An Empirical Study of the Effects of Organizational Structure on the Implementation of Data Warehouse Topologies

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I am submitting herewith a dissertation written by Sutee Sujitparapitaya entitled " An Empirical Study of the Effects of Organizational Structure on the Implementation of Data Warehouse Topologies." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy with a major in Business Administration.

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DEDICATIONS

For

My Grandmother and Mother

Somsong and Jitprasom Dhamsara

who always believe in me

My love

Cynthia Stobbe

who has given me unfailing support and without it this effort would never have been undertaken

My Whole Family

who I love dearly

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ABSTRACT

Sujitparapitaya, Sutee Ph.D. The University of Memphis. August, 2000. An Empirical Study of the Effects of Organizational Structure on the Implementation of Data Warehouse Topologies. Major Professor: Mark L. Gillenson, Ph.D. and Brian D. Janz, Ph.D.

In the data warehouse literature, it is widely held that a data warehousing (DWG) technology is a cornerstone of the organization's ability to provide effective information processing. If implemented correctly, DWG technology can enable and share the discovery and exploration of important business trends and dependencies that otherwise would have gone unnoticed. In this context, information systems strategic planners debate whether to start DW projects with enterprise-wide data warehouses (DWs) or with smaller-scale data marts (DMs). Enterprise-wide DW are built in the interests of overall business decision support and contain historical data summarized and consolidated from detailed individual records from a number of operational databases. At the same time, organizations are increasingly turning to smaller-scale DMs as alternative means of delivering information due to their quicker delivery, lower risk, and lower costs. DMs seem to provide specific solutions to specific business challenges.

In principle, DW can meet information needs and provide strategic business opportunities. These drivers for DWG technology can be found in successfully changing organizational structures. Thus, this dissertation seeks to explain whether or not the outcome differences in DW topology could be explained by differences in an organization's choice of structures. This leads to two primary objectives: a) to determine whether a potential relationship exists between organizational structure and the choice of data warehouse topology, and b) to utilize the research findings to develop appropriate organizational variables that can differentiate data warehouse topologies.

This dissertation focuses on a multiple case study with a research survey to provide a comprehensive understanding of the relationship between organizational structure and DW topology. The research question generally investigated in this context is: Are three particular aspects of organizational structure likely to differ with respect to the degree of centralization in their DWG implementation approach? These three aspects of organizational structure are formalization, decentralization, and level of IT decision-making authority. The results of data analyses indicate that formalization and level of IT decision-making authority were found to significantly affect the differences in outcome of DW topology. In addition, a higher degree of formalization and a highly centralized IT decision authority reflect a dominating enterprise-wide DWG implementation approach.

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CHAPTER 1

INTRODUCTION AND OVERVIEW OF THE STUDY

Introduction

For several decades, information technology advocates have promised upper-level management the ability to easily access the full breadth of organization data upon which logical business decisions can be made. Organizations allocate considerable resources to Information Systems (IS) departments to build and implement application systems (Ewer and Vessey 1981; Swanson and Beath 1989). However, all too often, IS delivers systems that are late, that exceed their budgets, and that fail to meet the expectations of organizational members (the users) who are dependent on those systems to do their work (Kidd 1989; Markus 1984; Swanson and Beath 1990). With many efforts falling short of these expectations, many organizations have simply accepted the limitations of technology as the status quo. According to Sprague and McNurlin (1993), strong pressures toward integrated information management emerged in the late 1970s and continue to increase today.

The primary focus of most early database technology was operational, usually transactional-processing. In recent years, a more sophisticated notion of database as a key element of success for decision making is the data warehouse (DW). The Meta Group conducted a survey in 1995, indicating that 95% of 250 companies contacted planned to introduce or continue to use a DW for the following year. This presented a significant change from a 1994 figure of only 15% (Bull 1995). In addition, Forrest Research Inc. conducted a similar survey and found that 96% of the senior IS managers at the Fortune

1000 firms surveyed planned to implement data warehouses. Of these, 60% expected data warehouses to improve overall access to corporate data, while 31% saw them as part of a broader corporate strategy to improve business processes, offer better customer support, and identify business opportunities (Adhikari 1996). Subsequently, many vendors have begun to manufacture various kinds of hardware, software, and tools to help data warehouses function more effectively and to target this profitable market (Francett 1994; Ricciuti 1994; White 1995). A study by the Meta Group speculated that data warehousing would grow to an $8 billion industry by 1998 (Barney 1995).

Data Warehousing Technology Background

Data Warehouse: Inmon (1994) describes a data warehouse as a subject-oriented, time-variant, nonvolatile collection of data in support of management decisions. It combines the synthesis of the data into a nonvolatile, integrated, subject-oriented database with a metadata "catalog" that will be described in more detail in Chapter 2 (Review of the Literature). Furthermore, a DW combines one or more tools to extract fields from any kind of data structure (flat, hierarchical, relational, or object-oriented; open or proprietary), including external data. Information in a DW could be summarized and aggregated from different operational databases in the organization. By extracting information from various operational databases to create a data warehouse, users gather only required information for decision making; this on-going commitment by the organization ensures the appropriate data is available to the appropriate end user at the appropriate time, as shown in Figure 1.

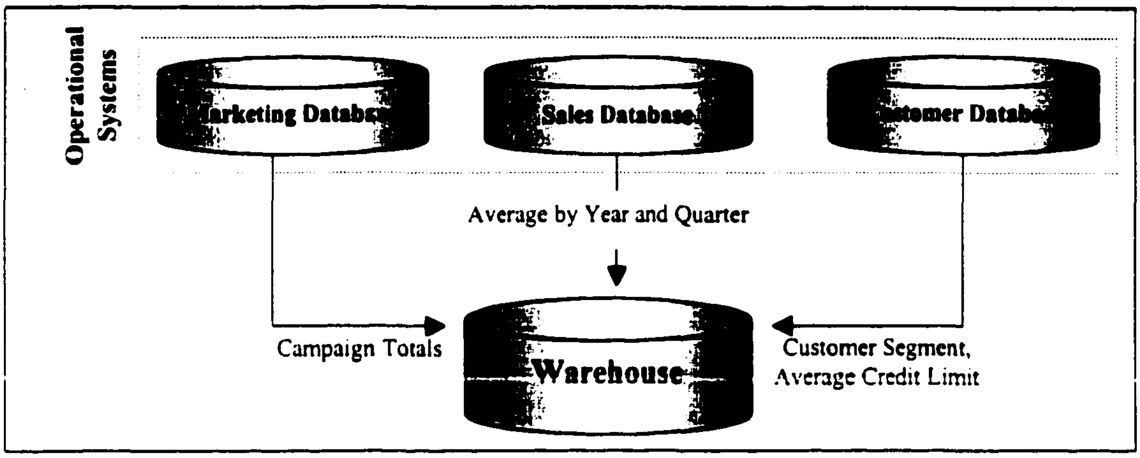

Figure 1: Building a Data Warehouse from Operational Databases

A DW stores the information in a manner that is accessible and understandable to non-technical decision makers, and delivers information to decision makers across the organization through various report writing and query tools (Chasin 1994; Graham 1996; Inmon 1996; Kimball 1996; Moriarty 1995; Paraye 1995; Poe, Klauer and Brobst 1998). Ralph Kimball, the founder of Red Brick Systems, suggests that data warehousing (DWG) is not a product or a product class. It is a process whereby organizations extract value from their information assets by using special stores called data warehouses (Kimball 1996). This process should be supported by a number of different technological products and IT professional services. Our focus should be on the DWG process itself rather than on the DW.

W.H. Inmon (1994), one of the early practitioners of DWG, described what he calls the evolution of decision support systems (DSS) and the differences in data requirements between operational data and derived DSS data. In the typical DW environment, operational data and processing are completely separate from the DWG process. As the data enters the DW from the operational data store, it is transformed into an integrated structure and format. The transformation process may involve conversion, summarization, filtering, and condensation of data. Because data within the DW contains a large historical component, the DW must be capable of holding and managing large volumes of data as well as different data structures for the same database over time. Therefore, a DW can be viewed as an information system with the following attributes:

- It is a database designed for analytical tasks, using data from multiple applications.
- It supports a relatively small number of users with relatively long interactions.
- Its usage is read-intensive.
- Its content is periodically updated (mostly additions).
- It contains current and historical data to provide a historical perspective of information.
- It contains a few large tables.
- Each query frequently yields a large result set and involves frequent full table scans and multiple joins.

Advantages and Disadvantages of Data Warehouses: Today's data warehouses can provide complex, versatile, multi-dimensional analysis, rather than just data collection and viewing. At the high level, DWs provide four specific benefits:

a. DWs allow an integrated and complete view of the organization's information. DWs provide the opportunity for existing legacy systems to continue in operation, consolidate inconsistent data from various legacy systems into one coherent set, and reap benefits from vital information about current operations (Hackathorn 1995;

Wallace 1994b). Furthermore, DWs are enterprise-wide systems (Hoffman and Nash 1995); therefore, they improve overall corporate communication (Seybold 1995).

b. DWs provide access to historical information about the organization. DWs can store large amounts of historical and corporate-wide data that companies need to turn into vital business information (Brown 1995; Bull 1995b; Cafasso 1994; Eckerson 1993; Hackathorn 1995; Lisker 1994; Nash 1995; Smith 1995a; Wallace 1994b).

c. DWs constitute an unambiguous source of informational truth within the organization to provide the better quality data to users (Wallace 1994a). Data quality issues include consistency, accuracy, and documentation (Ladaga 1995; Ricciuti 1994; Wallace 1994a). Improved decision making through on-line analytical processing (OLAP) and data mining analysis were mentioned as improvements in productivity (Barquin 1995; Barry 1995; Broda 1995).

d. DWs facilitate decision support systems without hindering operational systems (Taft 1995; Wallace 1994b). With user queries, a DW allows easy access to business data without slowing down the operational database. This can be done by selecting operational data and populating it in a separate database (Bull 1995b; Burleson 1995; Fairhead 1995; Lisker 1994; Ricciuti 1994; Smith 1995a, 1995b; Wallace 1994a, 1994b). DWs focus on subjects (Barquin 1995; Broda 1995) and support timely, ad-hoc queries for fast decision-making as well as regular reporting (Broda 1995; Myers 1995)

DW projects are inherently complex and many things can go wrong during a typical long deployment. Three major challenges in many organizations are:

a. DWs take a very long time to build, usually 2 or more years (Goldberg 1995b; Hildebrand 1995; Ladaga 1995; Redding 1995). In a situation lacking strong executive sponsorship, project leaders wishing to develop a warehouse may spend an inordinate amount of time justifying the need.

b. DWs are expensive to build, usually $2 to 5 million dollars (Harding 1994; Hildebrand 1995; Ladaga 1995; Redding 1995). One reason data warehouses are so expensive is that data must be moved or copied from existing databases often manually and must then be translated into a common format (Cole 1995h).

c. DW projects involve high complexity in development. In most cases, a customized DW is required for a unique architecture and a set of requirements that spring from the individual needs of the organization (Ladaga 1995; Myers 1995). A DW development team should ask a wide range of questions in building it (Goldberg 1995b; Redding 1995). DW designers need to pay as much attention to the structure, definitions, and flow of data as they do to choosing hardware and software (Adhikari 1996; Edwards 1995; Hildebrand 1995; Wallace 1994b). DW construction requires a sense of anticipation about future uses for the collected records (Goldberg 1995b). DW developers need to be aware of the constantly changing needs of their company's business and the capabilities of the available and emerging hardware and software (Lardear 1995a). Scaling the warehouse to meet increasing user demand for both volume and complexity (Lardear 1995a) makes its development more complex.

Data Mart: A data mart (DM), often referred to as a subject-oriented data warehouse, represents a data store that is subsidiary to a data warehouse. It contains the integrated data for a particular business function, such as marketing, sales, or finance (Hackney 1997b). Similar to data warehouses, DMs may contain data stored at various levels of granularity, depending on end-user functions and business requirements. A DM might, in fact, be a set of denormalized, summarized, or aggregated data. Sometimes, such a set could be placed on the same mainframe or server with the enterprise-wide DW database rather than a physically separate store of data. In many situations, DM users may require a lower-level of detailed data; therefore, a DM may often be larger than originally scoped in the overall DW design.

Organizations may choose to begin their corporate DW project with a small pilot project for a specific subject area (business function). In so doing, those organizations take a divisional DM approach to implementing the decision support environment. This approach moving data directly from operational systems into divisional DMs without passing through centralized DW is called *independent data marts*, which are used as independent information resources (Hackney 1997b; Kimball 1996, 1998). Such a DM usually has fewer feeds than an enterprise-wide DW and is correspondingly easier, faster, and less costly to build. It is constructed to address the needs of specific user groups and is used to demonstrate return on investment (ROI), architecture, methodology, technology, and processes.

In the enterprise-wide DW approach, on the other hand, the organization needs to move data from production databases or external data sources into a centralized DW; then data extraction, transformation, and loading will occur to other data into the child

DMs, called *dependent data marts* (Inmon 1996). In practice, this approach focuses on a single large server or mainframe that provides a consolidation point for enterprise-wide data from diverse production systems. This central DW could allow significant improvement in data integrity by keeping all required data in a single location and eliminating data inconsistency from multiple repositories. A more detailed explanation and illustration of these two approaches appears in Chapter 2 (Review of the Literature).

Advantages and Disadvantages of the Data Mart: Today's DMs allow organizations to build and deploy robust information resources that quickly address the needs of specific organizational groups, regardless of role, function, or mission. DMs have the following advantages:

- DMs take a much shorter time to build, since they focus on a single subject area that is generally determined by the department or line of business for which it is created. The content would be limited, but it would be tailored to the business intelligence needs of its small user community. Unlike enterprise-wide DWs, DMs, regardless of size, require far simpler data models in accordance with the smaller number of lines of business they serve.
- DMs cost much less. The specific groups within the organization can do whatever decision support systems (DSS) processing without considering the impact for resource utilization on other departments.
- DMs are usually single-purpose, solving a problem for a specific group of users, minimizing the need for extensive and sustained cross-functional, cross-department, or cross-divisional communication and cooperation.

- DMs require low levels of sponsorship, usually manager level.
- DMs are low risk, technically and politically. This is the case when a department has its own DM where it can customize the data as it flows into the DM. Data can be customized by summarizing, sorting, selecting, and structuring it for a department's needs with no need to serve the entire organization.

Unfortunately, misleading statements about the simplicity and low cost of DMs sometimes result in organizations or vendors incorrectly positioning them as an alternative to the data warehouse. Without the appropriate planning, organizations may end up with *independent data marts* that in fact represent fragmented point solutions to a range of business problems in the enterprise. This type of implementation should rarely be deployed in the context of an overall technology or applications architecture. Indeed, it is missing the two main ingredients at the heart of the DWG concept:

- Independent DMs allow potential problems of data integration. Each independent DM makes its own assumptions about how to consolidate the data, and the data across several DMs may not be consistent (Berson and Smith 1997; Hackney 1997b). Moreover, as the first DM is created, other user communities, groups, and functional areas within the enterprise embark on the task of building their own DMs. As a result, the organization creates an environment in which multiple operational systems feed multiple nonintegrated DMs that are often overlapping in data content, job scheduling, connectivity, and management. In other words, the organization has transformed a complex many-to-one problem of building a DW from operational and external data sources to a many-to-many sourcing and management nightmare (Berson and Smith 1997; Simon 1998).

- Independent DMs could face scalability problems. The first simple and inexpensive DM was probably designed without serious consideration of scalability. However, as usage begets usage, the initial small DM grows in both data size and the number of concurrent users without any ability to do so in a scalable fashion (Berson and Smith 1997).

Data Warehousing Process

Not surprisingly, integrated database systems often fail to meet organizational goals if the development process is long (often exceeding one year), complex, and filled with uncertainty (Hackney 1997a, 1997b; Simon 1998). In an attempt to make the process more predictable, organizations have invested in tools and techniques, such as structured development methodologies, user involvement, CASE (computer-aided software engineering) tools, and prototyping, which are designed to improve systems development efforts.

Inmon (1994, 1996) argued that in systems based on operational data, the classic systems development life cycle (SDLC) applies with the first step being requirements gathering. In the DW architecture, the life cycle is reversed. After a simple DW is built users gradually understand the data's uses and limitations as the warehouse evolves and the requirements become understood. In other words, the life cycle of the DW is data-driven rather than requirement-driven. Inmon notes that CASE tools are designed for requirement-driven analysis and hence do not apply here. DWs are evolutionary, designed and populated a step at a time.

Data Warehouse Topology

Data warehouse topology has been defined in many ways. Many researchers disagree about the specific ingredients and terminology, but most agree with its basic components. Kelly (1997b) suggests three levels of DW architecture: conceptual (what), logical (how), and physical (technology). In this study, the researcher emphasizes the first two levels of DW topology, considering only conceptual and logical design to describe DW layout and connectivity. Thus, DW topology refers to a set of rules or structures providing a framework by identifying and understanding how data will move throughout the system and be utilized within the organization. It also distinguishes what is being built and how DW is to be built to offer data consumers current and historical decision support information (Bontempo and Zagelow 1998; Devlin 1997; Hackney 1997b; Kachur, 2000; Kelly 1997b; Poe, Klauer and Brobst 1998). The conceptual DW architecture captures the user expectation of the system and explains the system's impacts on business processes as well as on the current IT infrastructure. In addition, the logical DW architecture is a detailed elaboration of the conceptual DW architecture explaining how the system is to be built. It is a communication tool to describe the goal of data integration and exploitation, and the scope and boundary of the project without reference to specific tools or technology products.

As described in Chapter 1, DW research classified DW topology into two primary categories: enterprise-wide DW (Bontempo and Zagelow 1998; Inmon 1994; Poe, Klauer and Brobst 1998) and divisional DM (Hackney 1997b; Inmon 1997; Simon 1998). As illustrated in Figures 2 and 3, these categories can be differentiated by a data populating approach from source data to target data. Typically, the source data for both architectures in Form A come from the operational applications that maintain little historical data. An exception might be an operational data store (ODS) in data staging in Form B that may be used to hold detailed data as a data staging area for DW data sourcing before performing data acquisition, cleanup, transformation, and loading. With simple processing and sequential processing, a staging area is a data store that is designed primarily to receive data into an intake layer. In many cases, data in the staging area does not need to be based on relational technology (only in a third normal form). Data entering an enterprise-wide DW or a divisional DM is transformed into an integrated structure and format. The transformation process may involve data conversion, summarization, filtering, and condensation. In many cases, because data within the enterprise-wide DW contain a large historical component and many subject areas, the database must be capable of holding and managing large volumes of data as well as different data structures for the same database over time.

Bontempo and Zagelow (1998) suggest that regardless of the type of database system used for decision making, the topologies for developing the system should enable critical business intelligence functionality. They should be built within appropriate time frames and budgets, and with the flexibility needed to meet the company's ever-evolving requirements. IT strategic planners should begin by determining which DW topology would be the most suitable for their company in the way the business process is viewed.

