be used in predefined data displays.

View Production Reports

DSS designers may create and store predefined, periodic reports as part of a data-driven DSS for users to easily access.

Specific data-driven decision support systems will have some subset of the above features depending upon the needs of users, the purpose of the system, the development environment selected, and the resources expended building the system. Performance monitoring may emphasize predefined data displays and production reports, while a system focused on ad hoc queries for historical data analysis would emphasize data filtering and retrieval, as well as data summarization and possibly statistical analysis.

Decisions made using data-driven DSS can be adversely affected by factors unrelated to the actual data so as part of the design of such systems careful consideration must be given to how data is framed and displayed.
A well-designed data-driven DSS emphasizes the design of data displays and helps ensure that appropriate data is retrieved.

Overall, with a data-driven DSS managers can more easily access a single version of the truth, perform their own analyses, have access to reliable, consistent and high-quality information, make better informed decisions, and have more timely information. To achieve these results we need to build an appropriate DSS data store, create a user interface with desired features, institute effective data governance and insure consistent data gathering. In general, we should start a development effort by focusing on the decision support capabilities and the features we need and want in a new data-driven DSS.

**Criteria for Evaluating Data-Driven DSS Development Software**

When asked how to evaluate competing software products, some people are quick to list criteria like ease of use, cost of the package, capabilities, vendor reputation and ease of installation. Although such factors are important and need to be considered in most situations, this evaluation question should be framed more broadly and some other issues should be addressed before specific criteria are discussed (cf., Power, 2002b). Software selection is a sequential decision process. Begin the process by specifying requirements and ask, “What functions and tasks will managers perform with the data-driven DSS? When and how will it be used?”

Then the first major issue is determining whether buying a vertical market package or assembling and customizing software for a data-driven DSS project is a more appropriate response to meeting the identified need. It is often hard to know where the dividing line is between “buying off-the-shelf” and “building” because once the customization for the data-driven DSS becomes significant, and then buying a vertical market package has been transformed into a development project (even though that may not have been intended).

Second, if the decision is to buy “off-the-shelf,” then one must determine what products might meet the need. It is important to recognize that one must identify comparable software packages. “Off-the-shelf” is often appropriate for task specific or vertical market data-driven DSS software like web-based reporting software.

Third, once comparable products are identified then one can ask, “which one is best in this particular situation?” At this point, criteria can be specified and products can be compared. Evaluators need to recognize that dominant alternatives and dominating criteria exist in situations. Sometimes one criterion is so important in making a choice that all other criteria take on a secondary role. For example, the cost of the package may be so important that relatively high cost packages have no chance of being selected. In the same vein, some software packages may be so appropriate and be such a “good fit” with the perceived need that other packages receive little consideration. For example, a manager developing a small-scale, model-driven DSS may almost—without explicit evaluation—“choose” to develop the application in Microsoft Excel. Prescreen the list of possible DSS products to eliminate those that do not meet constraints like the need to “fit” with other software or with existing processes, or the need to meet special regulatory or legal requirements. Also, eliminate products that do not meet technical constraints in terms of operating systems or infrastructure.

Fourth, if a dominant alternative does not exist, and if no one criterion dominates all others, then six major criteria should be identified and weighted for evaluating the comparable DSS packages. Criteria should be generally independent of each other. Based on Power (2002b), some criteria that should be considered include the following:

1. **Capabilities**—examine the functions that a DSS product can perform and how important they are to the decision support need of targeted users. Determine if the package can be customized and in what ways. Does it meet the need? Does it provide the desired support?
2. **Cost of the Package**—examine the total cost of ownership including acquisition costs, implementation and training costs, maintenance costs, and any annual software license costs.
3. **Ease-of-use**—the ease of learning and using the capabilities of a product to accomplish tasks. Ease of use is in the mind of the user so ask users to assess this criterion.
4. **Ease of installation and operation**—how easy is it to configure, deploy and control use of a product. Is it easy to transfer information to and/or from other company information systems? Are there potential technical implementation problems?
5. **Performance**—what is the speed or capacity of the product when performing its functions. In addition, part of the performance criterion should be software reliability.
6. **Vendor reputation and reliability**—the vendor matters, but in emerging product areas this criterion can be difficult to assess. What kind of vendor and technical support is needed and is available?

In the DSS literature, the debate has often been about using rapid prototyping or a more structured systems development life cycle (SDLC) method. With either approach it is important to start with pre-design description and diagnosis of the actual decision-making process.
(Stabell, 1983). This step creates a decision-oriented approach to DSS development.

A related diagnostic activity is conducting a DSS Audit. In general, it can be very useful to audit operational and managerial decision processes. An audit can be a first step in identifying opportunities to redesign business processes and include new data-driven DSS in business processes (cf., Power, 2002a). Rockart (1979) identified an approach for defining decision-making data needs that is appropriate for Data-Driven DSS and especially Executive Information Systems. Rockart’s Critical Success Factors (CSF) Design Method focuses on individual managers and on each manager’s current hard and soft information needs. Diagnosis of decision-making should be followed by additional initiation and diagnostic activities and preparation of a feasibility study of the technical and economic prospects related to developing a DSS. The feasibility study should include an evaluation of competing software products. This study should occur prior to actually committing resources to building a proposed DSS.

Conclusions

Helping managers monitor operational performance or gain “intelligence” from historical data is a worthwhile purpose for data-driven DSS. Such systems will be especially important in global enterprises. These distributed organizations generate data in many operational systems and the only way to gain a “single version” of the truth is to create an integrated decision support data store that is accessible to all decision makers no matter where they happen to be physically located. Small and medium sized enterprises can also benefit from data-driven DSS, but the data store is unlikely to be a large-scale data warehouse. A database on a web accessible server may provide the appropriate enabling technology.

What have we learned over the years about building data-driven DSS? One general conclusion is to identify what decisions will be supported and who might use the proposed data-driven DSS. A powerful sponsor increases the chances that an enterprise-wide DSS will be successfully built and deployed. Further, it is generally advisable to hire outside expert advice for the first project (cf., Solomon, 2005; Power, 2002a).

Companies have an increasing amount of data in historical data stores and that is creating storage and retrieval problems. Sadly, much of the historical data is of poor quality and source systems often need to be updated and improved as part of a data-driven DSS project. In some cases, new data collection systems may need to be designed and implemented prior to implementation of a data-driven DSS.

The technologies for building data-driven DSS are improving. Vendors have enhanced web-based interfaces with dashboards, visualization and animation. New tools simplify query development with pull down menus and other structured approaches. In coming years, many mainframe-based data-driven DSS will need to be updated or replaced by web-based or web-enabled systems. The Web 2.0 technologies, open source and new hardware like tablet PCs and smart phones are the frontier for data-driven DSS.

Author Bios

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