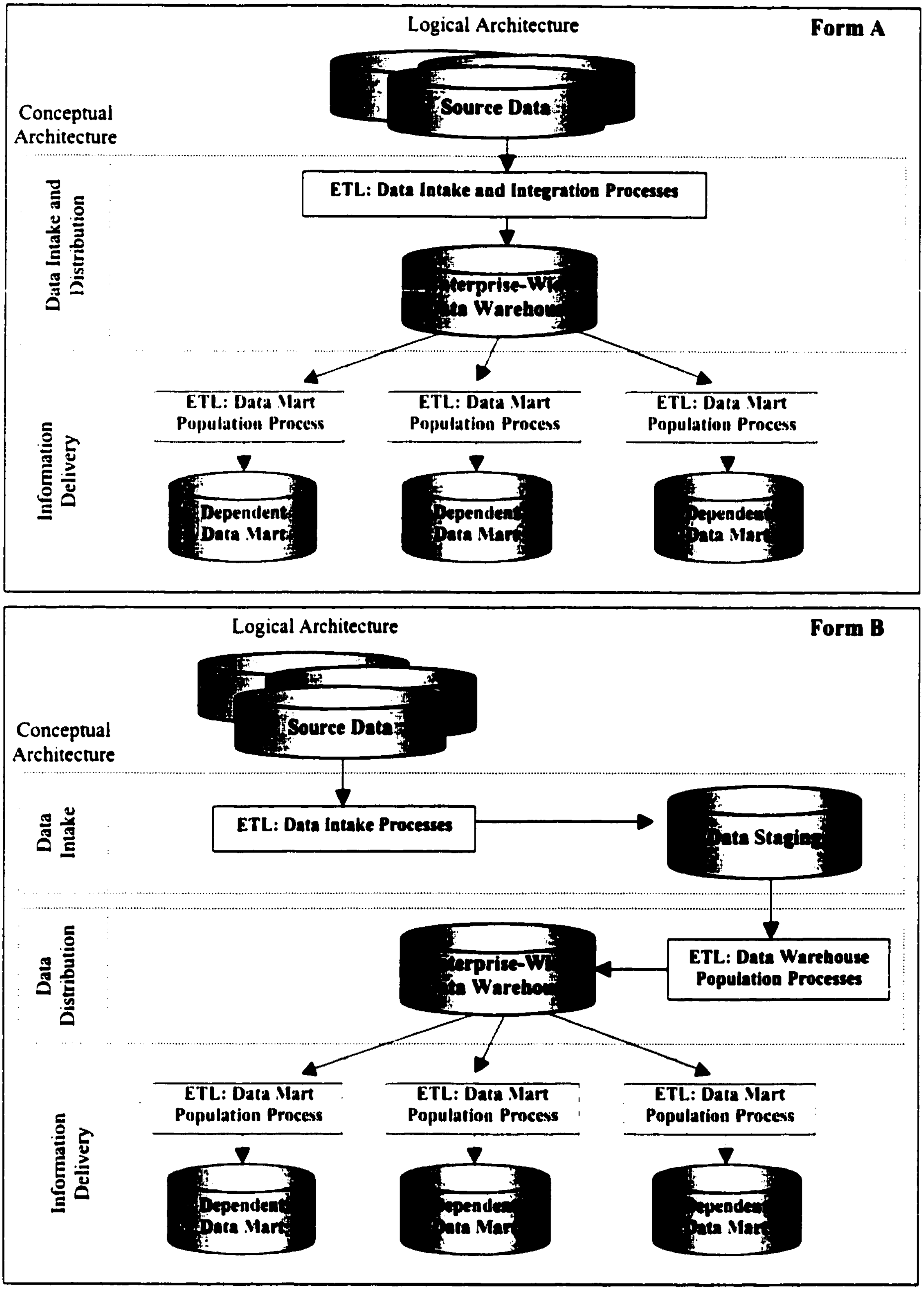

Figure 2: Enterprise-Wide Data Warehouse Topology

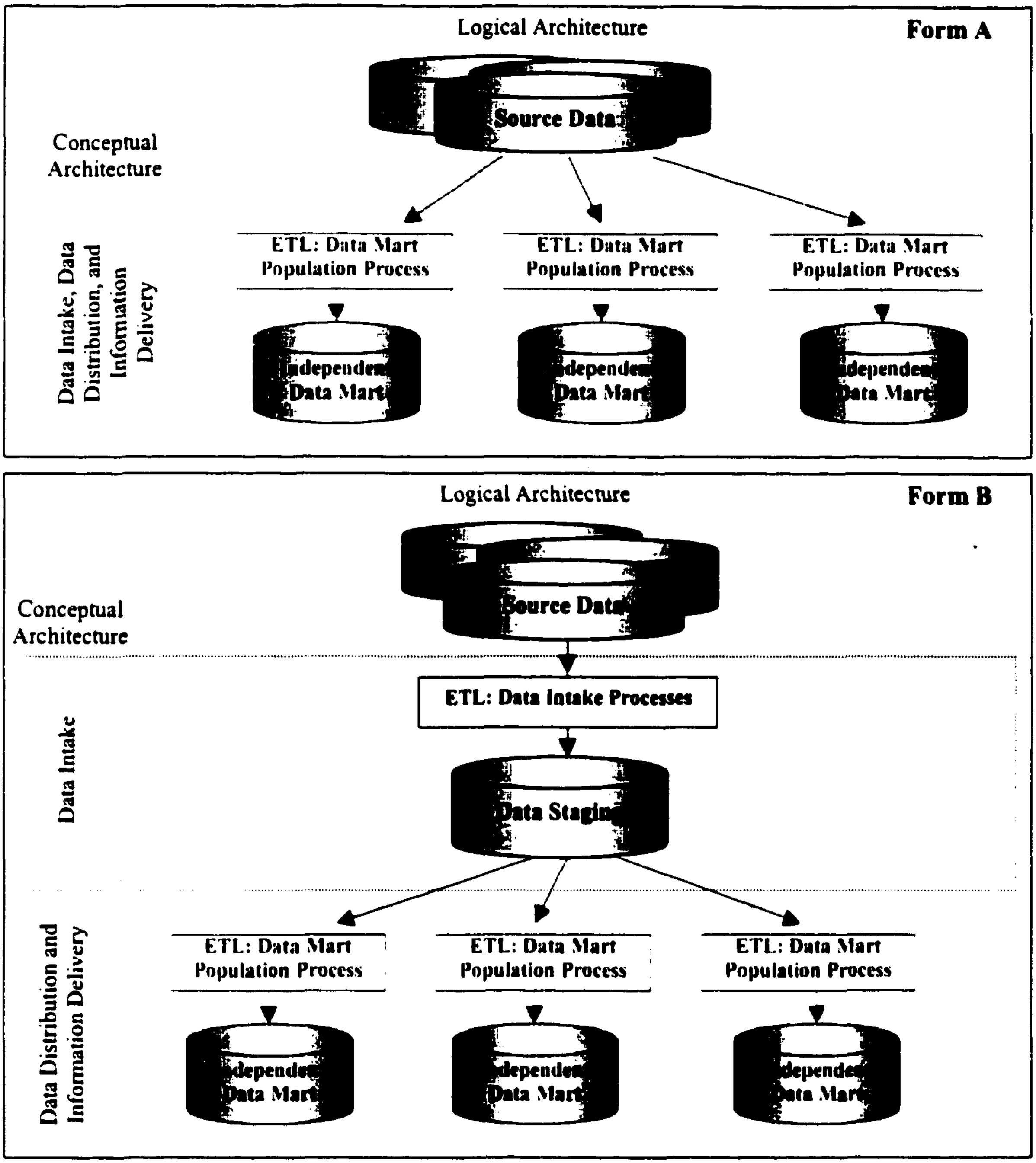

Figure 3: Divisional Data Mart Topology

Note: ETL = Data Extract, Transformation, and Loading.

Purpose of the Study

In the DW literature, it is widely held that a DWG technology is a cornerstone of the organization's ability to provide effective information processing. If implemented correctly, DWG technology can enable the discovery, exploration, and sharing of important business trends and dependencies that otherwise would have gone unnoticed. In this context, the question of whether DW architecture is to be implemented using an enterprise-wide DW or a divisional DM is interesting and difficult to answer. Thus, this study seeks to explain whether or not the outcome differences in DW topology could be explained by differences in an organization's choice of structures. The organizational structure can be delineated along three primary variables: formalization, decentralization, and patterns of IT-related authority. This leads to two primary objectives:

1. To determine whether a potential relationship exists between organizational structure and the choice of data warehouse topology.
2. To utilize the research findings to develop appropriate organizational variables that can differentiate data warehouse topologies.

Research Questions

Information systems strategic planners debate whether to start DW projects with enterprise-wide DWs or with smaller-scale DMs. Enterprise-wide DW are built in the interests of overall business decision support and contain historical data summarized and consolidated from detailed individual records from a number of operational databases. At the same time, organizations are increasingly turning to smaller-scale DMs as alternative means of delivering information due to their quicker delivery, lower risk, and lower costs. DMs seem to provide specific solutions to specific business challenges.

In principle, DW can meet information needs and provide strategic business opportunities. These drivers for DWG technology can be found in the changing organizational structures of successful organizations. Webber (1985) proposed that organizational structure could be revealed through the distribution and utilization of information, decision-making processes, and the social nature of the organization. More detailed information regarding organizational structure is presented in Chapter 3. Therefore, this study examines whether the organizational structure lends itself to successful implementation of the data warehouse. Researcher expects that

1. Organizations with higher levels of formalization, more centralized decision making, and more centralized IT-related authority are likely to implement an enterprise-wide DW architecture in order to build and sustain a lateral organization capacity across the corporation.
2. Organizations with lower-level of formalization, more decentralized decision making, and more decentralized IT-related authority are likely to implement a divisional DM architecture in order to build and sustain a lateral organization capacity across business units.

Although some theoretical observations will be presented in this study, the intended contribution of the study is to provide a point of departure for developing a well-articulated theory by finding a pattern that may exist between organizational structure and DWG technology. Because this study is the first of its kind, the research framework proposed will help provide a path for other researchers to follow.

The research findings will guide how an effective organization can be designed and how competitive strategy can be pursued using successful DM implementation. This study attempts to relate DW topologies to the following major aspects of organizational structure: formalization, decentralization, and patterns of IT-related authority. Possible outcomes of this study include:

1. Researchers and educators will gain new insights into the effect of organizational structure on the implementation of DW topology;
2. Upper-level management, systems owners, and project managers will be able to use the findings and recommendations to improve their own operations; and
3. Trade associations, and professional groups may use the findings to improve products and services to their members and customers.

This study was conducted through the replicated case studies with two primary phases. The first phase involved conducting a pre-test survey to validate two types of an initial survey instrument with participants from eight local (Memphis-based) organizations that had implemented DWG technology prior to our first on-site visit. Upon completion of the pre-test survey, the replicated case studies were performed to collect rich descriptive data on the DWG implementation process and organizational structure to enhance implementation of the data warehouse. This research approach allowed the researcher to take advantage of unique case features and opportunities for triangulation (Eisenhard 1989).

In Chapter 2, current literature is reviewed based on seven components of overall DW architecture. Chapter 3 indicates the major aspects of organizational structure, the relationship between DWG technology and organizational structure, and the organizational impact on data warehouse/data mart implementation. Chapter 4 describes the multiple case research methodology and instrument designs. Results of the survey, including analysis and interpretation of the cross-case study, are presented in Chapter 5. In Chapter 6, the conclusions, limitations, issues, and suggestions for future work are offered.

CHAPTER 2

REVIEW OF THE LITERATURE

This chapter presents a review of literature and prior research using DW architecture. Seven major DW components and indicators of DW and/or DM success allow us to categorize, present theoretical foundations, and scrutinize the research in a structured format.

The overall DW architecture provides a framework for overall system design by offering decision support information that is difficult to access or present in traditional operational data stores. DW architecture blends technologies and components aimed at effective integration of operational databases into an environment that enables a strategic use of data (Levin 1997; Mimno 1997).

Theoretical Foundations and Prior Research

Figure 4 illustrates the overall data warehouse architecture by identifying and explaining how data will move through the system and be used within the corporation. It is based on a relational database management system (RDBMS) server that functions as the central repository for informational data. In this architecture, operational data and processing are completed separate from DW processing. The central information repository is surrounded by a number of key components designed to make the entire environment functional, manageable, and accessible by both the operational systems that source data into the warehouse and by end-user query and analysis tools.

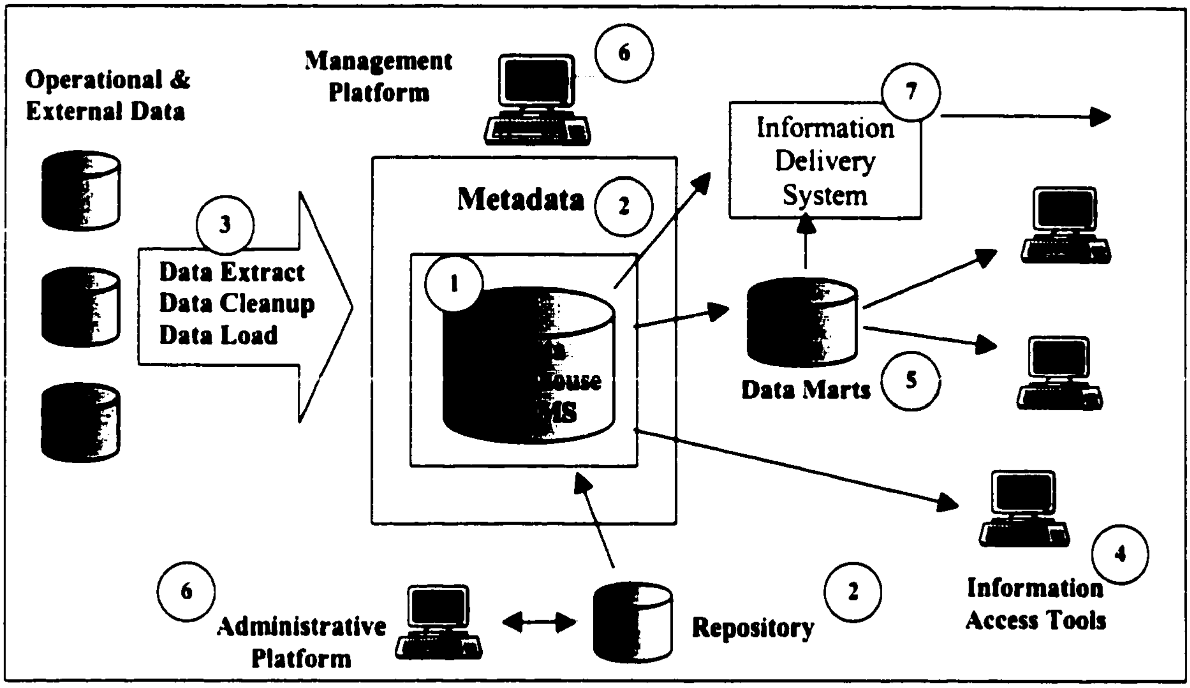

Figure 4: Overview Data Warehouse Architecture

Source: *Adapted from Levin 1997; Mimno 1997.*

Figure 4 illustrates seven major DWG components, each serving the needs of different processes within the DW architecture. In this study, the DWG literature is reviewed based on the following components.

Data Warehouse Database: The central DW database is a cornerstone of the data warehouse architecture. Kimball (1996) identifies an integrated series of two types of tables considered to be the optimal design for DW database: *transaction-grained fact tables* and *conformed dimension tables*. These tables provide the organization with a comprehensive analytical repository in the form of "data cube" structure that matches end users' needs for simplicity.

Kelly (1996, 1997b) emphasizes the use of a dimensional model for the DW design process. Using the transaction-grained fact tables and conformed dimensions tables, the designers can create a high-level design for the dimensional DW. A high-level design diagram for the retailer in Figure 5 presents the interaction of many fact to dimension tables. Typically, once the initial high-level design is created, the design team will add subject-area-specific dimensions and fact tables as the DW project proceeds.

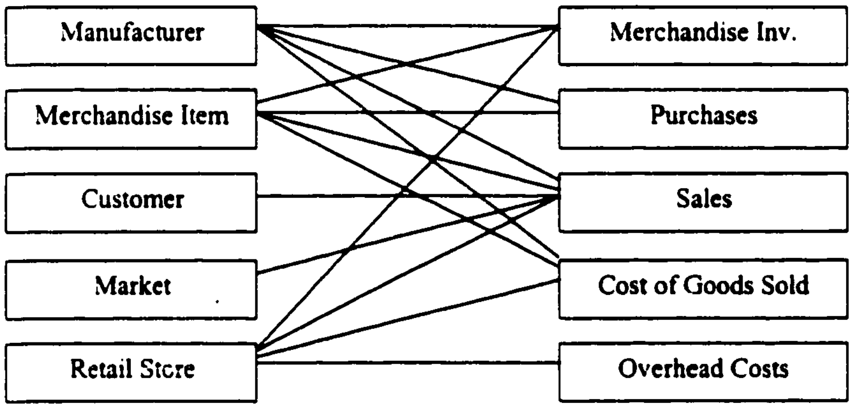

Figure 5: Interaction between Transaction-Grained Fact Tables and Conformed Dimensions Tables

Inmon (1994) believes the DW database addresses not only the challenge of data integration but also the issue of having data that is accurate at different points in time – the challenge of temporal inconsistency. He proposes using the DW as a target repository for migrating and transforming (or making consistent) an organization's data from different systems where it could then be accessed more easily. To achieve temporal inconsistency, the enterprise-wide DW allows for the time-stamping of both historical facts and descriptive data; allows the business to recreate the past and analyze point-in-time data at will.

Database Management Systems (DBMS) Technology. DBMS is a specialized application used to define a database, store the data, support a query language, produce reports, and create a data entry screen (Poe, Klauer and Brobst 1998). According to Brown (1995), DW databases have typically been implemented in a centralized fashion using traditional RDBMS technology. Mimno (1997) argued that one of the first issues to be resolved in the design of DWs is the selection of a target database. The issue is whether the target DW database should be a conventional, relational database, or a proprietary, multi-dimensional database.

Greenfeld (1996) states that there has presented several limitations associated with transactional database processing in areas of RDBMS technology. The given DW attributes have become drivers for different technological database approaches, such as very large database size; ad hoc query processing; and the need for flexible user view creation including aggregates, multi-table joins, and drill-downs for more detailed information.

Although a few researchers have suggested approaches to improve the performance of DW, no research has been devoted to the future advances of DW based on technologies in areas of DBMS. Brown (1995) and Kimball (1996) suggest four main technological approaches to the DW database with a view to the future: optimization of the execution strategy for star join queries, DBMSs that support parallel processing, new index structures, and multi-dimensional databases.

Inmon (1993), Kimball (1996), and others emphasize the importance of data granularity, which they perceive as the major design issue after the architecture is defined. Granularity refers to the level of detail provided by a data point in the data warehouse. The more detail, the lower the level of granularity. Therefore, details of individual transactions should serve as the lowest level of granularity.

Levin (1997) suggests that for decision support applications, where the unit of decision is not at the transaction level, a higher level of granularity may be appropriate. The choice of granularity is an important design issue because a) the lower the level of granularity, the larger the amount of data stored in the data warehouse, and b) the lower the level of granularity, the greater the level details for which queries can be answered.

Therefore, the choice of granularity requires trading off volume of data for level of query detail. Furthermore, the second trade-off is between the level of granularity and the amount of computing power required. Low levels of granularity require large amounts of detailed data. For every query not concerned with that level of granularity, computing power is required to aggregate the information so that answers are presented quickly on the screen. Summarization also reduces the number of indices required.

Inmon (1993) concludes by recommending that for a large data warehouse, data be kept at two levels of granularity: a high level for recent data and a lower-level for older data. Exactly when the transition should be made depends on the type of business involved. In addition, Inmon notices that DWs differ from conventional databases in that they are usually denormalized – that is, the same data may appear several times. Denormalization allows data to be combined into large tables and reduces the number of input/outputs that must be made, thereby speeding systems operation.

Metadata and Repository: Navigating through the data warehouse -- knowing what information is there, and understanding how to find it – determines the success or failure of the project from the perspective of end-users. The key to providing users and applications with a roadmap to the information stored in the warehouse is the metadata. Berson and Smith (1997) and Gentry and Stoddard (1998) define metadata as information about the information that describes the data warehouse. It can define all data elements and their attributes, data sources and timing, and the rules that govern data use and data transformation. Metadata provides a bridge between users of the warehouse and the data contained in it. Thus, metadata could be used for building, maintaining, managing, and using the data warehouse. In addition, metadata provides interactive access for users to help understand content and search data (Stedman 1997a). In other words, metadata provides decision-support-oriented pointers to warehouse data and the decision support application. Metadata can be categorized into three primary types: technical metadata, business metadata, and information navigator (Gray and Watson 1998; Hufford 1996).

In a complex environment such as a data warehouse, tools should be able to freely and easily access -- and in some cases manipulate and update -- the metadata created by other tools and stored in a variety of different storage facilities. To achieve this goal, Berson and Smith (1997) report that leading data warehousing vendors developed Metadata Interchange/Standard in 1997. The most important goal of such a standard is to define a mechanism that allows vendors to exchange common metadata as well as carry along "proprietary" metadata. The interchange standard metadata access methodology must be based on a framework that translates an access request into the interchange standard syntax and format for the meta model of choice.

The Metadata Interchange Standard is a promising step toward defining a common and effective way to enable cross-platform and cross-tool management of metadata. This or similar standards may also be used to define the structure for a focal point of metadata management. Weil (1998) reports that to achieve maximum results from DWG efforts, organizations are creating an information layer in their warehouses called metadata repositories. The metadata itself is housed in and managed by the metadata repository. In other words, the warehouse design should prevent direct access to the warehouse including updates if it does not use metadata definitions to gain the access. Atre (1997) and Hufford (1996) define metadata repository as a reincarnation of the idea of a data dictionary/directory that plays a key role in supporting unity in the data warehouse. A DW design should ensure that this is a mechanism that populates and maintains the metadata repository, that all access paths to the DW have metadata as an entry point. Metadata repository management software can be used to map the source data to the target database, generate code for data transformations, integrate and transform the data, and control moving data to the warehouse. Atre (1998) suggests four steps in building a metadata repository: establishing a cross-functional team by including business users into the development process; incorporating all of the metadata documentation in a standard, structured format; selecting the appropriate metadata application to integrate both business and technical metadata; and establishing mechanisms that allow business users to maintain their own business metadata.

Inmon and Hackathorn (1994) suggest the concept of the *operational data store (ODS)*, an extension of the data warehouse to operational systems. Like the DW, the ODS contains information that is subject-oriented and integrated. However, the ODS differs from the DW because it contains current and near-current data but not historical data, detailed data but almost no summarized data, and information that changes as it is updated rather than nonvolatile snapshots. Because an ODS contains only current data, it is much smaller than a DW. The authors assert that as a separate storage system, an ODS should never be combined with a DW. They also recommend that the DW be built first. The contents of the ODS serve as one of the inputs to the warehouse.

Data Sourcing, Acquisition, Cleanup, and Data Transformation Tools: Information in the data warehouse comes both from internal operational systems and from outside the organization. Only items that were loaded into the DW are ones that had been defined in the metadata. Van den Hoven (1998) indicates that the data warehouse loading process can be populated in three ways: a large volume load, a trickle load to replicate changes as they occur in OLTP, or a periodic load to refresh the database with new snapshots of the OLTP on a regular basis.

In the manner similar to Berson and Smith (1997), Gray and Watson (1998) indicate that it is time-consuming to extract data from operational systems and populate it in a format suitable for decision-supporting tools that retrieve information from the DW. These activities require data sourcing, cleanup, transformation, and migration tools that generate the programs and control statement, such as COBOL program, UNIX script, MVS JCL to perform the conversions, summarization, key changes, structural changes, and condensations. This functionality includes eliminating unwanted data from operational databases; transforming to common data names and definitions; calculating summaries and derived data; establishing defaults for missing data; and accommodating source data definition changes.

Berson and Smith (1997) and Singh (1998) suggest two significant issues for data sourcing, cleanup, extract, transformation, and migration tools: heterogeneous database environment and heterogeneity of data. For the heterogeneous database environment, DBMSs are very different in data models. data access language, and data navigation, operations, concurrency, integrity, and recovery. Heterogeneity of data, on the other hand, occurs when data is defined and used in different models –homonyms, synonyms, and unit incompatibility, such as US. vs. metric, different attributes for the same entity, and different ways of modeling the same fact.

Although many tools could save a considerable amount of time and effort, Leon (1996) identifies significant limitations. For example, customized extract routines need to be developed for the more complicated data extraction procedures. Several application developers currently provide customized products and services, including Prism Solutions, Evolutionary Technologies Inc. (ETI), Vality, Praxis and Carleton.

Access Tools: Gray and Watson (1998) define access tools as decision support tools that allow users to analyze information with ease. Access tools can help users make decisions that are non-structured or between structured and non-structured. Different kinds of users engage in different types of decision support activities, and thus require different types of tools.

In a manner similar to Gray and Watson, Van den Hoven (1998) defines an access tool as the means by which non-technical users or end-users can access data stored in a warehouse. Ease of use and the range of functions provided by the access tools determine the user's perception of the value and success of the DW. In addition, Van den Hoven (1998) suggests that access tools can be categorized as ad hoc access tools and predefined access tools. Ad hoc access tools, such as ad hoc query and reporting tools, allow end-users to manipulate table structures and contents and retrieve data on an as-needed basis. Predefined access tools, such as EIS, on the other hand, are provided through applications written to present the warehouse-stored data in the high-level views for executives and analysts.

Van der Lans (1997) states that during the four years preceding his study, companies had turned to not only predefined and ad hoc access tools but also data mining and OLAP tools. Whereas predefined and ad hoc access tools provide top-down, query-driven data analysis, Van der Lans says data mining and OLAP provide bottom-up, discovery-driven data analysis, such as knowledge discovery. In other words, the predefined and ad hoc access tools allow end-users to test their theories or hypotheses by exploring the data. For data mining and OLAP users require no assumptions and, instead identifying facts or conclusions by sifting through data to discover patterns or anomalies.

Query, Reporting Tools, and EIS: Not just any query and reporting tool will fulfill users' needs. DW designers must take IS and user needs into account by shielding them from the underlying data, the database structure, and the complexities of SQL. To do this, designers insert a metalayer between users and database. Berson and Smith (1997) describe metalayer as the software that provides subject-oriented views of a database and supports point-and-click creation of SQL.

Rosenfeld (1996) indicates that query and reporting tools are two important categories between the extremes. Managed Reporting Environments (MREs) let IS structure and filter data to turn it into information during the report development process. The emphasis of MREs is on efficient distribution and careful control. Managed Query Environments (MQEs), on the other hand, let the users create information when they need it, and the emphasis is ad hoc analysis of information. To fill a given information need, DW designers, administrators, and DW users must look closely at the trade-off between these two technologies.

In a manner similar to Rosenfeld, Hackney (1997b) believes that both MRE and MQE can and probably should exist together in any organization. However, it is of paramount importance to apply the appropriate approach to each problem. Table 1 shows how end users with relatively little need for analysis may be frustrated by MQE. The effort involved in creating reports from OLTP would seem too high, An analyst, on the other hand, who needs a flexible view of the data from both DW and DM could find the boundaries of the MRE approach confining.

Table 1: Example for MQE and MRE

Technology	**Use**	**Example**
MQE	Operational: "What"	Criteria Reporting
MRE	DW or Data Mart: "What"	Sales Reporting

Source: *Hackney 1997b, p.77*

Kador (1997) suggests that MRE has two main components: the report viewer and the report processor. Most of today's MRE report viewers are Web-enabled. Rahmel (1997) argues that simplifying the structure of the Web site and providing intuitive query tools are of paramount interest to a DW designer seeking to provide organization information both internally (an Intranet) and externally (an Internet). Although it is essential to understand how users use the site and what information they seek, this information may not objectively reflect the site's use to obtain the information from DW. The DW team might receive positive remarks from users about the query front end, but they may have difficulty applying that information to daily tasks. Without usage information, a large portion of functionality may remain unutilized.

Table 2: Level of Summarization for EIS, MQE, and MRE

Tool Type	**Level of Summarization**	**User**	**Purpose**
EIS	Highly Summarized	Executive Management	Business Overview, monitor operation
MQE	Detail	Analyst, Manager	Operational: understand "what"
MRE	Detail	Analyst, Manager	DW or Data Mart: understand "what"

Source: *Hackney 1997b, p.78-79*

As described in Table 2, executive information systems (EISs) are decision support tools that provide both general and detailed levels of information support and analytic capability for a wide range of executive decisions (Houdeshel and Watson 1987; Rockart and DeLong 1988). EISs are designed to make the information contained in the organization's lower-level systems available in a form that is easy to access, easy to use, and germane to decision making (Stevenson 1994). In addition, EISs provide executives with access to external information, such as news, regulations, and competitive analyses (Young and Watson 1995).

Berson and Smith (1997) indicate that EIS vendors are moving in two directions regarding DWG technology. Many are adding managed query functions to compete head-on with other decision support tools. Others are building applications that address horizontal functions, such as sales, budgeting, and marketing; or vertical industries, such as financial services and retail industry.

Data Mining: Data mining tools, sometimes called knowledge discovery tools, can have rules, which are derived from data. The tools draw on technology used in old-fashioned statistics and artificial intelligence. Weiss and Indurkhya (1997) and Westphal and Blaxton (1998) define data mining as the process of discovering meaning in new correlation, patterns, and trends by digging into (mining) large amounts of data stored in warehouses, using artificial-intelligence (AI) and statistical and mathematical techniques. Unlike the situations in which the users might employ standard mathematical or statistical analyses to test predefined hypotheses, data mining is most useful in exploratory analysis scenarios in which there are no predetermined notions about what will constitute an "interesting" outcome.

Berry and Linoff (1997) suggest that DW provides the organization with a memory, and data mining provides the enterprise with intelligence. Data mining may occur within a single data source or across multiple sources. Whatever exact form the analysis takes, the key is to adopt a flexible approach that allows users to make unexpected discoveries beyond the bounds of the established expectations within a problem domain. In other words, data mining allows users to keep their options open.

In many situations, the interesting discoveries may be made only when the data are approached from multiple perspectives. Angstenberger and Webster (1997) believe that data from a warehouse that is already organized and transformed helps simplify the data mining process. This is done by combining DW databases and data mining techniques to support the variety of analysis tasks. In these areas, data mining can reach beyond the capabilities of the OLAP, especially since the major attraction of data mining is its ability to build predictive rather than retrospective models.

Westphal and Blaxton (1998), noting Berry and Linoff's emphasis on the cautionary information that developers should consider before beginning any data mining engagement, identify six potential pitfalls that might lie along the analytical path: (1) evaluating return on data mining investment; (2) working efficiently by accessing the appropriate data to the problem in order to produce the most useful results in a timely fashion; (3) establishing the limitations of the company's data resources; (4) defining the problem up front; (5) determining the right target audience; and (6) anticipating and overcoming organizational inertia due to the results of data mining analyses.

In a similar manner to Berry and Linoff (1997), Bigus (1996) and Westphal and Blaxton (1998) suggests data mining is not specific to any industry –it requires intelligent technologies and the willingness to explore the possibility of hidden knowledge that resides in the data. Industries already taking advantage of data mining include retail, financial, medical, manufacturing, environmental, utilities, security, transportation, chemical, insurance, and aerospace companies. The early success stories came primarily from the retail, financial, and medical sectors. Most organizations engage in data mining to discover knowledge, estimate data, predict data, virtualize data, and correct data (Anand 1995; Berry and Linoff 1997; Gessaroli 1995; Westphal and Blaxton 1998).

On-line Analytical Processing (OLAP): Codd (1995) defines OLAP as an analyst's tool for planning and decision making. It is described as a multi-dimensional data cube or a spreadsheet extended into multiple dimensions with a set of robust computational capabilities that are essential for the analysis of data stored in a DW. In other words, OLAP tools provide an intuitive way to view data in the warehouse. These tools aggregate data along common business dimensions that represent the key factors of the business data. OLAP also allows users to navigate through the hierarchies and dimensions with the friendly interface. Users can drill down, across, or up levels in each dimension or pivot and swap out dimensions to change their view of data. Codd's 12 rules for OLAP consist of the following: Multi-dimensional conceptual view; Transparency, Accessibility, Consistent Reporting Performance, Client-server architecture, Generic Dimensionality, Dynamic Sparse Matrix Handling, Multi-use support, Unrestricted Cross-dimensional Operations, Intuitive Data Manipulation, Flexible Reporting, and Unlimited Dimensions and Aggregation Levels.

Berry and Linoff (1997) suggest that OLAP and data mining are complementary, both important parts of exploiting data. Data mining tools focus on finding patterns in data, in contrast to OLAP tools, which are powerful and fast tools for reporting on data. In other words, data mining can help build better cubes by defining appropriate dimensions, and further by determining how to break up continuous values on dimensions. OLAP provides powerful visualization to better understand the results of data mining. They believe that used together, OLAP and data mining reinforce each other's strengths and provide more opportunities for exploiting data.

Gray and Watson (1998) indicate that the commercial availability of Web-enabled DWG applications for complex OLAP application is quite new. These applications provide a low-level functionality with straightforward information retrieval but are able to present information in a multiplicity of formats to broad audiences. Functionally intensive applications with a small number of users, typically analysts, are more difficult. Gary and Watson report that OLAP developers are still working on three issues: upgrading the browser's procedural environment to make it closer to Windows than to DOS; improving delivery of information and user friendliness in the browser, including how best to use new technologies, such as Java COBRA, and ActiveX, and how to provide plug-ins and helper applications; and handling the volume of data that potentially can be needed on the client.

The growing interest in OLAP applications has prompted the inevitable debate surrounding an open relational database management system for ROLAP versus a proprietary multi-dimensional database for MOLAP to manage the data warehouse. For a five year-period, Anderson (1995) found that many experts suggested that RDBMSs supporting OLAP offered more effective capabilities in managing a large database than MOLAP.

Because OLAP data is denormalized before being loaded into the data warehouse, most OLAP applications involve large amounts of "zero" data. If the applications use a multi-dimensional DBMS, these zeros must usually be stored to preserve the "cube" data structure. This dramatically increases the size of the database, sometimes by many orders of magnitude. In contrast, the join-star schema is a sparse matrix, which means that the zeros are not stored. As a result, RDBMS data warehouses are usually capable of handling much larger OLAP applications than the corresponding multi-dimensional DBMS applications.

In addition, RDBMS vendors have developed the performance tuning and management utilities required to manage large databases. Relational databases can be incrementally loaded, in contrast to most multi-dimensional DBMSs, which must be reloaded with each update or change in structure to preserve the "cube" shape. Relational databases also offer an unlimited number of dimensions; most multi-dimensional DBMSs limit flexibility by imposing on the database a maximum number of dimensions.

Raden (1997) argues that OLAP questions typically are more business oriented, involving trends, comparisons and consolidations that span several business dimensions. In addition, most OLAP tools offer a user-friendly interface for executing unlimited searches and looking at data from any viewpoint. Users can study, for example, sales data for the year, month, week, or day and at the country, city, regional or branch levels. Looking at data from different viewpoints means that sales data can be studied from a geographical, time, product or sales force perspective.

Whereas Codd (1995) called for the use of multi-dimensional databases, most DW providers have proceeded to work on ways of simulating multidimensionality with their relational databases. At this point the issue of ROLAP versus MOLAP is not resolved. There is no single book that treats DWG from the multidimensional database approach.

Data Mart: As described in Chapter 1, DM in this study is a data store that is subsidiary to a DW of integrated data. The data mart is directed at a partition of data (often called a subject area) created for use by a dedicated group of users. A data mart might, in fact, be a set of denormalized, summarized, or aggregated data (Kimball 1996, 1998). Hackney (1997a 1997b) and Stedman (1997a) argue that today's DMs offer an enterprise the opportunity to build and deploy robust information resources that quickly address the needs of special groups within the organization, regardless of role, function, or mission. According to Tanler (1996a), a DM takes significantly less time and money to build that is presented as an inexpensive alternative to a DW. In a manner similar to Kimball (1996), Hackney conceptualized DM as broad categories: dependent and independent DM.

Dependent Data Mart: It is a subset created from enterprise-wide DW or parent DM. The DW architecture may incorporate data mining tools that extract sets of data for a particular type of analysis. In most cases, their data content, which is sourced from the data warehouse, have a high value because no matter how many are deployed and no matter how many different enabling technologies are used, the different users all access the information views derived from the same single integrated version of the data.

Independent Data Mart: It refers to incremental DM and is used as independent information resources. With the simplicity and low cost of DMs, organizations may develop independent DMs that in fact represent fragmented point solutions to a range of business problems. The concept of an independent DM is dangerous – as soon as the first

DM is created, other organizations, groups, and subject areas within the enterprise embark on the task of building their own DMs. As a result, the environment has multiple operational systems feeding multiple nonintegrated DMs that are often overlapping in data content, job scheduling, connectivity, and management.

This viewpoint misses the ingredient at the heart of the DWG concept: data integration. Each independent DM makes its own assumptions about how to consolidate data, and data across several DMs may not be consistent. Another consideration against independent DMs relates to the potential scalability problem: the first simple and inexpensive DM was probably designed without any serious consideration about scalability. But, as usage begets usage, the initial small DM needs to grow (i.e., in data sizes and the number of concurrent users), without any ability to do so in a scalable fashion.

The desire to reconcile disparate operational systems and share data across applications has been a major goal of companies for decades. But with data warehouses, many companies have been unable or unwilling to tackle enterprise modeling and top-down design. They have avoided the tough issues of reconciling data for an enterprise DW by building stand-alone DM, as demonstration projects. Atre (1997) argues that the issues of data fragmentation from stand-alone DMs cause many organizations to change their strategies from a pure DM strategy to a DWG scheme, in which DMs are fed from a strong central component.

Kimball (1996) argues that the point-solution-independent DM is not necessarily a bad thing, and it is often a necessary and valid solution to a pressing business problem, thus achieving the goal of rapid delivery of enhanced decision support functionality to end users. The business drivers underlying such developments include extremely urgent user requirements; the absence of a budget for a full DW strategy; the absence of a sponsor for an enterprise-wide decision support strategy; the decentralization of business units; and the attraction of easy-to-use tools and a mid-sized project.

Kimball (1996) addresses data integration issues associated with DMs. For any two DMs in an organization, the common dimensions must conform to the *equality and roll-up rule,* which states that these dimensions are either the same or that one is a strict roll-up of another. Thus, in a retail store chain, if the purchase orders database is one DM and the sales database is another DM, the two DMs will form a coherent part of an overall enterprise DW if their common dimensions (e.g., time and product) conform. The time dimensions from both DMs might be at the individual day level; or conversely, one time dimension is at the day level, but the other is at the week level. Because days roll up to weeks, the two time dimensions are conformed. Without common time dimensions, the resulting DMs could not usefully coexist in the same application.

Kelly (1997a) and Rudin (1997), noting Kimball's emphasis on issues of DMs, identify two problems associated with stand-alone DMs: scalability in situations where an initial small DM grows quickly in multiple dimensions, and data integration. Therefore, when designing DMs, the organizations should pay close attention to system scalability, data consistency, and manageability issues. The key to a successful DM strategy is the development of an overall scalable DW architecture and the most important step in that architecture is identifying and implementing the common dimensions.

Data Warehouse Planning, Administration, and Management: Strategic planning for management information systems (MIS) regarding the DW is an extremely difficult exercise. The process requires the voluntary cooperation of executives, departmental managers, technical staff, systems analysts, and end-users with diverse interests and perspectives. Clearly, not all information would be placed in the warehouse, and not all departments are equipped to use information in the same physical format. Before dwelling on detailed aspects of the warehouse design, therefore, it is useful to perform an information system requirements analysis to determine the types of information required for effective management of operations, organizational control, and strategic planning.

Several researchers have described processes and analytical methods for shaping DW strategy and for determining the contents of DW (Chasin 1994; Graham 1996; Inmon 1996; Kimball 1996; Moriarty 1995; Paraye 1995; Poe, Klauer and Brobst 1998; Subbramanian, Smith, Nelson, Campbell and Bird 1996).

Poe, Klauer, and Brobst (1998) suggest an extended checklist of things that need to be done during the planning stage of building a DW. Although their work is not comprehensive, it is a good place to start. It contains four important concepts:

1. Accelerated decision making requires having the right information at the right time and assuming that it is easily accessible.
2. Don't underestimate the effort needed to create the infrastructure to support the DW.
3. Requirement definition is more difficult because a DW requires developing a system to support undefined requests.

4. A DW is not an operating system that people have to use to do their jobs. It has value, therefore, only if used.

In a manner similar to Glassey (1998), and Poe, Klauer, and Brobst (1998) recommends that four design criteria should be used during the DW implementation: organizing and structuring the database with a star schema that allows users to understand the conceptual design; cleansing the data from different sources before populating in the warehouse; storing and reusing the metadata in the warehouse; and optimizing the database management systems to support the overall architecture as the backbone of the warehouse. He believes that before attempting to help users be more capable and productive, the fundamental DW infrastructure has to be in place, and it has to be user-centric as well. This will allow users to embrace and actively use the DWG solution in their routine business activities.

In management, Kimball (1996) separates what he calls the back room and the front room. The back room refers to the tasks handled by the DBA, whereas the front room is for business-oriented people. Back-room functions deal with creating and maintaining technical aspects of the data. Building application templates, training, and keeping the network running are front-room responsibilities.

To administer DW technology, almost all DW products include gateways to transparently access multiple enterprise data sources without having to rewrite applications to interpret and utilize the data. Typically, an organization's IS department is responsible for administering DW. One approach proposed by Inmon and Hackathorn (1994) is to form a data architecture group. This group, which interfaces with all the concerned parties, such as management, IS, and the end user, is responsible for the DW.

Gray and Watson (1998) suggest nine duties for the data architecture group: security and priority management; monitoring updates from multiple sources; data quality checks; managing and updating metadata; auditing and reporting data warehouse usage and status (for managing response time and resource utilization, and providing chargeback information); purging data; replicating, subsetting, and distributing data; backup and recovery; and DW storage management. such as capacity planning, hierarchical storage management (HSM), and purging of obsolete data.

Information Delivery System: Hackathorn (1995) and Kimball and Strehlo (1994) indicate that DWG has been proposed as an effective method of consolidating corporate information and sharing it among organizational entities for purposes of analysis and decision support. Much of the literature on this topic has focused on the technology required to establish and support information delivery systems (Appleton 1995; Orr 1995).

Rewari (1998) defines an information delivery system as an information broadcasting system that enables the process of subscribing to DWG information and having it delivered to one or more chosen destinations according to a user-specified scheduling algorithm. In other words, the information delivery system distributes warehouse-stored data and other information objectives to other warehouses and end-user products, such as spreadsheets and local databases. Delivery of information may be based on time of day, or on completion of an external event. He suggests three fundamental questions that should be considered regarding data extraction via an information delivery system: how much insight can be derived from using the system; how many people in the environment can access warehouse-stored data; and how frequently these people use the system to retrieve data.

Radding (1995) and White (1995) argue that attention needs to be given to procedures for determining when a data warehouse would be effective, gauging potential demand in the user community, and identifying data elements that should be maintained in various forms. The rationale for the delivery system component is based on the fact that once the data warehouse is installed and operational, its users do not have to be aware of its location and maintenance.

The value of DWG is maximized when the right information gets into the hands of those individuals who need it, where they need it, and when they need it the most. However, many corporations have struggled with complex client/server systems to give end users the access they need. The issues become even more difficult to resolve when the users are physically remote from the data warehouse location. Crandall and Swenson (1996) and Tanler (1996b) suggest that the Web can remove a lot of these issues by giving users universal and relatively inexpensive access to data. Couple this access with the ability to deliver the required information on demand, or according to a schedule, or based on a predefined set of events, and the result is a Web-enabled information delivery system. Such a system allows users dispersed across continents to perform sophisticated business-critical analysis, and to engage in decision making based on timely and valid information.

Indicators of Success and Common Mistakes

The final section of the DWG literature review is on the indicators of success and the common mistakes encountered during DW development. Many researchers and professionals define indicators of success in DW development as the factors that must go right if an undertaking is to succeed. Indicators of DW success are presented in Table 3:

Table 3: Indicators of Data Warehousing Success

Indicators	Sources
1. Selecting the appropriate management sponsorship and maintaining approval of changes (such as high management commitment, universal approval, measures and rewards, and cross-functional sponsorship)	Anonymous 1998; COMPASS,1996; Devlin 1997; Dodge and Goreman 1998; Gary and Watson (1998); Hammergren 1996; Kelly 1997; MacDonald (1998); Onder and Nash (1998); Perkins (1999a); Sauls (1996); Stackowiak (1997); Switzer 1997; Watson and Haley 1997.
2. Setting specific, achievable, and measurable goals	Gary and Watson (1998); Onder and Nash (1998); Stackowiak (1997).
3. Understanding of business requirements	Adelman and Moss (1999); COMPASS 1996; Dodge and Goreman 1998; Freed (1996); Gary and Watson (1998); Lehmann and Jaszewski (1999); Perkins (1999a); Sauls (1996); Stackowiak (1997); Zimmer 1998.
4. Having user involvement, such as selecting a DW project leader and manager who is user-oriented rather than technology-oriented, applying technology to business needs, focusing on the business rather than on the technology, and including end-users on the implementation team.	Adelman and Moss (1999); COMPASS 1996; Dodge and Goreman 1998; Hildebrand 1996; Kight 1996; Lehmann and Jaszewski (1999); MacDonald (1998); Mundy 1995; Onder and Nash (1998); Poe, Klauer, and Brobst (1998); Stedman 1997b; Stedman 1998; Watson and Haley 1997.
5. Planning and implementing the DW architecture and design – a subset of the enterprise architecture, such as scalability.	Perkins (1999a); Perkins (1999b); Stackowiak (1997)
6. Paying attention to assumptions and details to obtain high quality and detailed historical data to answer business problems, such as clear data definition, appropriately detailed warehouse-stored information.	Adelman and Moss (1999); Freed (1996); Gary and Watson (1998); Kelly 1997; Lehmann and Jaszewski (1999); MacDonald (1998); Onder and Nash (1998); Perkins (1999a); Sauls (1996).

Table 3: Indicators of Data Warehousing Success

7. Planning and implementing well-defined metadata and its repository, such as having an information directory available.	Anonymous 1997a; Freed (1996); Onder and Nash (1998).
8. Utilizing an appropriate DW development methodology and modeling technique in building the data architecture.	Adelman and Moss (1999); COMPASS 1996; Devlin 1997; Gary and Watson (1998); Handen and Boyle 1998; Inmon 1997; Perkins (1999a); Stedman 1998; Watson and Haley 1997; Zimmer 1998.
9. Transforming and cleansing operational data to meet the DW quality standard.	Ambrosio 1993; Burch 1997; English 1996; Foley 1997a 1997b; Kay 1997a; Watson and Haley 1997.
10. Establishing corporate-wide standards and procedures regarding data quality, access, exploitation, and presentation.	Anonymous 1997b; Hamilton 1997; Mundy 1995.
11. Selecting DW hardware and software to meet the project's requirements.	Raden and Peterson 1997; Beitler and Leary 1997; COMPASS 1996.
12. Matching query tools with different users' access skills, preferences, and requirements.	Beitler and Leary 1997; Kelly 1997.
13. Managing user expectations to obtain user buy-in by promoting the success of the initial project.	Anonymous 1997a.
14. Providing the appropriate user training and support programs.	Mundy 1995.
15. Constantly adapting the system to meet changing business requirements over time.	Anonymous 1998; Beitler and Leary 1997; Kay 1997b; Kight 1996; Mundy 1995; Switzer 1997; Teach 1996.
16. Avoiding bleeding-edge technology.	Zimmer 1998.

In addition, the DW literature review concludes with a discussion of common mistakes that are made when building data warehouses. An analysis of these mistakes by researchers and professionals is identified in Table 4:

Table 4: Data Warehouse Common Mistakes

Mistakes	Sources
1. Starting with the wrong sponsorship chain (such as selecting an IT executive rather than a business executive as a sponsor, lack of high authority, lack of respect of peers. Lack of excitement about the technology, and unwilling to react to problems quickly)	Berson and Smith (1997); Adelman and Moss (1999); Barquin, Paller, Edelstein (1995)

Table 4: Data Warehouse Common Mistakes

2. Believing that once the data warehouse is up and running, all problems are eliminated (such as lack of long-term commitment, and limited budget)	Berson and Smith (1997); Barquin, Paller, Edelstein (1995)
3. Setting expectations that cannot be met (such as underestimating or minimizing the importance of business participation, understanding, and communication)	Berson and Smith (1997); Adelman and Moss (1999); Gary and Watson (1998); Barquin, Paller, Edelstein (1995)
4. Engaging in politically naïve behavior (such as being the change agents that the objectives of project could make people in the organization assume that they have been ineffective)	Berson and Smith (1997): Barquin, Paller, Edelstein (1995)
5. Believing that data warehouse database design is the same as transactional database design (such as the wrong assumption that DW data should be non-aggregated data and normalization for static query without time-series information rather than ad hoc query)	Berson and Smith (1997); Barquin, Paller, Edelstein (1995)
6. Engaging in technical limitations (such as lack of systems performance capacity and systems scalability)	Berson and Smith (1997); Adelman and Moss (1999); Gary and Watson (1998); Barquin, Paller, Edelstein (1995)
7. Obtaining a development infrastructure without development team training	Gary and Watson (1998);
8. Choosing a data warehouse manager who is technology-oriented rather than user-oriented (such as selecting the wrong access tools and data delivery tools for end-users)	Berson and Smith (1997); Adelman and Moss (1999); Barquin, Paller, Edelstein (1995)
9. Focusing on traditional, internal record-oriented data, and ignoring the potential value of external data, text images, and sound and video.	Berson and Smith (1997); Barquin, Paller, Edelstein (1995)
10. Delivering data with overlapping and confusing definitions (such as conflicting with data definition, and loading irrelevant data from OLTP)	Berson and Smith (1997); Adelman and Moss (1999); Gary and Watson (1998); Barquin, Paller, Edelstein (1995)
11. Focusing on ad hoc, data mining, and periodic reporting (such as altering key people with useful ad hoc information as needed)	Berson and Smith (1997)
12. Loading the warehouse with data just because it is available, which causes overload and too detailed information.	Berson and Smith (1997); Barquin, Paller, Edelstein (1995)

While many practitioner articles and books have addressed the success factors and common mistakes affecting the implementation of DWG in organization, only two recent empirical studies have rigorously addressed such key factors. In the first study, members of DW project implementation teams directly involved in the projects were used to test hypotheses based on theoretical support. The second is an attempt to develop hypotheses about the relationship among organizational, project. and infrastructure factors and the success of data warehousing. All participants in this study were from the same pool of organizations that had implemented successful DW projects.

In the first study, a doctoral dissertation, Little (1998) provides a list of significant factors affecting DW implementation in an organization. Little seeks to determine the nature of the factors by identifying survey items that load significantly on each factor. His first research question derives from an extensive review of the literature that touches on DW from two perspectives. The first perspective is to determine and categorize the DW literature in more general terms; the second perspective is an exhaustive review of the literature that is much more narrow in scope and seeks to emphasize research strictly on the factors affecting data warehousing. The second research question seeks to define factors reflecting team members' perceptions of what should have impacted the implementation process. The last research question seeks to define the unique nature of each suspected factor that will define the relationship between the factor groups. Little collected data using in-depth interviews with members of DW project implementation teams in 41 companies. The respondents included three categories of project team members: functional managers/staff, IS managers/staff, and consultants directly involved in the DW project.

The research discovered nine factors that impacted DW implementation and eight factors affecting the implementation as perceived by project team members. These factors represent key areas of the implementation process that should be addressed and resolved within the organization if the process is to be effective. Using multiple comparison analysis, significant differences were discovered between one or more pairs of three categories of project team members. The results of data analysis also indicated over half of the research items respondents perceived to impact the implementation process and over two-thirds of the research items that respondent groups believed should have impacted the process.

Little's (1998) study suggested that members of the implementation project team, as well as the organization's management team, must understand the existing corporate culture and be prepared to deal with negative aspects during implementation. Such a finding might be combined with the findings of organizational management to help develop a normative models. This will assist researchers in understanding organizational issues affecting DW implementation.

The second recent empirical study is a dissertation by Haley (1997), which divides overall DW implementation factors into three sub-groups: project, organizational, and infrastructure. Haley used a mail survey to collect data from the University of Georgia DW database. Two survey instruments were developed to measure the relationship between DW factors and success factors, from DW managers and DW users, respectively. A DW manager was needed to provide data regarding the organization's DW implementation. DW users supplied perceptions on data warehousing success. The data were analyzed using descriptive techniques, factor analysis, and structural equation modeling to test the hypotheses.

Haley (1997) identified a relationship between DW implementation factors and success factors. Each of three implementation factors had a significant positive relationship on its outcomes. Only two of the three factors, including project and organizational outcomes, directly relate to the success factors. Infrastructure outcomes, on the other hand, did not support her hypothesis, since they do not influence the success of the data warehousing initiative.

Haley's study did provide one key piece of evidence. It showed that organizational factors, such as having the right resources, a champion, and management support, were found to affect the success of DW projects. Such a finding suggests multiple avenues for future research. Additional research is needed regarding organizational aspects and success factors within the academic community.

Our research was developed with these two empirical studies in mind. It addresses the relationship between DW topology and organizational structure to determine the success of DWG implementation. Data warehouse topology includes two DWG implementation approaches: enterprise-wide DWG, and divisional DM. In addition, this study examines the effects of three components of organizational structure that derive from the extensive review of organizational management theories: formalization, decentralization, and patterns of IT-related authority. The literature review in this area is presented in the following chapter.

The research question generally investigated in this context is: Are three particular aspects of organizational structure likely to differ with respect to the degree of centralization in their DWG implementation approach? These three aspects are formalization, decentralization, level of IT decision. Based on previous research (Ein-Dor and Segev 1982; Gordon and Narayanan 1984; Wheelock 1982; Zeffane 1989; Zmud 1994), the researcher expects that organizations with a higher degree of formalization, centralization of authority, and centralized IT decision making to be likely to implement a more centralized DWG approach. Comparing two traditional designs, a decentralized approach for a divisional DM architecture is more favorable to support high volume knowledge users than a centralized DWG approach. This provides valuable insight regarding organizational structure as a causal variable for DWG approach change.

Summary

This chapter reviewed the data warehousing literature for each of the components within DW architecture. The discussion about DW architecture is based on seven major DW components: the DW database; metadata and repository; data sourcing acquisition, cleanup, and data transformation tools; DM; DW planning, administration, and management; and information delivery systems. In addition, indicators of DW and DM success are mentioned and reviewed to provide measures of success from opinions and personal experience of IT professionals and business sponsors.

Chapter 3 provides the variables needed to understand and predict the effect of information technology changes in organizational structures. The dimensions of organizational structure used in this study is explained based on previous research. Because the fit between technology and organizational structure is considered key to organizational success (Daft 1992; Miller et al 1991), it is imperative that organizations be able to predict the structural effects of adopting various kinds of information technology.

CHAPTER 3

DIMENSIONS OF ORGANIZATIONAL STRUCTURE

Information technology plays a critical role in helping determine organizational structure (Huber 1990), but that role has not been adequately defined, especially in the areas of DWG and DM technology. Chapter 2 identified seven components of DW architecture as well as measures of success and common mistakes during DW implementation. This chapter will relate these components to several dimensions of organizational structure: formalization, centralization, and patterns of IT-related authority. These dimensions were chosen not only because of their theoretical importance, but also to compare the results with those of previous studies.

Organizational Structure

Organizational structure (OS) can be defined as the sum total of the ways in which an organization divides its labor into distinct tasks and then achieves coordination among them (Mintzberg 1979). In addition, structural organization consists of more than a differentiation of job levels. For example, Webber (1985) propose that organizational structure is also revealed through the distribution and utilization of information, decision-making processes and the organization's social nature. The complexity of interactions occurring in the organizational structure is obviously important. Whisler (1970a, 1970b) perceives a temporal dimension in the concept of organizational structure when he outlines the need for an organizational memory, which models the system's interaction in terms of the past, the present, and the future.

Several variables have been considered as influences on organizational structure (Daft 1992, Mintzberg 1979). Many variables that have received the support include information technology (Huber 1990; Zefanne 1992), environment (Burns and Stalker 1961; Keats and Hitt 1988), strategy (Ansoff 1965; Miller 1987), power and politics (Pfeffer 1981; Stephenson 1985), and organizational size (Lal 1991; Pugh et al 1968).

Based on prior literature, there is a great deal of controversy in organization theory as to exactly what the key influences on organizational structure are. It is unlikely that all researchers would agree on the model. As Figure 6 illustrates, three variables that may affect the DWG approach are examined: formalization, decentralization of authority, and level of IT decision making.

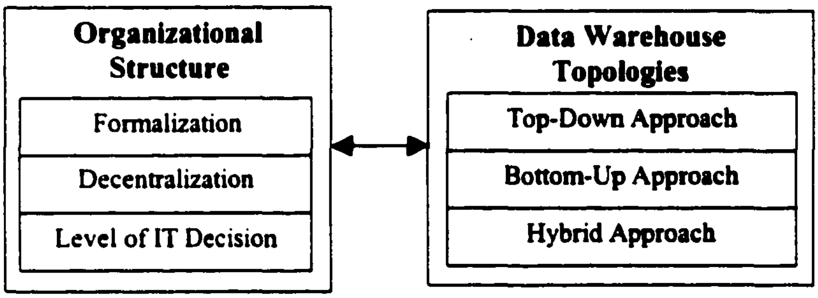

Figure 6: Influences from Organizational Structure on Data Warehouse Topologies

Formalization: Formalization is defined as the amount of written documentation used to direct and control organizational activities, such as job descriptions and standard operating procedures manuals (Dewar, Whettem and Boje 1980; Hage and Aiken 1969; Hickson, Pugh and Pheysey 1969; Miller 1986; Pugh et al. 1968; Reimann 1980; Sathe 1978). One indication of formalization is the degree to which decisions for handling various situations are programmed. Decision rules are specified in advance. The more formalized the organization, the less discretion individual members have in making decisions (Davis and Olson 1985; Hall 1982). In this situation, managers have to make more and more decisions for their subordinates and may overload themselves with information to support decision-making process when the tasks become less predictable and more differentiate. According to Galbraith (1974, 1977), three techniques managers can use to ensure that the amount of information they have to deal with is kept within reasonable limits while at the same time they effectively coordinate their subordinates' task. Three techniques are coordination by rules or programs, coordination by targets or goals, and coordination using organizational hierarchy. In addition, Galbraith suggests that there are five organization-design adjustments that managers can make to avoid becoming overloaded: environmental management, creation of slack resources, creation of self contained tasks, investment in vertical information systems, and creation of lateral relationships.

To measure degree of formalization, Measurement techniques have been fairly consistent throughout its use. These techniques have focused on how much documentation exists to constrict the procedures of work (Dewar, Whetten and Boje 1980; Huge and Aiken 1969; Hickson, Pugh and Pheysey 1969; Inkson et al 1970; Milller 1986; Pugh et al 1968; Reimann 1980; Sathe 1978). Two approaches have been used to measure formalization. Both are based on questionnaires.

The first approach measures the type and the number of pages of documentation that apply directly to the job (Miller 1986; Hickson, Pugh and Pheysey 1969; Pugh et al 1968). This technique is direct and verifiable; however, it does not capture some of the more informal documentation.

The second approach uses less direct questions to decide how documented a job is. It refers to how often workers need to refer to an external source. This includes manuals, supervisors, or systems analysis methodologies and procedures to help workers decide what they are supposed to do (Dewar, Whetten and Boje 1980; Hage and Aike 1969). This questioning technique has the advantage of being able to detect the degree to which formalization mandates a worker's behavior, which is the critical question when considering formalization in relationship to information technology.

Information technology is considered to be positively related to formalization because the variability of employees' behaviors needs to be controlled. IT cannot provide a full spectrum of benefits without controlling the variability using empirical surveys. Gordon and Narayanan (1984), Zeffane (1989) and Zmud (1982) confirm that IT facilitates more formalization, while Pfeffer and Leblebici (1977) find less formalization due to IT. DW technology, which links diverse sources of data, enables reference to the rules and procedures in a metadata repository. Thus, the frequent use of an enterprise-wide DW requires frequent reference to the organization's predefined rules and procedures.

Decentralization of Decision-Making Authority: Decentralization has been defined in many ways. Many authors emphasize the term decentralization (Blau 1976; Miller 1986; Mintzberg 1979). Others, however, reverse the term and define and measure centralization (Caufield 1989; Miller et al 1991; Pugh et al. 1968). However, researchers from both viewpoints have their emphasis on the location of the locus to make decisions (Blau et al. 1976; Miller 1986; Miller et al 1991). The difference in their measures, therefore, can easily be accommodated by reversing their scales (Caufield 1989; Miller et al 1991).

The measurement of both centralization and decentralization has been consistent throughout its use. Measurement techniques have focused on the highest level of authority that makes a decision on specific types of questions (Blau et al 1976; Dewar, Whitten and Boje 1980; Hage and Aiken 1969; Miller 1986; Pugh et al 1968). In a highly centralized organization, most decision making occurs at the top of the hierarchy; the more decision-making authority is delegated to lower-levels, the greater the decentralization.

Conflicts within the organization rarely arise between groups not required to work interdependently. Thompson (1967) suggests the approach to reduce conflict is to reduce the required inter-unit interdependencies. Three types of interdependence are pooled, sequential, and reciprocal. To prevent or manage conflicts, his approach is to move from reciprocal (fully centralized) to sequential and finally pooled interdependence (fully decentralized).

Decentralization is related to formalization. In a highly formalized organization, operating personnel at low levels make decisions based on rules and procedures provided to them; exceptions are referred to higher levels for decisions. Decisions simply cannot be passed to the top of the hierarchy, or senior managers would be overloaded. In other words, greater formalization in a large organization facilitates decentralization of routine decision making because rules define boundaries so that decisions can be made at a lower-level without loss of control (Davis and Olson 1985; Hall 1982).

Robbins (1983) argues that decentralization is usually justified by the assumption that it improves organizational effectiveness by 1) providing subordinates with a powerful motivator, 2) making the organization respond more rapidly to local contingencies, 3) freeing top management from the drudgery of routine decisions, and 4) providing training opportunities for lower-level managers.

The organization theory suggests that technology does not independently affect the degree of decentralization or centralization of decision-making authority (Child and Mansfield 1972; Davis and Olson 1985; Hickson et al. 1969; Inkson, et al 1970; Marsh and Mannari 1981). In this context, the question of whether DW technology or IT creates more centralization or decentralization is perhaps the most interesting as well as the most difficult to answer.

In fact, the issue is not entirely new, for since the 1950s there has been a long-standing controversy over the computer's role in centralizing or decentralizing decision-making authority (Leavitt and Whisler 1958; Myer 1967; Simon 1965, 1977). Few clear-cut conclusions have emerged from this debate and related empirical studies. Most studies found that IT made decision-making authority more decentralized (Ahituv et al 1989; Dawson and McLaughlin 1986; Gordon and Narayanan 1984; Klatzky 1970; Pfeffer and Leblebici 1977). On the other hand, opponents of this perspective claim that IT led to centralization (Blau et al 1976; Reif 1968; Zmud 1982). This argument claims that IT eliminates weaknesses of decentralized structures, such as suboptimization and high costs of coordination. In addition, Carter (1984) indicates no change on either centralization or decentralization.

Many researchers believe that the degree of IT system centralization reflects the degree of centralization of an organizational decision-making structure (Ein-Dor and Segev 1982; Wheelock 1982). An organization, then, with a centralized decision-making structure would have a more centralized IT structure than an organization with a decentralized decision-making structure. This proposition is supported by studies conducted by Ein-Dor, and Segev (1982) and Wheelock (1982), but is disputed by studies undertaken by Olson and Chervany (1980), and Olson and Davis (1981). This researcher proposes that organizations with centralized decision-making authority are more likely to implement enterprise-wide DWs than ones with decentralized decision-making authority.

Level of IT Decision Making: Information technology refers to the whole spectrum of information systems. Great skill and new conceptual level of thinking are required to shape the governance of IT within an organization. Rief (1966) points out that there is more conflict and disagreement about the effect of the computer on levels of decision making than over any other organizational innovation. In this study, the level of IT decision making refers to how authority and responsibility for primary IT activities are shared between two levels of IS management and service provider: corporate IS from centralized IT department, and divisional IS and/or line management from business functional areas (Brown and Magill 1994; Sambamurthy and Zmud 1993).

Many IS researchers (Cross et al. 1997; Sambamurthy and Zmud 1994; Weil and Broadbent 1998) suggest that three primary activities are composed of IT infrastructure, IT use, and project management. IT infrastructure decisions involve decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets (Von Simson 1990; Weil and Broadbent 1998; Wilder 1990). IT use decisions refer to decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services (Von Simson 1990; Wilder 1990). IT project management decisions emphasize the process of defining, planning, directing, monitoring, and controlling the IT development and deployment at a minimum cost within a specific time and budget (Curtis et al. 1988; Walz et al. 1993).

Organizing IT is an essential management issue. Economies of scale, connectivity, and control are forces that push many organizations toward a centralized IT decision mode, while decentralized structures favor effectiveness and responsiveness (Berger 1990; LaPlante 1991; Messmer 1990, Von Simson 1990; Wetherbe 1988; Wilder 1989). A centralized IT decision mode has authority and responsibility for all three primary IT activities located at an organization-wide IS unit. With a decentralized IT decision mode, IT decision authority regarding three primary IT activities is pushed to the business unit or divisional IS unit that reports to a business functional area. IT organizations have to find the correct hierarchical level at which to make decisions.

More recently a hybrid (distributed) IT decision mode has been proposed. Such a mode allows corporate IS units and divisional IS units to assume primary authority and responsibility for specific IT activities (Brown and Magill 1994; LaPlante 1991; Von Simson 1990; Zmud 1988). With this mode, decision for IT infrastructure, for example, is highly centralized by corporate IS unit, but IT use and project management decisions are highly decentralized by business unit or divisional IS staff.

This study expands on the set of three traditional IT decision modes utilized in earlier empirical studies in order to address the choice of DWG approach that supports IS strategic alignment – the fit between business strategic orientation and IS strategic orientation. This researcher proposes that organizations with centralized IT decision modes where decision-making authority belongs to a central IS unit are likely to implement enterprise-wide DW architectures. Divisional DM architectures, on the other hand, are expected to be implemented by organizations that divisional IS staff has primary IT decision-making authority.

Summary

A review of the literature relevant to the organizational structure is presented in this chapter. The relationships between the various influences on DW topologies (structures) are conceptually defined. The chapter begins with a review of three structural measures of an organization: formalization, decentralization, and level of IT decision-making. Next, hypotheses that predict the relationships between the three measures and DW topologies are provided.

To prove the research hypotheses, a field study is conducted. This study consists of two overlapping phases. The first phase is a pretest survey to help develop and administer the questionnaire. The pretest survey results will improve the validity of the questionnaire and allow participants to respond to items with the same construct. The second phase is to conduct replicated case studies for six large organizations to meet specific objectives. DW architecture and organizational structure for each organization will be examined. Research methodology and design of the research instruments for these two phases is detailed in Chapter 4. Analysis and interpretation of survey findings, research contributions, limitations and issues, and future research are presented in Chapter 5 and Chapter 6.

CHAPTER 4

RESEARCH METHODOLOGY AND DESIGN

The purpose of this chapter is to present the research framework, research methodology and design within which the hypotheses can be tested. The chapter is divided into six sections. The first section addresses the methodology of multiple case research that allows the researcher to take advantage of unique case features and opportunities. Subsequent sections present development and design of the instrument and research procedure. This includes data collection methods and sample case selection. The last section of this chapter describes six selected organizations regarding their DW implementation, organizational structure, data warehousing success, and critical success factors.

The research framework in Figure 7 helps to illustrate the choices faced by different research sites and data collection approaches. For decades, a major goal of many organizations has been to reconcile disparate operational systems and share data across applications. Business functional requirements provide significant details that assist in defining the technology that will be used to implement a final solution. The architectural requirements help to define the answers to physical implementation issues like: Will the warehouse be centralized or distributed? The impact of not defining this type of architectural information is enormous, forcing the development team to replace the current underpinnings with products that support the undiscovered requirements (Hammergren 1996).

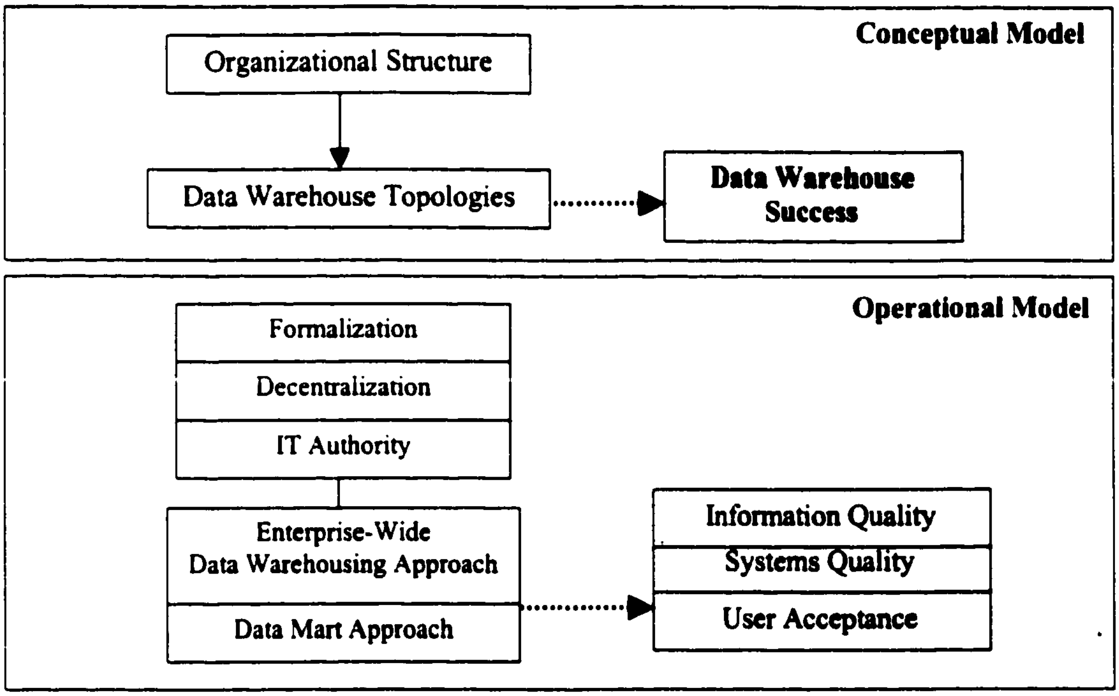

Figure 7: Research Framework

In adopting DWG technology, organizations have often been unable or unwilling to tackle enterprise-wide DW modeling and design. They have avoided the tough issues of reconciling data for an enterprise architecture by building multiple divisional DMs. But because divisional DMs breed fragmentation, the pendulum is swinging back from a pure DM approach to centralized DWG schemes in which each of these DMs is fed from a strong central component (Atre 1997).

The choice of an enterprise-wide DW and a divisional DM approach is more than just a method or technique. In addition, process issues and the question of implementation appear to be important. These interdependent elements combine to form our research approach. The research question generally investigated in this context is: What is the effect of organizational structures on the implementation of DWG approaches? This will provide valuable insight regarding organizational structure as a causal variable for DWG approach change. The study will focus on key organizational structure components such as formalization, decentralization, and IT authority. Based on the prior literature, the researcher expects that DW topology is related to organizational structure.

Hypothesis: Three aspects of organizational structure are likely to influence the degree of centralization in their data warehousing approach.

H1: Organizations with a higher degree of formalization are likely to implement a more centralized data warehousing approach.

H2: Organizations with a higher degree of centralization in decision-making authority are likely to implement a more centralized data warehousing approach.

H3: Organizations with a higher level of centralized IT authority are likely to implement a more centralized data warehousing approach.

Research Methodology

A multiple case research methodology was chosen for this study in order to collect rich descriptive data on the organizational structure that may lend itself to successful implementation of the DW. Eisenhardt (1989) indicates that multiple case research approach allows researchers to take advantage of unique case features and opportunities for triangulation. She found that such an approach encourages researchers to study patterns common to cases and theory and avoid chance associations (Eisenhardt 1991). The primary drawback to this approach is that the generalizability of the results is limited to propositions for future research, not to a population (Yin 1984). Multiples case research does not eliminate the variation identified with single cases. Herriott and

Friestone (1983) indicate that the evidence from multiple cases is often considered more compelling, and the overall study is therefore regarded as being more robust. Generalizability is a quality describing a theory that has been tested and confirmed in a variety of situations. According to Allen Lee (1989), generalizability poses a similar problem for MIS case research as it does for studies conducted in the natural sciences. In taking this position, the MIS researcher would be in step with the natural science model.

Study Design and Conduct

This study focuses on the multiple case study with research survey to provide an comprehensive understanding of the relationship between organizational structure and DW topology. Yin (1994) suggests that if research questions focus mainly on "why" and "how" questions, case study research is a preferred research strategy. Two primary sources of evidence, which are direct investigation and systematic interviewing, can help researchers investigate an empirical topic by following a set of prespecified procedures. By incorporating a research survey to this study, it allows us to form research "what", "where", and "how much" questions in examining contemporary events beyond what might be available in the conventional case study. Sieber (1973) indicates that even though each strategy has its distinctive characteristics, there are large areas of overlap among them. His recommendation is to avoid gross misfits when researchers plan to utilize one type of strategy but another is really more advantageous. Thus, both multiple case study and research survey are undeniably valuable when used alone; but this study is based on a belief that they are strongest when combined (Yin 1981a, 1981b). Therefore, to prove our research hypotheses, this study was conducted the multiple case study with research survey in Tennessee, Arkansas, and Arizona beginning in April 1999 and ending in March 2000. This study consists of two overlapping phases: a pre-test survey and multiple case research.

Pre-test Survey: After several months of internal revisions, a version of the questionnaire that seemed quite complete was pre-tested under "real world" conditions in April 1999. This procedure was particularly important for validating the measure of the relationship between DW topology and organizational structure. The relationship between these two variables is expected to differentiate the level of systems success, since they were designed based on a literature review.

To make the results more easily generalized, the researcher gathered data from six Memphis-based organizations deemed typical of the desired target population that successfully implemented DW architecture. Two organizations were contacted personally and the other four received the questionnaires by e-mail. A contact person in each of the participating organizations was selected and e-mails with questionnaires attached were sent, allowing one week to complete the questionnaire. The contact person distributed questionnaires to DW managers and business functional managers. A DW manager was needed to provide information regarding the organization's system implementation. DW business functional managers supplied perceptions on data warehousing success and organizational structure. Self-administered questionnaires were followed by 20-minute telephone interviews.

Twenty-seven participants from six organizations returned the questionnaire, and their comments as well as the pattern of responses were examined. The questionnaire appeared to have adequate face validity since almost all items were answered clearly. Telephone follow-up interviews with selected participants were conducted to ensure the researcher understood their comments and to refine the questionnaires. If critical comments required modifications, necessary changes were made in the questionnaire. These included proper design, clarity of the questions, and level of data measurement. For example, the key definitions used in this study should be described early in order to give participants the impression that this study was intended for them. Modifications made to the questionnaire as a result of the pretest included elimination of numbering for each research item, and restructuring items based on perceived clarity and content. Two important procedures the researcher included in the pretest survey to help improve the validity of the questionnaires were:

a) Participants were encouraged to volunteer any information about the questionnaire (e.g., lack of clarity) after completing the questionnaires.

b) Participants were asked to verify agreement between self-administered questionnaire responses and the follow-up telephone interview. For example, if a participant indicated in the interview that data extraction occurred directly from the enterprise DW to a smaller- scaled DM without acquiring information from OLTP, then the survey response for the best description of the company's DM should be dependent DM.

The questionnaires went through a number of revisions with additional changes to research items, as well as to the administration and data analysis methodologies. Other organizational variables, such as strategy, power and politics, and organizational size were withdrew. Three structural variables: formalization, decentralization, and level of IT decision were recommended to be investigated in this study. Once these changes were made and refinements were incorporated into the questionnaire, the in-depth multiple case research was conducted.

Multiple Case Research: Figure 8 illustrates the overall multiple case research method for this study. Case selection and design of data collection procedures were determined as the initial step in designing this study. Since the late 1990s, several organizations that have implemented DWG technology have relocated in the southern states, providing a convenience sample for the case selection. Six large organizations that had implemented DWG technology prior to our first on-site visit agreed to take part in the study. Each case study was addressed as a whole study for which the report explained how and why a particular proposition was demonstrated (or not demonstrated), and involved multiple forms of data collection. Multiple data collection methods allowed the researcher to conduct a more thorough examination of each organization than is possible with a quantitative study alone. Researchers (Hersen and Barlow 1976; Yin 1994) indicates that with multiple sources of evidence from multiple case studies, researchers can address a broader range of historical, attitudinal, and observational issues than would be possible in survey research. Multiple sources also help to prevent subjective bias. Finally, a cross-case study was conducted to examine the extent of the replication logic and why certain cases were predicted to have certain results.

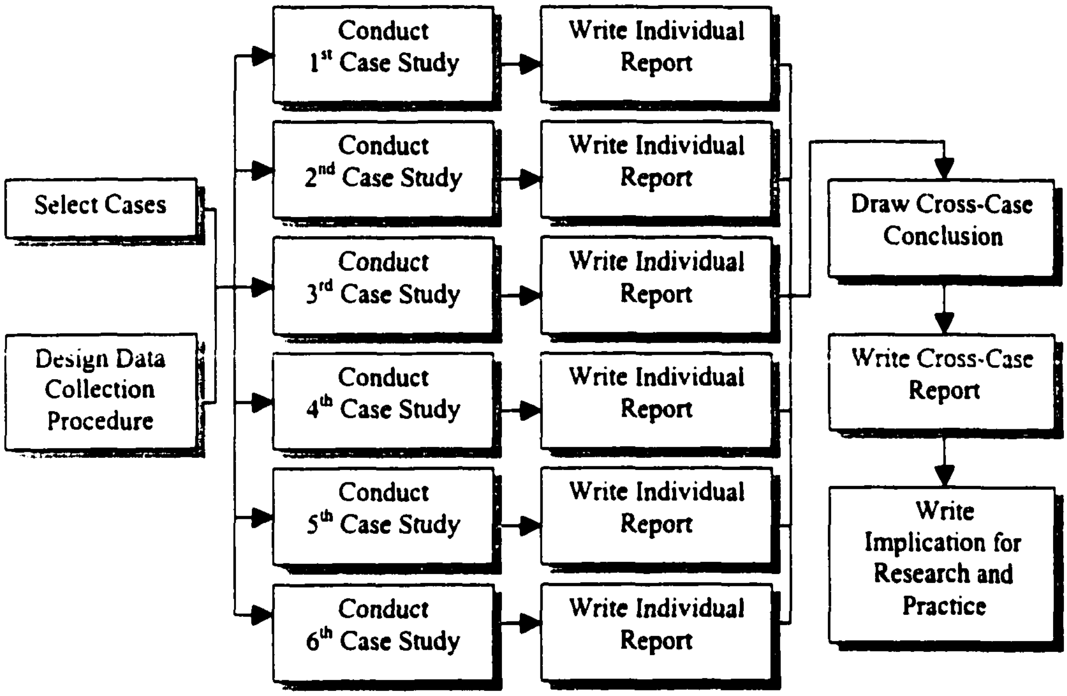

Figure 8: Overall Multiple Case Research Method

Source: Yin 1994; Yin, Bateman, and Moore 1983

Data Collection

Given the limited number of cases that can usually be studied, it is suitable to select cases, which are likely to replicate or extend emergent theory. In this study, it was almost impossible to form an adequate sampling frame for a random sample without investigating the whole population. In addition, certain organizations with DWG technology refused to participate in this study. Thus, the sample in this study consisted of large six organizations classified into two DWG approaches. Three organizations with an enterprise-wide DWG approach and three organizations with a divisional DM approach were selected. In addition, all six organizations must implement their DW architecture prior to our first on-site visit.

Although quantitative methods of research have been considered appropriate by many researchers, qualitative approaches are rapidly gaining in popularity (Creswell 1994). Both qualitative and quantitative methods are very valuable when used alone; but this study is based on a belief that they are strongest when combined (Benbasat, et al. 1987; Cale Jr. and Curley 1987; Jick 1979; Lee and Liebenau 1997; Paré and Elam 1997). Comparative case studies containing both qualitative and quantitative data were used in this work; therefore the study required a set of participants from each organization who could provide data on the overall structure and DWG context, past and present. At each case site, a direct report to the DW manager or project manager served as the primary contact for the researcher. The primary contact provided relevant historical information about the company, the IT function, and DW implementation process; assisted with identification and solicitation of the target participants; scheduled all interviews; and provided feedback for various confirmatory documents that will be described in more detail later in this chapter. In consultation with the researcher, a sample of DW manager and business functional managers who provided similar stakeholder viewpoints across the six case sites and were considered knowledgeable about DW implementation were identified and asked to participate. As can be seen in Table 5, the DW manager at each organization included the systems manager and project manager of either an enterprise-wide DW or business functional DM, as relevant. The DW business functional managers included two or more divisional/functional managers or department heads that heavily utilize DW/DM technology to gain competitive advantages for their business functional areas.

Table 5: Data Warehouse Common Mistakes

	Organizations with					
	Enterprise-wide Data Warehousing Approach			Departmental Data Mart Approach		
	A	B	C	D	E	F
DW Manager						
- Systems/ Project Manager	2	2	1	2	1	1
- Project Team Members	1		1			1
DW Business Functional Manager						
- Divisional/Functional Manager					1	2
- Departmental Manager	3	2	2	2	2	1
Total:	**6**	**4**	**4**	**4**	**4**	**5**

The data collection process in this study was a communication vehicle for confirming measurement of the overall organizational and DW factors. The process also allowed the researcher to capture a scaled rating of importance of the organizational structure factors as drivers for each organizational DWG approach. Two questionnaires were developed, one for senior IT managers or DW managers and one for DW business functional managers. Each questionnaire was estimated to take 15 minutes to complete. At each organization, there were three major phases:

1. Initial Telephone Interview. Before data collection, the primary contact at each case site received a one-page prospectus developed by the researcher that introduced the study and its objectives. The initial telephone interview began with a discussion of the current DWG process and implementation, overall IT organization, and DW topology.
2. Primary Data Collection. After all six organizations had agreed to participate in the study, the revised questionnaires were emailed to the primary contact person in February 2000. The primary contact person identified an additional DW manager and two or more DW business functional managers. In many

cases, site visits were necessary to collect case-specific information and to tour the IT facility.

For DW managers, questions were asked regarding the organizational IS structure, systems quality, information quality, and perception of usefulness and ease of use. For the DW business functional managers, prepared questions were used to measure the overall organizational structure variables. Relevant documents were also collected at each site. The survey form asked for ratings of importance for each mechanism on a 5-point scale. In addition, upon the completion of the primary data collection process, follow-up interviews for both DW managers and business functional managers from each case site were scheduled to clarify answers and provide additional relevant information. The follow-up interviews were conducted with a series of open-ended questions regarding the overall DW architecture, the locus of IT decisions for the IT infrastructure, technology use, and project management.

3. Report confirmation. A confidential report that profiled the firm in terms of its current organizational structure and DWG approach based on both interviews and survey data was prepared for each organization after the surveys were returned. After receiving feedback, the individual case profiles prepared for this study were prepared for a cross-case report and implications for both research and practice.

The overlapping of these three data collection phases across multiple sites is presented as a key feature of the research design because it enabled the researcher to incorporate insights gained from one organization into the data collection and analysis of another (Eisenhardt 1989; Miles and Huberman 1984).

Case Selection

Eisenhardt (1989) suggests that researchers conducting multiple case studies should identify their theoretical unit of interest and carefully select the case sites to produce sufficient variation in the variables of greatest research interest. An intensive literature review in both academic and practice literatures as well as pre-test surveys with six Memphis-based organizations were conducted to validate the survey instrument and to gather information on DW implementation, organizational structures, and data warehousing success.

In addition, data regarding the level of IT decision making in six organizations was collected during the follow-up interviews. It included the IT decision roles of corporate (centralized) IT units and divisional (decentralized) IS staff in primary IT activities: IT infrastructures, IT use, and project management. Levels of IT decision-making across business units of the sampled organizations were examined to detect if there were any significant variations across units. In almost all six organizations, the IT implementation decisions were found to be similar across the two DW topologies. More detailed information is described in the cross-case discussion. This provided the justification for inferring an overall firm-level pattern in the level of IT decision regarding DW topologies. In addition, data from Hoover's Company Profile database for American Public Companies 2000 was gathered on sales revenues, net income, number of employees, officer information, and business overview over the three years prior to the data-gathering effort. Thus, DW implementation decisions and size of each organization were used as the criteria for case site selection in selecting six case sites.

Table 6 illustrates the summary information that provides the "snapshot" description of the overall organization, its DWG approach, firm size, and degree of IT decision-making authority for DW activities. These differences across sites point out the importance of treating each site as an individual case study, which is done in the next section.

Table 6: Case Site Selection Criteria and Description

Organization	DW Approach	Firm Size	IT Decision-Making Authority	Description
A	Enterprise-wide DWG	Large (a) 141,000 Emps. $ 16.7 Billion	Hybrid toward Centralized	Multinational corporation pursuing the corporate strategy of effective delivery programs, order processing, and transportation management
B	Enterprise-wide DWG	Large (b) 8,324 Emps. $740 Million	Centralized	Prestigious Research I university that has emerged as a leading national and international research and teaching institution
C	Enterprise-wide DWG	Large (a) 5,260 Emps. $ 730 Million	Centralized	Leading provider of computer-based marketing information services
D	Divisional DM	Large (a) 40,500 Emps. $ 4.1 Billion	Hybrid toward Decentralized	Leading specialty retailer emphasizing the business transactions through both industrial and consumer markets
E	Divisional DM	Large (a) 19,330 Emps. $ 2.3 Billion	Decentralized	Manufacturer and distributor of electrical and electronic components.
F	Divisional DM	Large (a) 12,356 Emps. $ 1.7 Billion	Decentralized	Multinational healthcare organization that manufactures and sells medical and consumer healthcare products

(a) Based on 1999 Financial Report from Hoover's Company Profile Database, Hoover's Inc.
(b) Based on Fiscal Year of 1999 Budget Report to Arizona Board of Regents and 1999 IPED Report.

Individual Case Study

The section presents six case studies in which the researcher examines the relationships between organizational structures and DW implementation approaches. Within each individual case, four components are used to provide the framework of the organization to answer "what", "why", and "how" questions regarding the relationships stated above. As described in Figure 9, the four components for each individual case study consists of a) overview of the organization; b) description of current DW architecture, primary variables and individual measurements of DWG success, and factors for DWG success; c) description of current organizational structure, and primary variables and individual measurement of organizational structure; and d) individual case conclusion.

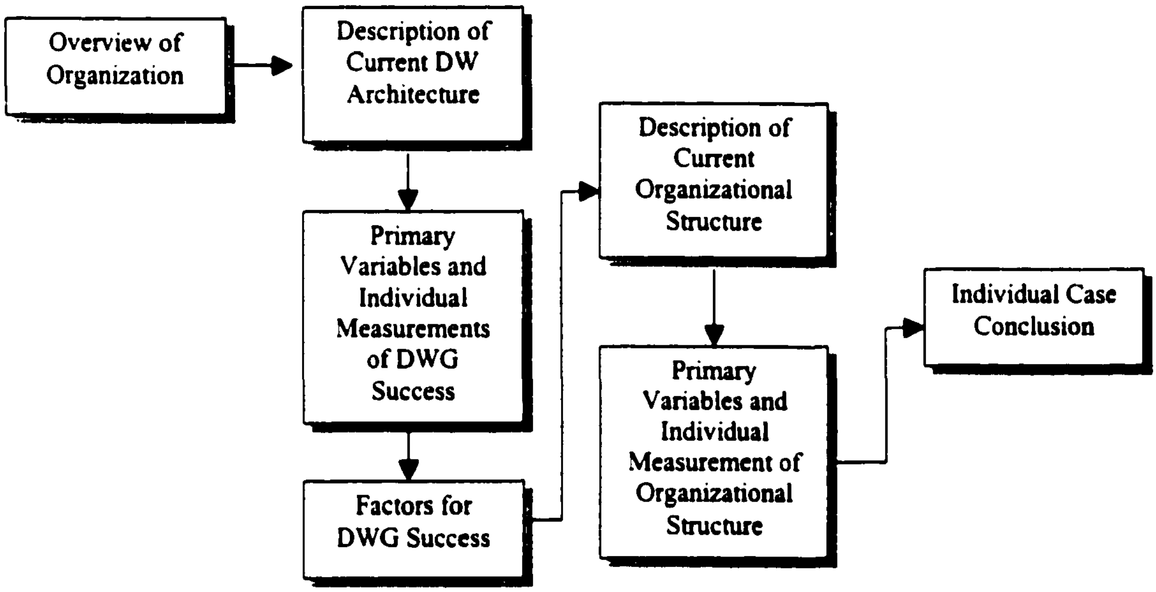

Figure 9: Primary Components of Individual Case Study

Organization A

Overview

Organization A is a multinational organization pursuing a corporate strategy of effective delivery programs, order processing, and transportation management. It has more than 141,000 employees, excluding contractors. According to the 1999 Financial Report by Hoover's Inc., corporate annual sales were $16.7 billion, with over $631 million in annual net income. The organization's activities are structured by function; in its five main subsidiaries for trucking and transportation, employees are grouped by type of work: marketing development and corporate communications, information systems, finance, accounting, and personnel.

Organization A comprises six major subsidiaries that operate independently but compete collectively, focusing on distinct market segments. These subsidiaries leverage cross-organizational synergies to create end-to-end business solutions. The organization allocates a large amount of its operating budget to technology in support of such a commitment. Facing a new millennium, the organization is aggressively searching for effective approaches to improve both DWG technology and electronic commerce to offer its customers personal touches with high-quality products and services in the high tech, high-speed, global marketplace.

In today's world of global connections, Organization A embraces information technology as an expected medium of exchange. The CIO is a corporate officer at the executive vice president level, reporting to the president (highest corporate executive). With only one level separating him from the top of the organizational hierarchy and the supervision of over 2,000 IT staff, the CIO is provided with great decision-making authority and a large span of control in the IT organization.

Table 7: Pattern of IT-Related Authority

Primary IT Activities	Level of IT Decision Making
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling IT development and deployment at a minimum cost within a specific time and budget)	**Corporate IS: Primary Role** Divisional IS: Minor Role Line Management: Minor Role

Organization A is structured around primary operating groups, with each group composed of various business functional units. The organization, which has grown through a series of acquisitions, needs an overall centralized governance mode to manage diversified IT resources. During the follow-up interviews, the senior technology advisor was concerned with improving the economics of scope through the consolidation of IT assets. Such a factor presented a strong disposition toward centralization. As Table 7 illustrates, the level of IT decision arrangement for Organization A is a hybrid toward centralization where divisional IS has decision authority for IT use, but the corporate IS group has decision authority for both infrastructure and project implementation decisions. Thus, although infrastructure and project management decisions are centralized, the Senior Technical Advisor believed that moving IT use to business functional areas would enable the group to become more deeply involved in development activities and better understand the true costs and benefits associated with successful IT use. The corporate IS group is also expected to play an influential role in identifying avenues for enhancing the efficient use of IT assets across the organization.

Data Warehousing Implementation

The development of a DWG strategy for Organization A is closely related to its mission and objectives. Therefore, the development of the organization's strategic plan corresponds to that of the DW, requiring a detailed analysis of the organization's goals, situation, and business needs. To guide development of this overall plan, *Information Engineering (IE)* is required as an integrating methodology. The senior technical advisor comments that IE allows the DW team to translate the strategic plans into a set of plans conforming data and applications. Implementing the enterprise-wide DW strategy is a crucial process, which is influenced by managerial, technological, and cultural issues. To help translate strategic plans into operational plans, the DW team selected a three-layer architecture for their environment. As Figure 10 depicts, the transformation of real-time data from transactional systems is separated into two steps: operational data store (ODS) and then enterprise-wide DW for data distribution.

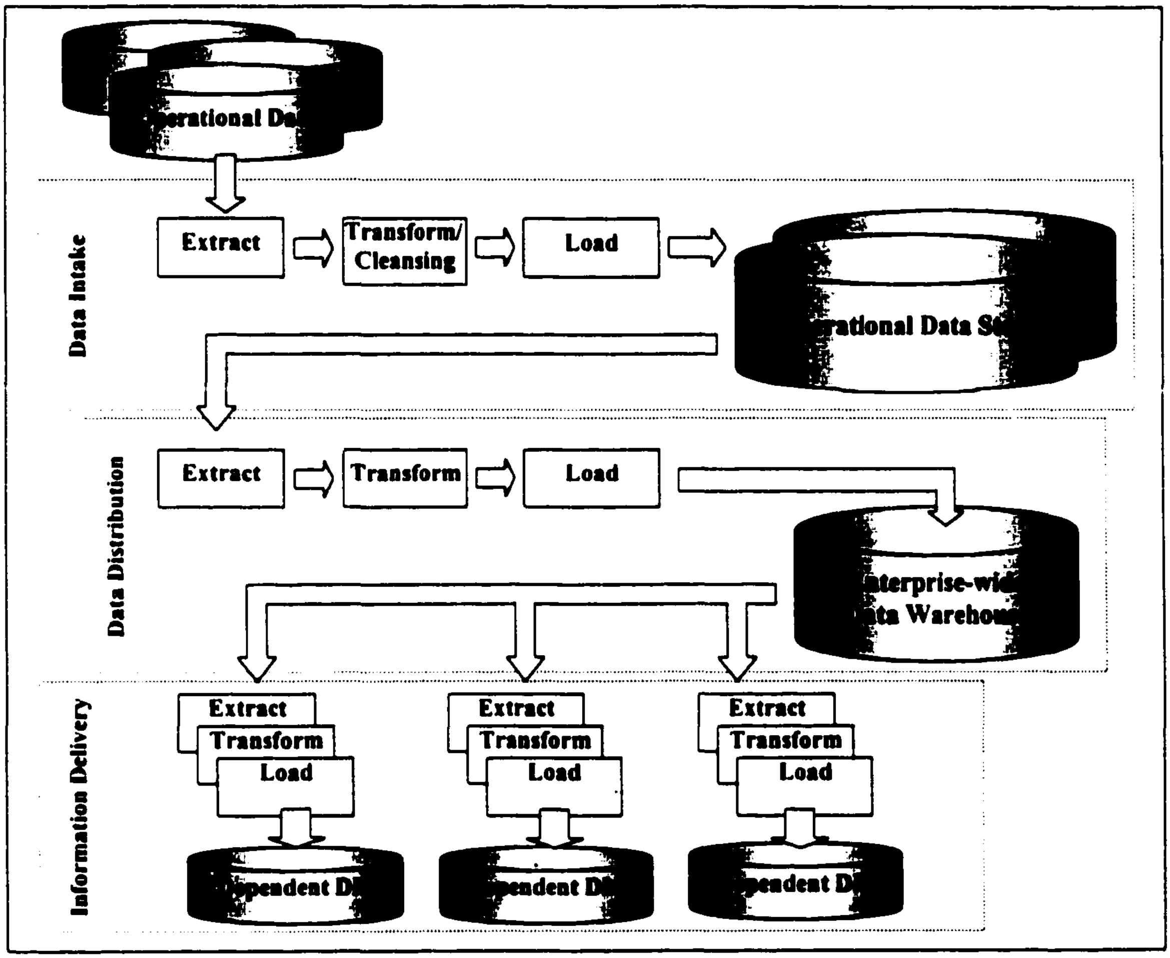

Figure 10: Enterprise-Wide DW Topology with Centralized Data Intake Layer

As Figure 10 illustrates, ODS, the first data layer, was designed to receive data into the DWG environment that will be used for tactical decision making. DW team has worked with production systems group to correct the causes of data problems. The development team believes that fixing the data downstream does not solve the problem in the long run. However, the production systems group does not have the resources available immediately, so DW team agree to fix the data in the ODS transformation process. ODS has some similar characteristics to the DW but is dramatically different in other respects, including being subject-oriented, fully integrated, and updateable. In addition, ODS is the central point of data integration for business management, contains little or no history and is as current as is technologically possible. This causes the data maintained in ODS to be subjected to frequent modifications as corresponding data in transactional systems change. Organization A utilizes ODS as an alternate to operational DSS applications, accessing data directly from transactional systems, and eliminating the performance impact of such DSS activities on transactional systems.

In the second data layer, the enterprise-wide DW was designed mainly for optimization of data distribution. It contains the lowest level of detailed data needed to support the variety of divisional DMs. With the transformation process from production systems to ODS that had been well designed to improve data quality, data extraction from ODS to DW can be performed without the additional data cleansing. Access to the enterprise-wide DW is restricted to those users with a relatively sophisticated understanding of how to use this database or to the IT staff performing ad hoc requests, extractions or one-time reports for other users.

Divisional DMs, the final data layer, contain customized and/or summarized data that is derived from the DW and/or from OLTP systems. They are tailored to support the specific analytical requirements of given business units or business functions. Each DM shares a common enterprise view of strategic data and provides business units with more flexibility, control and responsibility. These dependent DMs are located on the divisional servers, where most analytical activities take place. The data in the DMs is tailored with a high level of data transformation and cleansing for a particular capability and function.

Data Warehousing Success: Successful data warehousing initiatives have yielded significant returns on investment within short time frames. The real benefits, however, lie with the impact that such knowledge capital has on the business. Not only can a DW promote operational efficiency, but it can also lead to significant organizational change, where the business literally reinvents itself to become much more competitive and profitable. This is the real attraction in deploying this business intelligence driven technology. Thus, successful data warehousing in business requires that the benefits be stated in tangible and intangible terms, where the data collected and best new practices lead to knowledge management organization. In this study, the researcher measured the success of DW technology based on three primary variables: systems quality, information quality, and DW user acceptance.

Tables 8 and 9 presents a comparison of the DWG success in Organization A. All six participants prefer DW architecture over transactional systems for all three success variables: systems quality (mean = 3.69), information quality (mean = 3.56), and user acceptance (mean = 3.58). Clearly, DW managers who participated in DW development projects indicate higher mean scores for success in comparison to scores indicated by DW business functional managers or divisional IS staff. This pattern of mean differences may be explained by the roles that the corporate IS unit played during system implementation. A more detailed explanation is presented in the cross-case analysis. Table 10 indicates five factors that lead to success of Organization A's enterprise-wide DW architecture.

Table 8: Overall Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Quality	3.69	1.03	4.04	0.81	3.33	1.13
Information Quality	3.56	1.27	4.21	0.83	2.92	1.32
User Acceptance	3.58	1.41	4.08	1.08	3.08	1.56

Table 9: Sub Components of Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Reliability	3.83	1.03	4.33	0.52	3.33	1.21
Flexibility	3.33	0.89	3.50	1.05	3.17	0.75
Integration	3.83	1.19	4.00	0.89	3.67	1.51
Access Authorization	3.75	1.06	4.33	0.52	3.17	1.17
Timeliness of Information	3.50	1.24	4.33	0.52	2.67	1.21
Accuracy of Information	3.67	1.15	4.33	1.03	3.00	0.89
Meaning of Information	3.67	1.50	4.00	1.10	3.33	1.86
Consistency of Information	3.42	1.31	4.17	0.75	2.67	1.37
Perceived Usefulness	3.83	1.40	4.50	0.55	3.17	1.72
Perceived Ease of Use	3.33	1.44	3.67	1.37	3.00	1.55

Table 10: Factors for Enterprise-Wide DWG Success

1.	Ensure that upper management provides sufficient support and commitment during the DW development effort.
2.	Maintain good coordination between users and technical staff.
3.	Ensure that the DW development team has both the necessary technical and business-related skills (e.g., obtain quality technical services and reliable support from knowledgeable DW staff in response to system requests and modifications).
4.	Select an IT infrastructure (e.g., simple ODBC setup) that meets the project's requirements.
5.	Ensure that needed data exist and can be obtained from internal and external data sources.

Organizational Structure

Studies related to organizational structure and behavior have not all used the same set of structural variables. This has resulted in a literature review in Chapter 3 that is inconsistent in many respects, but still allows for some useful generalizations. Two primary structural variables (formalization and decentralization of decision authority), which describe components that make up organizational structure, are used in this study.

Three business functional managers were selected to share their experiences regarding organizational design and behavior. As Table 11 illustrates, Organization A is an example of an organization with a high degree of formalization and a moderate level of decentralization that typically indicates a functional structure. The grouping of positions into departments is based on similar skills, expertise, and resource use. Such a structure in Organization A can be thought of as departmentalization by organizational resources because each type of functional activity represents specific resources for performing the organization's task. To measure such a structure, individual survey items were prepared, depicted in Table 12, that contain of four formalization and six decentralization questions for decision authority measured using a 5-point scale measurement.

Table 11: Overall Measurements of Organizational Structure

	Mean	
Formalization	4.89	**Very high formalization**
Decentralization of Decision Making	3.29	**Moderate decentralization**

Table 12: Individual Measurements of Organizational Structure

•	**Mean**
Formalization	
How frequently does your organization use fixed written rules and business policies?	4.50
How many employees in your organization receive written business policies and procedures?	5.00
How many employees in your organization receive written job descriptions?	5.00
Who receives the organizational chart?	5.00
Decentralization of Decision Making	
Which level of your organization typically has the authority to make decisions?	3.33
Which level in your organization typically has the authority for making decisions concerning employee promotions?	2.33
Which level in your organization typically has the primary authority for making decisions concerning number of employees assigned to a project?	3.67
Which level in your organization typically has the authority to make decisions concerning hiring a full-time professional employee?	3.33
Which level in your organization typically has the authority to make decisions concerning work methods to be used?	4.00
Which level in your organization typically has the authority to make decisions concerning delivery dates and priority of orders?	3.00

The researcher measures the degree of formalization by the amount of written documentation used to direct and control organizational activities, such as standard operating procedures manuals, business policies, and job descriptions. With a mean of 4.89, this organization is described as being a very highly formalized organization in which decisions for handling various situations have been predefined and decision rules have been specified in advance. Written documentation includes standardized guidelines and rules (mean = 4.5), procedure and policy manuals (mean = 5.0), and job descriptions (mean = 5.0). Much of the research on such a variable has indicated that large organizations tend to place higher emphasis on formalization. The importance of formalization within an organization is that it can regulate its employees' behavior by standardizing it, while reducing variability in their activities. This standardization promotes coordination and reduces costs because less discretion is required from an employee.

To locate levels of decision-making authority, the researcher examines how planning, implementation, and control procedures have been established, and where the staff units have been placed. In this case, the decision-making power lies at the middle management level with a mean score of 3.29. The senior sales analyst from business functional units indicates that moderate decentralization is absolutely essential in running a large organization, since increased size subsequently increases the number and difficulty of decisions demanded of upper management. The objective of this setting is to make each unit a manageable business in itself. Since the early 1990s, the organization has expanded its autonomous units in several foreign countries under the coordination of central headquarters. Functional managers at middle management levels have a great deal of control. Each of the major functional units is headed by an executive vice president and represents a separate division. The functional managers from autonomous units are responsible for their divisional performance and maintain complete strategic and operating decision-making authority concerning employee promotion (mean = 3.67), number of employees assigned to a project (mean = 3.33), work methods to be used (mean = 4.00), and delivery data and priority of orders (mean = 3.00). The centralized control units at the headquarters provide support services and act as external overseers, evaluating and controlling performance. Divisions, therefore, are autonomous within given parameters, allowing their managers freedom to direct their own divisions within guidelines set down by the centralized unit.

Organization B

Overview

Organization B is a prestigious Research I university that has emerged as a leading national and international research and teaching institution. The organization offers programs from the baccalaureate through the doctoral level for approximately 49,000 full-time and part-time students. Based on the 1999 fiscal year budget reports, total operating revenue, including educational and general revenues and auxiliary enterprises, was over $740 million from all campuses. It is the policy of Organization B to provide equal opportunity, through affirmative action in employment and educational programs and activities, to more than 8,000 employees. The organization is part of a university system governed by a Board of Regents, a body with perpetual succession under the state's constitution and laws. Its activities are structured by function, and large decisions, including instructional programs, research, and technology, have historically been centralized, with decision-making emanating from the board, which reviews all major university-wide activities.

The Regents select and appoint the university's president, who is the liaison between the board and the institution. This president is aided in the administrative work of the institution by a senior vice president and provost, other provosts, vice presidents, deans, directors, department chairs, faculty, and other officers. The CIO is an executive officer, who provides technological leadership for the institution through the development and ongoing operation of its IT Strategic Planning and Management process. Eight IS directors report to the CIO. Because the CIO is two levels from the top of the organizational hierarchy and supervises of over 400 IT staff, that individual has great decision-making authority and a large horizontal span of control in the IT organization. During follow-up interviews, respondents indicated that the responsibility of the CIO is to ensure that IT initiatives are in direct support of university goals, follow the institution's strategic plan, keep within realistic budget parameters, and result in measurable objectives leading to successful outcomes. Maintaining appropriate involvement in IT initiatives by the Executive Officers is the responsibility of the CIO.

Table 13 illustrates that Organization B has adopted highly centralized IT decision-making governance. Although corporate IS holds ultimate decision-making authority for most IT decisions, divisional IS staff and business functional managers across the organization are very active in initiating and prioritizing application development requests. Most IS activities are performed by IS units that report to the same IS management team. Coordination across these IS units (e.g., data administration, data center operations, and systems development) can be accomplished via hierarchical reporting arrangements. IT infrastructures, such as hardware, telecommunications, network planning and operations are totally centralized, although decision making for some distributed platforms resides in business functional units, including users' access tools. Regarding IT use management, steering committees were selected to address DW investments that have been implemented at the divisional level. DW investment decisions include decisions concerning application priority, budgeting, and the day-to-day delivery of operations and services.

Table 13: Pattern of IT-Related Authority

Primary IT Activities	**Level of IT Decision Making**
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling IT development and deployment at a minimum cost within a specific time and budget)	**Corporate IS: Primary Role** Divisional IS: Minor Role Line Management: Minor Role

Data Warehousing Implementation

Data management is a critical activity for Organization B. The value of a data set is measured by the utility of the information derived from it. During the interviews, the assistant database administrator indicated that good data management is likely to produce good information, which is the basis for better decisions and trust from the data users. To achieve such commitments, the DW team implements its enterprise-wide DW as the prime storage location for decision support data and it promotes data integration.

As a way to better respond to users' needs when potential problems have not been well structured, the DW team decided to incorporate *prototyping approach* into their development life cycle. With smaller-scale development, prototyping provides them and the potential DW users with an idea of how the system will function when completed. Communications between the DW team and users are improved. These advantages enable prototyping to cut developmental costs and increase overall user satisfaction. Users and development team were been aware of pitfalls when they elected to use the prototyping approach, the users and development team were aware of such pitfalls as unrealistic expectations; less efficiency than systems coded in a programming language; and shortcuts in problem definition, alternative evaluation, and documentation.

From the interviews with the assistant data administrator, a three-layered architecture was chosen. This allows decision support processing to occur in an easy-to-understand format, and allows analytical information to be used in making tactical and strategic business decisions across business functional units. With quality historical data, business functional managers can perform comparative analysis and monitor trends and information patterns over time. Therefore, three primary reasons that organization B implements an enterprise-wide DW architecture are:

a) to fulfill a strategic initiative requirement that all databases use the enterprise data model as their base,
b) to separate the processes of source data integration from processes of database design and denormalization, and

c) to use the enterprise DW as a consistent source for all source-to-target mappings for multiple business-area warehouses, including human resources (HRS), financial (FRS), and student information systems (SIS).

As Figure 11 illustrates, the operational data store (ODS) is used for the first data layer to provide a centralized view of near-real-time data from transactional systems. This causes the data maintained in the ODS to be subjected to frequent changes as the corresponding data in corporate transactional systems change. Data extraction, transformation, and loading are performed to cleanse and integrate data into the standard format. Various audit and control programs are executed to ensure the integrity of data entering the ODS. Like the DW, the ODS contains little or no historical data for tactical decision making. According to the assistant data administrator, although data in the DW is refreshed daily, in certain circumstances (e.g., student information, financial information, and human resources information) a rapid analysis is required to manage the business; and if the data exists in separate files, a central ODS can facilitate this analysis.

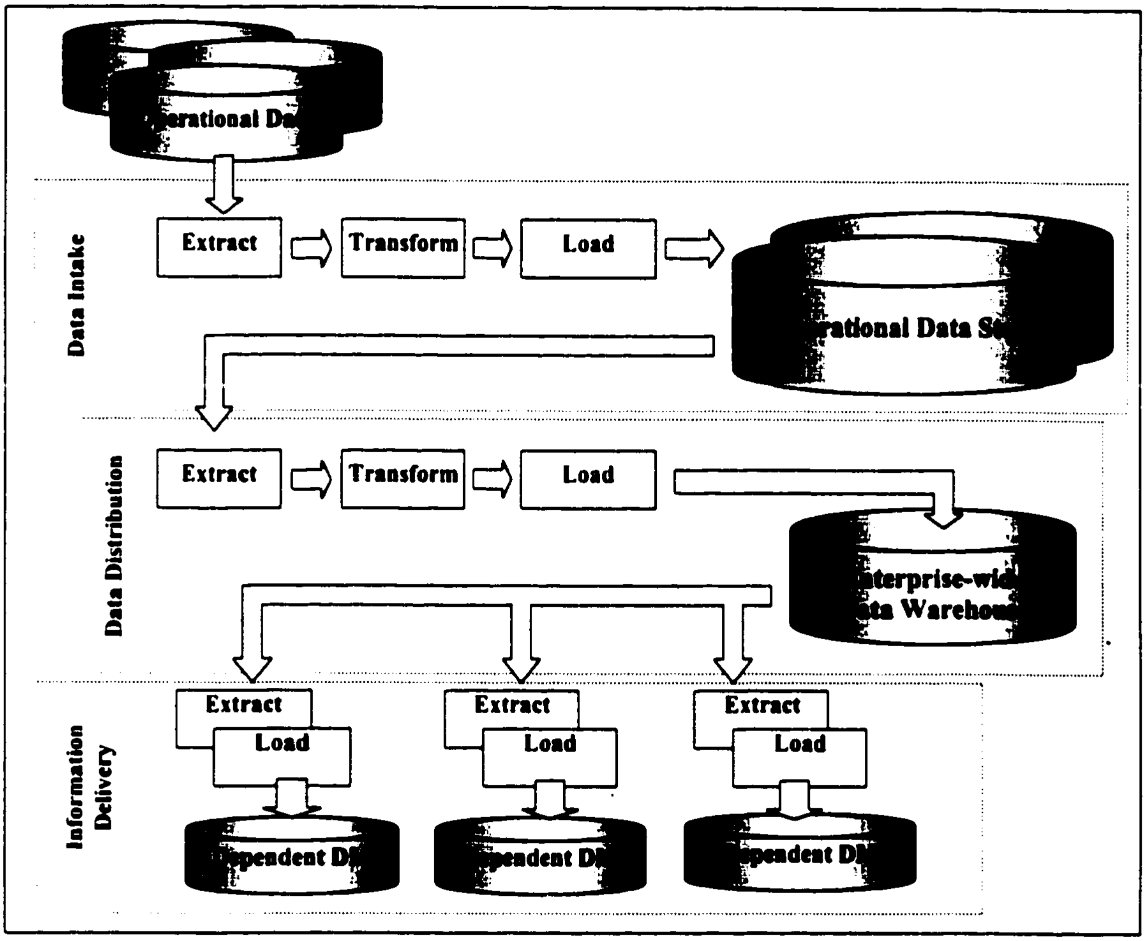

Figure 11: Enterprise-Wide DW Topology with Centralized Data Intake Layer

A series of data integration and transformation processes occur to capture, validate, integrate, and transform all data needed for the centralized DW from the ODS. The enterprise-wide DW, the second layer, is designed to distribute data as a source of strategic data for all analyses. It contains the lowest level of detail data needed to support the variety of DMs in Organization B's environment. This data layer is envisioned as normalized, and is implemented in a relational environment. It is also designed to address the different time dependencies of the underlying transactional systems. Access to this layer is restricted to those users with a relatively sophisticated understanding of how to use this database. The principle reason for this is that most decision support processes require data combined from a number of normalized tables. End users are uncomfortable with this joining process, as it requires a very formal approach to ensure its validity. Moreover, the data in this layer spans the complete organization and, is of a broader scope than most users would ever require.

In the third data layer, a set of divisional DMs are populated with data delivery that has been optimized for the needs of particular groups of users. Within each smaller, less formally structured DM, users can run their regular reports or develop needed queries. The senior systems analyst from the business functional unit indicates that one reason for the success of Organization B's DW implementation, which separates data distribution from the delivery layer, is that many management information needs are largely predefined and repetitive. The technical implication of this observation is a dramatic reduction in the computing resources needed to support the warehouse. The computationally intensive activities already identified (e.g., joining and subsetting the distributed data) are normally only performed when moving data, usually on a daily basis, from the warehouse (data distribution layer) to DMs (data delivery layer), rather than every time a user makes a query.

The researcher discovered that implementation of the three-layer data architecture in Organization B may lead to a long-term increase in data storage volumes. A successful implementation released the pent-up demand for data, particularly historical data that was previously either discarded or archived to tape. During the interviews, respondents emphasized that appropriate planning for DW infrastructure was essential to support the strength of the three-layer architecture in a controlled and comprehensive way; this planning would satisfy new and unpredicted business requirements, especially higher education.

Data Warehousing Success: A large volume of historical data and external data can be turned into useful corporate information with the creation of a data warehouse encompassing a single enterprise-wide data repository with the tools necessary to extract and analyze the data. Organization B realizes that because its DW integrates data from systems across the organization, management can get "big picture" information in order to make strategic decisions. To ensure a high degree of systems quality, information quality, and user acceptance, DWG success variables were measured.

From Tables 14 and 15, Organization B is running a successful DW architecture. Five participants attribute higher success level in their existing DW architecture than in transactional systems. In this study, the researcher considers three primary success variables: systems quality (mean = 3.69), information quality (mean = 3.56), and user acceptance (mean = 3.58). The evidence indicates that DW managers who participated in the DW development project responded with higher mean scores for their DW success than those indicated by the DW business functional managers or divisional IS staff. This pattern of mean differences can be explained by the roles that the corporate IS unit played during the system implementation. More detailed explanation is presented in the cross-case analysis. Table 16 indicates seven factors that the participants identified that led to the success of Organization B's enterprise-wide DW architecture.

Table 14: Overall Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Quality	3.74	1.16	3.79	1.22	3.67	1.11
Information Quality	3.59	1.29	3.70	1.36	3.44	1.21
User Acceptance	4.65	0.49	4.58	0.51	4.75	0.46

Table 15: Sub Components of Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Reliability	3.67	1.32	3.33	1.51	4.33	0.58
Flexibility	4.00	1.15	4.33	1.21	3.50	1.00
Integration	3.50	1.18	3.50	1.38	3.50	1.00
Access Authorization	3.80	1.14	4.00	0.63	3.50	1.73
Timeliness of Information	4.10	1.20	4.00	1.10	4.25	1.50
Accuracy of Information	2.56	1.24	2.20	1.30	3.00	1.15
Meaning of Information	3.80	1.32	4.00	1.55	3.50	1.00
Consistency of Information	3.80	1.03	4.33	0.52	3.00	1.15
Perceived Usefulness	4.90	0.32	4.83	0.41	5.00	0.00
Perceived Ease of Use	4.40	0.52	4.33	0.52	4.50	0.58

Table 16: Factors for Enterprise-Wide DWG Success

1. Ensure that executive officers encourage the use of the DW architecture once it is built.
2. Develop enterprise-wide data standards and procedures regarding data quality, access, exploitation, and presentation (e.g., easier and faster access to quality data).
3. Ensure a long-term commitment from the DW development team that understands the users' needs (e.g., excellent and dedicated IT and Data Administration staffs).
4. Establish a good partnership between users and DW developers.
5. Select DW hardware to meet the project's requirements (e.g., centralized IS unit purchased DW servers to fit long-term DW strategic needs).
6. Match query tools with different users' access skills, preferences, and requirements (e.g. include users in the meetings that determine DW use).
7. Provide appropriate user training and support programs.

Organizational Structure

Organization B has used its organizing process to deploy organizational resources and achieve strategic objectives. In a higher education environment, the deployment of organizational resources is reflected in the organization's division of labor into specific departments and jobs, formal lines of authority, and mechanisms for coordinating diverse organization tasks. Under the approval of the Board of Regents, a divisional structure is the approach for Organization B, which relies heavily on the chain of command to define departmental groupings and reporting relationships throughout the hierarchy. Departments are grouped together into separate, self-contained divisions based on organizational outputs. Diverse skills rather than similar skills are the basis of departmentalization. Therefore, from Table 17, separate divisions perform different tasks, serve different clients, and use different technology in a formalized fashion (mean = 4.25). High centralization (mean = 2.25) pertains to its top management level where decisions are made.

Table 17: Overall Measurements of Organizational Structure

	Mean	
Formalization	4.25	**High formalization.**
Decentralization of Decision Making	2.25	**Decision making occurring between top and middle management.**

Table 18: Individual Measurements of Organizational Structure

	Mean
Formalization	
How frequently does your organization use fixed written rules and business policies?	4.00
How many employees in your organization receive written business policies and procedures?	4.50
How many employees in your organization receive written job descriptions?	4.50
Who receives the organizational chart?	4.00
Decentralization of Decision Making	
Which level of your organization typically has the authority to make decisions?	2.00
Which level of your organization typically has the authority for making decisions concerning employee promotions?	2.00
Which level of your organization typically has the primary authority for making decisions concerning number of employees assigned to a project?	2.00
Which level of your organization typically has the authority to make decisions concerning hiring a full-time professional employee?	2.00
Which level of your organization typically has the authority to make decisions concerning work methods to be used?	3.50
Which level of your organization typically has the authority to make decisions concerning delivery dates and priority of orders?	2.00

In a highly formalized setting, written documentation is used to direct and control employees. Employees can be expected to handle the same input in the same way, resulting in a consistent and uniform output. There are explicit job descriptions (mean = 4.50), an abundance of organizational rules (mean = 4.00), and clearly defined procedures covering work processes (mean = 4.50). These written documents complement the organizational chart (mean = 4.00) by providing descriptions of tasks, responsibilities and decision authority. The researcher recognizes that formalization can be explicit or implicit, the latter including both written records and employees' perceptions. For measurement purposes in this study, the researcher has used the explicit definition, referring to the organization's written documentation.

Most research concurs that centralization refers to the degree to which decision making is concentrated at the top level of management. High concentration implies high centralization. Unlike other sample organizations, the higher-level decision makers in Organization B typically have the authority to make decisions concerning employee promotion (mean = 2.00), number of employees assigned to a project (mean = 2.00), and delivery data and priority of order (mean = 2.00). Only decision authority regarding work methods to be used is pushed downward to a lower organizational level (mean = 3.50). Therefore, formal authority to make discretionary choices is mostly concentrated at the higher level in the organization, permitting employees at the lower level minimal input into their work. However, in many circumstances, a filtering process may occur as information passes through vertical levels. The top executive administrators are free to verify the information they receive and to hold subordinates accountable in their choices of what they filter out, but control of information input is a form of de facto decentralization. In such a situation, management decisions are centralized if concentrated at the top, but the more the information input to those decisions is filtered through others, the less concentrated and controlled the decision is.

Organization C

Overview

Organization C is a leading provider of computer-based marketing information services with more than 5,260 employees. The organization is primarily uses informational databases to pinpoint appropriate customers for a client's products and/or services. Organization C's products and leadership in technologies, such as data warehousing and data integration help some of the world's largest companies understand their customers better and drive business decisions. In addition, the organization has developed applications for its clients to access and manipulate data, and offers data processing and outsourcing services. By providing customers with the ability to target their marketing efforts with greater accuracy, the organization ended its fiscal year with over $730 million in total revenue. In 1998, Organization C was listed as one of the top 20 best places to work for according to *FORTUNE* magazine's "100 Best Companies to Work for in America"

In such a dynamic and complex business environment, Organization C has designed its organization in matrix fashion for both differentiation and integration. This design consists of an organic structure with extensive horizontal job specifications based on formal training and a tendency to group professional specialists into functional units that can be deployed into small, market-based teams for their project work. The design relies on liaison devices to encourage mutual adjustment as the key coordinating mechanism with and between these teams. Thus, the organization's activities are organized by both the functions and services they provide to customers to maximize economies of scale and specialization. These include areas such as marketing information services, outsourcing services, finance services, and international services.

According to 1999 Hoover's Company Profile Database for American public companies, Organization C is one of the most advanced data warehousers and allocates a large amount of its operating budget to modern information technology. The highest IT executive holds the title of divisional leader and reports to the organization's president. With the CIO one levels from the top of the organizational hierarchy and supervising over 60 IT staff, a relatively pure hybrid form of governance, which the primary IT decision-making authority is shared between the corporate and divisional IS units, is used in describing overall IT activities.

Table 19 shows the hybrid IT governance mode in which corporate-wide IS, known as Shared Services, has the primary decision-making authority for IT infrastructures. This occurred when the in-house IT Research and Development group proposed hardware recommendations (e.g., file servers and personal computers) to a given vendor, which had a major impact on DW infrastructure. Divisional IS staff from business functional areas have only a supporting role in such an activity. In terms of IT use management and project management decisions, major business functional units have primary decision authority within the guidelines of corporate-wide IT standards and procedures. A similar arrangement applies to the use of their own DW technology and DW project management.

Table 19: Pattern of IT-Related Authority

Primary IT Activities	Level of IT Decision Making
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling IT development and deployment at a minimum cost within a specific time and budget)	**Divisional IS: Primary Role** Corporate IS: Minor Role

Data Warehousing Implementation

Organization C is in the business of data delivery and information integration and management. With DWG technology, the organization customizes a large volume of data for corporations that want to improve their marketing efforts. Some of this information is used for direct mail, telemarketing, credit reporting, or marketing planning. In the past the company's business practices emphasized the provision of data processing and related computer-based services, mainly to direct marketing organizations; but in recent years, Organization C has expanded its business beyond the direct marketing industry. For some of its major customers, the organization provides assistance through information/database management, data center management, and/or the provision of data. Therefore, the three-layer architecture in Figure 12 was designed to provide data consumers with an information framework that represents a comprehensive business model and serves a broad range of services and data. Generally, Organization C's enterprise-wide DW supports the following:

a. Rapid Response. Data consumers need to analyze large amounts of external data from various sources to make business decisions. They are often faced with a limited window of time in which to perform this analysis and make timely business decisions in order to react quickly to changing market conditions.
b. Complex Analysis. Business analysis involves determining the answers to some extremely complex questions, often requiring iterative analysis of data. Data consumers typically issue queries that invoke multiple conditions, summarization, and complex subqueries – all of which place increased demands on a centralized database.
c. Dynamic Business Environment. Data consumers need flexibility to access information in a variety of ways to resolve specific business problems quickly. As the fewer environment changes, consumers are required to view and analyze data in complex and constantly involving methods. This often involves the ability to cross-correlate different subject areas and business measures.

Many failed systems were abandoned because the development team tried to build an effective system without clearly understanding how it would conform to the organization's goals, current business processes, and other information systems to provide value. DW developers at Organization C believed that *prototyping approach* was the most suitable DW development methodology to use in order to create value for the organization. With this approach, the DW analysis and design were performed, and work immediately began on a system prototype that provides a minimal number of features.

This was then demonstrated to the users and the project sponsor, who in turn supplied comments, which were used to reanalyze, redesign, and re-implement a second prototype with additional features. The process continued in a cycle until the DW developers, users, and sponsor agreed that the prototype functioned well enough to be installed and used. After the prototype, which at that point was the "system" was installed, refinement occurred until it was accepted as the new DW system and consequently moved to the production stage. Figure 12 illustrates the three-layer enterprise-wide DW topology that identifies how the data will move throughout the system and how it will be used within the organization.

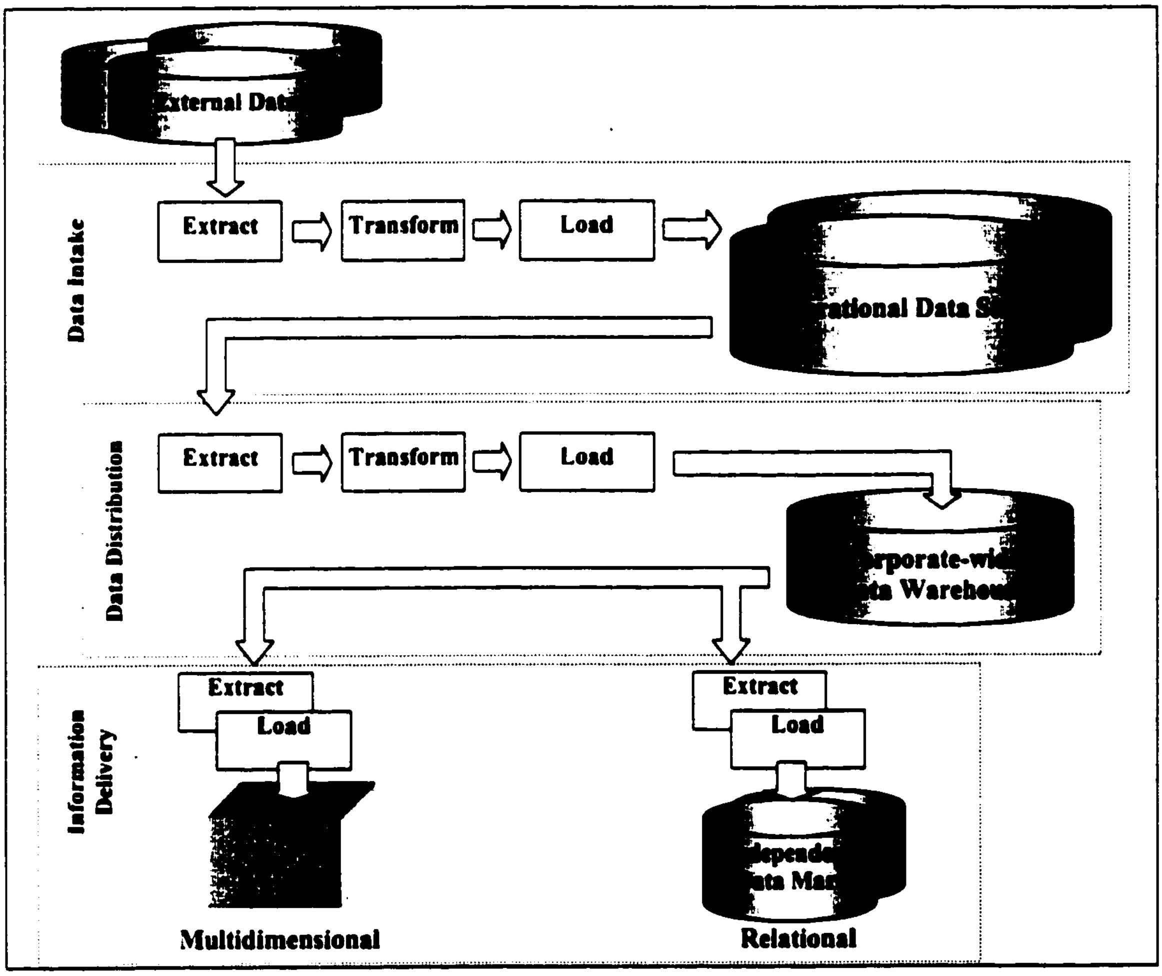

Figure 12: Enterprise-Wide DW with Centralized Data Intake Layer

Organization C's DW architecture helps create a data source that is accurate, shareable, and easily accessible throughout the organization. This architecture provides a blueprint explaining the vision, goals, and objectives that Organization C can deliver. The blueprint starts with ODS as its first data layer, which provides a centralized view of data from various external sources. This causes the data maintained in the ODS to be subjected to frequent changes as the corresponding external data changes. Data extraction, transformation, and loading are performed to cleanse and integrate data into the standard format. Various audit and control programs are executed to ensure the integrity of data as it enters the ODS.

The DW, the second layer, is designed to distribute data as a source of strategic data for all analyses. It contains the lowest level of detailed data needed to support the variety of DMs in Organization C's environment. Integration and transformation occur to capture, validate, integrate, and transform all data needed for the DW from ODS. At this layer, the DW team needs a clear understanding of the transformation requirements that must be supported, including business rules and complexity. Access to this layer is restricted to users with relatively sophisticated understandings of how to use the database.

The third layer in this DW environment for information delivery consists of a set of DMs that have been optimized for the needs of particular user groups. Within each smaller and less formally structured DM, users can run their regular reports or develop the queries they need for their customers' specific needs. The technical implication of this observation is a dramatic reduction in computing resources needed to support the warehouse. This architecture clearly defines the DW's content, level of granularity, and level of retention. Data from enterprise-wide DW is extracted and loaded into two forms of DM: multidimensional database (MDDB) and relational database (RDB). MDDSs store data as an n-dimensional cube that implies vary spare matrices. It allows DM users to deal simultaneously with data views defined by such combinations of qualities as product, region, sales, actual expenses, and budget. More important, MDDB adds time as a dimension. RDB, on the other hand, was chosen because of the maturity of the database technology that divisional IS staff feel more comfortable using the better-known and better understood relational database products. Divisional IS staff indicate the relational database vendors are protecting their client base by working to improve the star and snowflake schema in terms of optimization for speed and ease of query response to make RDBs more competitive.

At the early stage of DW development, Organization C began its DW project with smaller, subject-oriented DWs that were inevitably connected. Over time, they built the enterprise-wide DW through smaller, iterative phases. The DW team believes that without proper data architecture, the interconnectivity required by the data models, tools, and underlying technologies will not occur and will cause their DW implementation to fail.

Data Warehousing Success: A DW has emerged as a recognition of the value and role of information. Businesses are desperate for a system that delivers competitive advantage. Efficiency is no longer the single ingredient to business success. Flexibility and responsiveness have been added to the requirements for DW success.

Tables 20 and 21 summarizes the findings regarding overall DWG success. From Table 20, all five participants agree that their DW environment is an effective information processing system in terms of systems quality (mean = 4.19), information quality (mean = 4.47), and user acceptance (mean = 4.17). With the highest mean of information quality, enterprise-wide DW can meet information needs of knowledge works and can provide strategic business opportunities by allowing data consumers access to more timely, accurate, meaningful, and consistent information than those of transactional systems. In addition, the research evidence indicates that DW managers who play a primary role in a DW development project respond with higher mean scores on DW success than those indicated by DW business functional managers or divisional IS staff. Thus, this pattern of mean differences can be explained by the roles that the corporate IS unit play during system implementation. A more detailed explanation is presented in cross-case analysis. Table 22 indicates five factors that lead to the success of Organization C's enterprise-wide DW architecture.

Table 20: Overall Data Warehousing Success

	Total		**Tech**		**Users**	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Systems Quality	4.19	0.95	4.38	0.74	4.13	1.01
Information Quality	4.47	0.78	4.88	0.35	4.32	0.84
User Acceptance	4.17	0.83	4.25	0.50	4.13	0.99

Table 21: Sub Components of Data Warehousing Success

	Total		**Tech**		**Users**	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Systems Reliability	4.63	0.52	4.50	0.71	4.67	0.52
Flexibility	4.25	0.71	5.00	0.00	4.00	0.63
Integration	4.00	1.41	4.50	0.71	3.80	1.64
Access Authorization	3.88	0.99	3.50	0.71	4.00	1.10
Timeliness of Information	4.75	0.46	5.00	0.00	4.67	0.52
Accuracy of Information	4.33	1.03	5.00	0.00	4.00	1.15
Meaning of Information	4.38	0.92	4.50	0.71	4.33	1.03
Consistency of Information	4.38	0.74	5.00	0.00	4.17	0.75
Perceived Usefulness	4.67	0.52	4.50	0.71	4.75	0.50
Perceived Ease of Use	3.67	0.82	4.00	0.00	3.50	1.00

Table 22: Factors for Enterprise-Wide DWG Success

1. Ensure that upper management provides sufficient support and commitment during the DW development efforts.
2. Establish corporate-wide standards and procedures regarding data quality, access, exploitation, and presentation.
3. Ensure that the metadata provides a clear roadmap for all data in the warehouse.
4. Use an appropriate DW development methodology and modeling technique to build the data architecture (e.g., allowing faster and easier processes to deploy data warehouse)
5. Transform and cleanse operational data to meet the DW quality standard.

Organizational Structure

Effective organizers try to group duties into meaningful subunits while avoiding duplication of efforts or excessive specialization, which can lead to boredom or tunnel vision in the enterprise's executives. A great deal of research indicates that when the strategy is properly implemented with the right organizational structure, the organization is more effective (Ansoff 1965; Miller 1987). Organization C is a leading data warehouser in that its products change frequently and are short-lived. To achieve speedier responses and better coordination, the organization grouped their activities in a matrix structure. A matrix structure was designed as a multiple-command system that certain managers have at least two bosses – usually one of a functional nature and one for the product or product group. Such a structure allows the organization to utilize functional and divisional chains of command simultaneously. Tables 23 and 24 illustrate the measurements of organizational Structure. The lateral structure provides coordination across functional departments while the vertical structure provides traditional control within these departments leading to highly formalized (mean = 4.00) and decentralized (mean = 3.94) model of organizational design.

Table 23: Overall Measurements of Organizational Structure

	Mean	
Formalization	4.00	High formalization
Decentralization of Decision Making	3.94	High decentralization toward the lower management

Table 24: Individual Measurements of Organizational Structure

	Mean
Formalization	
How frequently does your organization use written fixed rules and business policies?	3.33
How many employees in your organization receive written business policies and procedures?	3.67
How many employees in your organization receive written job descriptions?	4.00
Who receives the organizational chart?	5.00
Decentralization of Decision Making	
What level of your organization typically has the authority to make decisions?	5.00
Which level of your organization typically has the authority for making decisions concerning employee promotions?	4.00
Which level of your organization typically has the major authority for making decisions concerning number of employees assigned to a project?	3.67
Which level of your organization typically has the authority for making decisions concerning hiring a full-time professional employee?	4.00
Which level of your organization typically has the authority for making decisions concerning work methods to be used?	4.33
Which level of your organization typically has the authority for making decisions concerning delivery dates and priority of orders?	2.67

As mentioned above, Organization C uses a matrix structure to achieve speedier responses and better coordination that reflect the founding age of the marketing information services industry. A relatively large organization maintains a high degree of formalization indicated by frequent use of written documentation to direct and control its employees. Written documentation includes rulebooks (mean = 3.33), policies and procedures (mean = 3.67), and job descriptions (mean = 4.00). These documents complement the organizational chart (mean = 5.00) by providing descriptions of tasks, responsibilities, and decision authority. Several business functional areas associated with sophisticated and automated technical systems are becoming less formal in order to be flexible and responsive in a changing environment.

Business functional managers believe that highly decentralized authority is absolutely necessary in running their business. The decision making that usually occurs at the lower level of management with the mean of 3.94 has been pushed downwards to lower organizational levels in order to serve greater changes and uncertainty in its business environment. This evidence supports the overall structure of such an organization in a matrix setting for a high degree of decentralization without power concentration. It is carried out by creating, under a central organization, a number of autonomous units that typically have major decision-making authority concerning the number of employees promoted (mean = 4.00), number of employees assigned to a project (mean = 3.67), hiring of full-time professionals (mean = 4.00), and work methods to be used. Thus, the major divisions are autonomous, with full responsibility for results and authority commensurate with that responsibility. Divisions within the organization are frequently regarded as being competitive with each other with respect to cost, efficiency, and profits.

Organization D

Overview

Organization D is a Fortune 500 leading retailer, which sells a broad line of auto replacement parts, heavy-duty truck parts, automotive diagnostic and repair software, and chemicals and accessories through multiple chain stores. The organization was reported as the nation's leading specialty retail chains. The organization began operations in 1979, and, as of December 1999, had generated over $4.1 billion in total sales, and $244 million in net income, according to *Hoover's Handbook of American Business 2000.*

With more than 40,000 employees, a functional structure is used as the chain of command grouping people together to perform their work. The organization is structured around main operating groups. In general, the organization's activities are structured based on similar skills, expertise, and resource use. Major departments reporting to the chairman are groupings of similar expertise and resources, such as technology, employee relations, distribution, store development, advertising, merchandizing, and marketing. Each of the functional departments at Organization D is concerned with automobile parts and accessories. The department head of employee relations is concerned with human resources issues for the entire organization, and the marketing department is responsible for all sales and marketing.

The organization emphasizes on customer service, and a large amount of the operating budget for technology is allocated to improve its business processes and overall customer satisfaction. By using advanced information systems, the organization offers professional technicians a software package for electronic diagnostics, and repair information via Internet technology. In the IT organization, the CIO is a corporate officer at the senior vice president level, reporting to the president. With only a single level separating him from the top of the organizational hierarchy, the CIO, supervising in excess of 300 IT staff, has great decision-making authority and an extremely large span of control in the IT organization. Six IS directors report to the CIO. Coordination across these IS units is accomplished via these hierarchical reporting arrangements.

Organization D has been structured around major operating departments that lead the overall IT decision arrangement in a hybrid toward decentralization. Such an arrangement enables each operating division to better configure its work and management systems to its specific functional environment. Senior management understood the significance of the IT strategic alignment that allows a good fit between business strategic orientation and IS strategic orientation; but business functional managers from primary functional areas have limited experience with IT decision-making. Therefore, while business managers clearly understood the direction of business, the corporate IS unit and divisional IS staff were best positioned to react technologically to this business direction.

As a result of the dispositions depicted in Table 25, IT decision arrangements at Organization D reflect decentralization for both IT use and project management decisions. Major business functional areas that have their own IS staff have the primary authority and responsibility for IS resource areas in terms of usage and project management within the guidelines of corporate-wide IT standards and procedures. Common dimensions, for example, are used to maintain data integration and scalability across multiple DMs. This approach is used to conform to the equality and roll-up rule, which states that these dimensions in different DMs are either the same or that one is a strict roll-up of another. In addition, with such an IT decision-making authority, corporate-wide IS has primary decision authority only over IT infrastructures as well as DW infrastructure. Hybrid IT governance that is directed toward decentralization prohibits business functional managers and divisional IS staff from performing passive roles in the IT decision-making process.

Table 25: Pattern of IT Related Authority

Primary IT Activities	Level of IT Decision Making
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling the IT development and deployment at a minimum cost within a specific time and budget)	**Divisional IS: Primary Role** Corporate IS: Minor Role

Data Warehousing Implementation

Through experience, many DW developers concluded that traditional structured analysis based on data flow and process may not always be adequate to design DW architecture. While DWs derived from data flow diagrams (DFDs) and structure analysis meet current requirements, those same systems are not always flexible enough to adapt to tomorrow's requirements. In looking at an answer to these problems, the DW development team at Organization D began turning to a technique based on data modeling, called *Information Engineering (IE).* Database modelers built the DW by studying the data independently of how the data was used. They modeled the data for completeness, stability, and adaptability.

By using IE, the DW development team placed much greater responsibility for development on user participation. It began at the upper level, with strategic information resource planning applied to the entire organization. Next, each business functional unit was subjected to business-area analysis to define the activities, processes, and data necessary for the unit to function as intended. With the completion of business unit analysis, a rapid development technique was used to quickly develop DW and present it to the users. Because the users began to work with the system earlier, they had the opportunity to identify important additional requirements more quickly than with the structured design situation. As Figure 13 depicts, Organization D implemented its DW environment in a two-layer data architecture that consisted of data reconciliation and distribution, and information delivery. Such an organization considers its DW architecture to be a centralized and subject area based DW that contains a function-bounded set of data. The data that is extracted, transformed, cleansed, and loaded into DMs is provided by multiple sources relating to a set of functions within the organization.

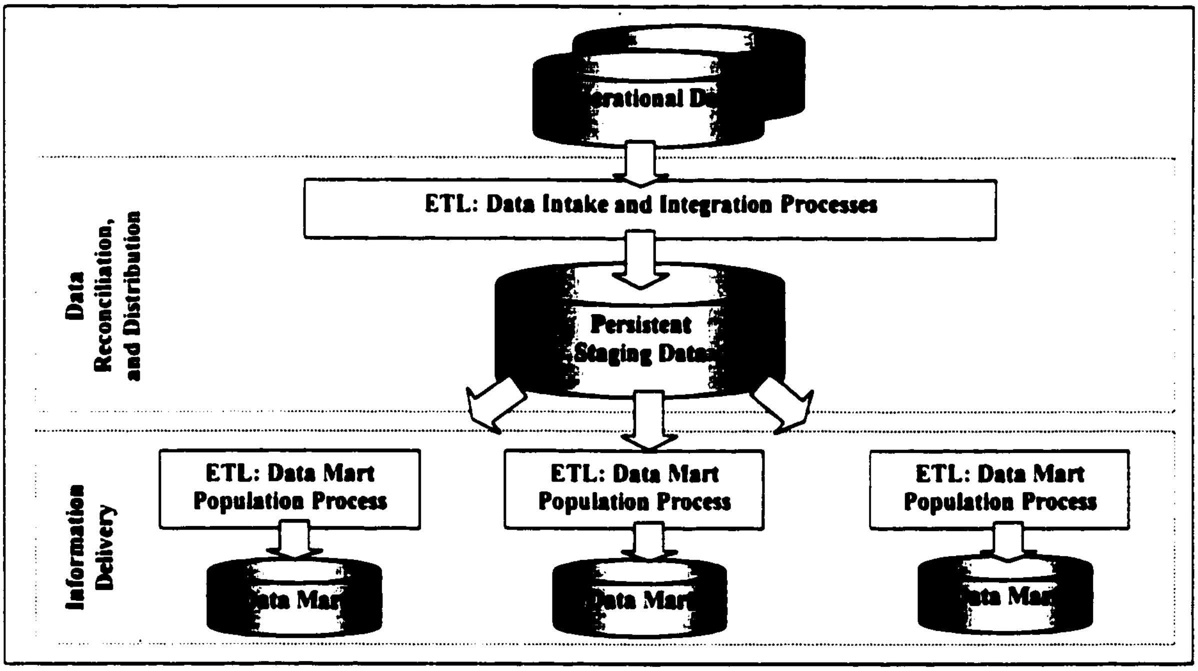

Figure 13: Divisional Data Mart Topology

Several sites in this study implement ODS to provide a centralized view of enterprise-wide data from transactional systems. Instead, a persistent staging area is used in Organization D. According to the business intelligent manager, persistent data staging is to be the single, definitive source for all data required by users of management information as well as decision support systems. During data reconciliation and distribution, sets of data in transactional systems are reconciled with one another as part of the process of being copied to the persistent data staging. This step is driven by the need for cleansing real-time data to eliminate its inconsistencies and irregularities. No new data is created from this layer. The value comes from the reconciliation itself. Organization D uses this persistent data staging area to reconcile only subject-area data that supports the specific analytical requirements of given business functions from geographically distributed transactional systems and combines and enhances it into a single, logical image of the data model.

The second layer is the information delivery layer, which enables business functional users and their supporting IS staff to build and manage views of the DW within their DMs. This layer involves a three-step process of filtering, formatting, and delivering data from a staging area into departmental DMs. All metadata for the DW environment is managed here. The Lead DSS analyst indicates that metadata is the "glue" that holds the entire DW together. Metadata is data concerning data that describes the centralized subject-area based DW.

To avoid future data integration and scalability problems, Organization D used the DM implementation approach, named Common Dimensions, that was recommended by Ralph Kimball (1996). The common dimensions were used to conform to the equality and roll-up rule, which states that these dimensions in different DMs are either the same or that one is a strict roll-up of another. For example, two DMs (sales DM and merchandizing DM) form a coherent part of an overall enterprise DW if their common dimensions (e.g., time and product) conform. The time dimensions from both DMs might be at the individual day level; conversely, one time dimension might be at the day level but the other at the month level. Since days can roll up to months, these two time dimensions are considered to be conformed.

The DW development team at Organization D had taken the time to understand their architecture and infrastructures before building their first DM. The development team, which was responsible for the DW project plan, time lines, and budget preferred to know whether or not they were responsible for setting up the full architecture and infrastructures for implementing it, or just the design and development of the database itself. Obviously this had a considerable effect on all aspects of the development project, including resources, time lines, tasks, deliverables, and training needs.

Data Warehousing Success: Organization D's long-range vision and carefully executed marketing DW have shifted the company's focus from product to customer. In the process, the company has empowered its marketers by giving them direct access to information. This offers business functional areas with highly targeted and customized communications. The bottom-line benefit is high returns on direct marketing dollars. To ensure the success of this sophisticated marketing system, DWG success variables were measured.

Table 26: Overall Measurements of Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Quality	4.00	0.64	3.94	0.77	4.07	0.47
Information Quality	3.60	0.93	4.00	0.78	3.25	0.93
User Acceptance	4.56	0.51	4.50	0.53	4.63	0.52

Table 27: Individual Measurements of Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Reliability	3.50	0.76	3.00	0.82	4.00	0.00
Flexibility	4.13	0.64	4.00	0.00	4.25	0.96
Integration	4.17	0.41	4.25	0.50	4.00	0.00
Access Authorization	4.25	0.46	4.50	0.58	4.00	0.00
Timeliness of Information	3.50	1.07	3.50	1.29	3.50	1.00
Accuracy of Information	3.50	0.93	4.00	0.00	3.00	1.15
Meaning of Information	3.63	0.74	4.00	0.00	3.25	0.96
Consistency of Information	3.83	1.17	5.00	0.00	3.25	0.96
Perceived Usefulness	4.75	0.46	4.75	0.50	4.75	0.50
Perceived Ease of Use	4.38	0.52	4.25	0.50	4.50	0.58

Table 26 presents a comparison of the DWG success in Organization D. Four participants agree that the DW architecture has provided better management visibility and more insight than transactional systems used to support day-to-day operations. The measurement of DWG success was based on systems quality (mean = 4.00), information quality (mean = 3.60), and user acceptance (mean = 3.56). The evidence indicates that divisional IS staff and business functional managers who have primary roles in DW development decisions respond with higher mean scores to DW success in comparison to those indicated by corporate DW managers. This pattern of mean differences can be explained by the roles that divisional IS staff and business managers play during system implementation. A more detailed explanation is presented in the cross-case analysis. Table 28 indicates six factors that led to the success of Organization D's divisional DM architecture.

Table 28: Factors for Divisional DM Success

1.	Ensure that upper management from both business functional areas and IT organization provide sufficient support and commitment during the development effort.
2.	Include users in the meetings that determine users' needs during the design of data subject areas.
3.	Maintain a cooperative relationship between DW technical staff and business functional managers.
4.	Use an appropriate DW development methodology and modeling technique to manage project scope.
5.	Constantly adapt the system to meet changing business requirements over time.
6.	Select products that meet the project's requirements (e.g., appropriate selection of Online Analytical Processing (OLAP) tools).

Organizational Structure

Chandler (1962) argues that organizational strategy has an important influence on organizational structure. In turn, this study expects that the type of organizational structure has an influence on the design of the DW environment. Two structural variables – formalization and decentralization of authority as management control system – are used to classify its structure. The survey's results indicate that Organization D is an example of organizations that have a high degree of formalization and moderate decentralization as illustrated in Table 23. Employees are grouped into departments based on skills, thus permitting economies of scale and efficient use of resources.

As illustrated in Figure 14, all information systems staff in Systems Technology work in the same department. They have the experience for handling almost any problem within a single, large department. The large functional departments enhance the development of in-depth skills because people work on a variety of problems and are associated with other experts. Career progress is based on functional expertise; therefore, employees are motivated to develop their skills. Managers and employees are compatible because of similar training and expertise.

Figure 14: Functional Structure for Organization D.

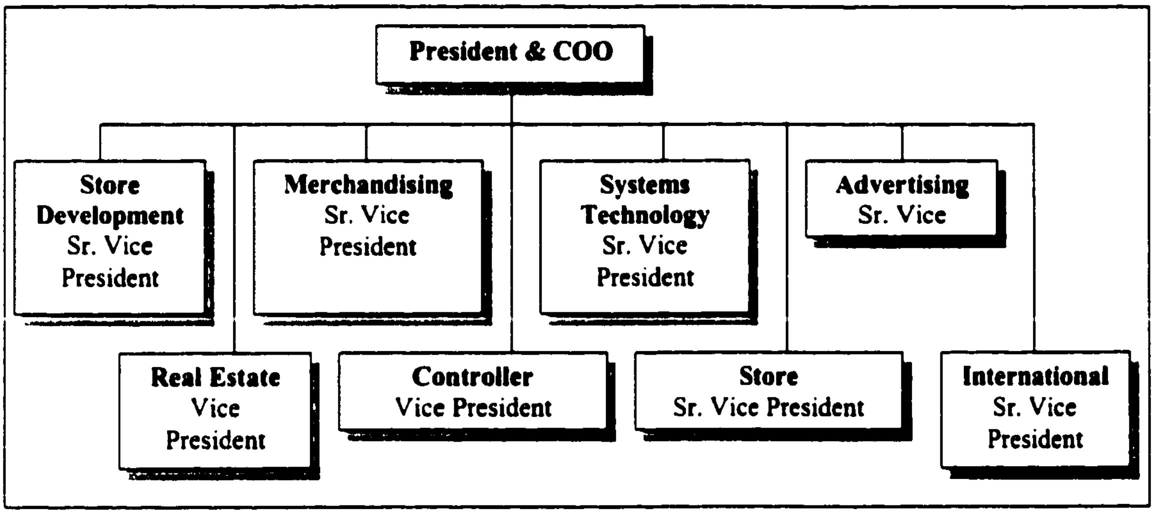

Table 29: Overall Measurements of Organizational Structure

	Mean	
Formalization	3.75	**Moderate formalization**
Decentralization of Decision Making	3.25	**Decision making occurs between middle and lower management**

Table 30: Overall Measurements of Organizational Structure

	Mean
Formalization	
How frequently does your organization use written fixed rules and business policies?	2.50
How many employees in your organization receive written business policies and procedures?	5.00
How many employees in your organization receive written job descriptions?	3.50
Who receives the organizational chart?	4.00
Decentralization of Decision Making	
What level of your organization typically has the authority to make decisions?	3.00
Which level of your organization typically has the authority for making decisions concerning employee promotions?	3.50
Which level of your organization typically has the major authority for making decisions concerning number of employees assigned to a project?	3.50
Which level of your organization typically has the authority for making decisions concerning hiring a full-time professional employee?	2.50
Which level of your organization typically has the authority for making decisions concerning work methods to be used?	3.50
Which level of your organization typically has the authority for making decisions concerning delivery dates and priority of orders?	3.50

Tables 29 and 30 describe the measurements of organizational structure. In divisional specialization, division of labor in Organization D is developed on the basis of specialized knowledge, skill, and action. Activities are formed with a moderate level of formalization (mean = 3.75) and decision-making authority normally occurs at the middle and lower level of management (mean = 3.25).

The researcher measured formalization by asking business functional managers the extent to which rules, procedures, and communications are written and the extent to which jobs are explicitly defined, such as in a manual. The coordination activities at this organization call for rules and regulations (mean = 2.50), and rarely refer to job functionality based on formal job descriptions (mean = 3.50). The use of written policies and procedures, however, occur much more frequently in describing employees' tasks and responsibilities.

Formalization, then, appears to be a rough but combined measure of sophistication of control. The location of decision-making authority occurs near lower organizational levels. This arrangement seems to relieve the burden on top managers, allowing for greater use of workers' skills and ability at the middle and lower levels. It ensures that decisions are made close to the action by well-informed employees and permits Organization D a more rapid response to external changes in the specialty retail chain environment. These decisions are typically concerned with employee promotion (mean = 3.50), number of employees assigned to a project (mean = 2.50), hiring of full-time professional employees (mean = 3.50), work methods to be used (mean = 3.50), and delivery data and priority of order (mean = 3.50).

Organization E

Overview

Organization E is a leading manufacturer pursuing a corporate strategy of related diversification in the electronics, electrical, utility, and mechanical markets. According to a *1999 Business Week Survey of the S&P 500*, the organization was ranked second in the Electrical and Electronics industry group. Its earnings' performance over the last several years has been consistent with the S&P 400s'. Its earnings' growth performance, especially in recent years, has been consistent and above that of many of our industry peers. According to a 1999 Financial Report by Hoover's Inc., this Fortune 500 manufacturer produced annual sales of $2.3 billion.

With more than 19,330 employees, the organization's activities are organized in a matrix form, providing strong supports to its products and services that have changed frequently and been short-lived. The functional managers have formed project groups to achieve speedier responses and better coordination. With a matrix organization, an effort was made to combine the best features of the functional (Administration, Finance, Operations and Administration) and product (Electrical Component Group and Electronics Group) forms of organization.

In an effort to manage advanced technology, the highest IT executive is the CIO, who holds the title of executive director and reports to an executive vice president. With a position two levels from the top of the organizational hierarchy and the supervision of over 80 IT staff, a relatively pure hybrid governance form is indicated for primary IT activities. Table 31 illustrates that Organization E has decentralized IT decisions for IT use and project management and highly centralized IT infrastructure decisions. Most of the IT-related decision making was, in fact, being handled by the divisional IS staff. In general, the centralized IS unit developed corporate-wide infrastructure standards, with the divisions retaining the autonomy to conform to these standards; planned, developed, and operated organization-wide applications; and approved of IT infrastructure from the perspective of a good fit with corporate infrastructure standards.

Table 31: Pattern of IT-Related Authority

Primary IT Activities	**Level of IT Decision Making**
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Corporate IS: Primary Role** Divisional IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling the IT development and deployment at a minimum cost within a specific time and budget)	**Divisional IS: Primary Role** Corporate IS: Minor Role

Data Warehousing Implementation

Traditionally, the data modeling process has been a paper-and-pencil concern. The DW development team drew pictures depicting the layout or structure of output, input, and files and flow of dialogue and procedures. This time-consuming process is prone to considerable error and omissions. At Organization E, the DW team turned to a modern, engineering-based approach called prototyping. The DW Prototype was a smaller-scale version of a planned feature for a new DW architecture that was quickly used to experiment with different requirements until users, developers, and sponsors accept the requirements.

Iteration and change are a natural consequence of DW development. Users tend to change their minds. DW prototyping better fits this natural situation since it assumes that a prototype evolves, through iteration, into the required system. The financial manager indicated that users must be sure they have adequate input in the design process. DW developers never use the system they created. They move on to another system after completing a given project. The users often figure out too late that developers have stuck them with an inconvenient or unusable system. All three business functional managers believe that if users insist on influencing the DW design and develop ownership of it, the chances for success are much greater. Figure 15 illustrates an example of user-oriented design in the form of a two-layer DW architecture. Such a design allows data to be integrated and redesigned and then loaded into business area DMs. Unlike traditional dependent DMs, this architecture does not have one large database. With the emphasis on business issues, Organization E designed its architecture by starting with an operational data store (ODS) rather than a centralized DW, based on the following reasons:

a) The focus of the business is improving customer management
b) Marketing channel integration is considered more critical than analytical functions
c) Data volume and processing complexity do not require separate physical data stores for information distribution and delivery
d) Automatically deploying the resulting opportunities to the market channels for execution is a higher priority than identifying cross-sell opportunities.

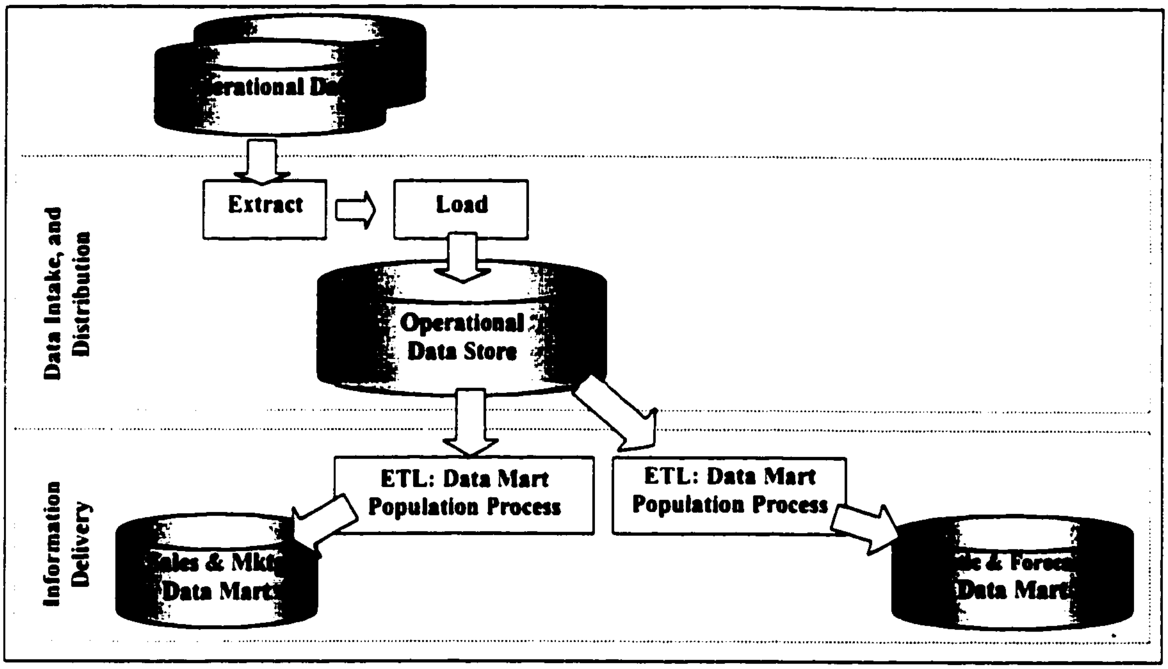

Figure 15: Divisional Data Mart Topology

The first data layer extracts operational data from transactional systems and directly loads it into ODS without data transformation and cleansing. Each derivation to ODS, at the detailed level, is aligned to address business users' needs. Data in the ODS is subject-oriented, fully integrated, and updateable to support the tactical decision-making process. ODS sustains the same frequency of updates as the underlying operational data, thus providing a consistent view of operational data for decision support and analysis. Organization E uses ODS as a data staging area for DM data sourcing.

In this case, the two-layer data architecture is a "fat" client model, in which client system functions include a user interface, query specification, data analysis, report formatting, aggregation, and data access. As a result of the initial cleanup in the first layer, data starts to become queryable because it can be tied via a simple star-join to the primary dimensions of the surrounding business. Thus, DMs are in the second data layer that was designed to deliver data for two major divisions: sales and marketing, and logistics and forecasting. Data delivery processes select the data of interest to the DM users (filter), place the data in a form and format that is usable by users (format), and physically provide the data to DMs (deliver). Metadata plays an active role in managing these data delivery processes, and holding the entire corporate information factory together.

Data Warehousing Success: Most organizations recognize that future success involves providing superior value to customers, employees, shareholders and the public. It is imperative that the DW dynamically supports changes in business needs and is capable of providing critical business views by customers, markets, service sectors, and profitability. To assess performance, DWG success variables in Organization E were monitored

Table 32: Overall Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Quality	3.77	0.62	3.75	0.71	3.78	0.60
Information Quality	3.79	0.50	3.50	0.76	3.90	0.31
User Acceptance	3.56	0.89	3.50	0.58	3.58	1.00

Table 33: Sub Components of Data Warehousing Success

	Total		Tech		Users	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**Mean**	**Std.Dev.**
Systems Reliability	3.88	0.64	4.00	0.00	3.83	0.75
Flexibility	3.50	0.76	3.00	1.41	3.67	0.52
Integration	3.57	0.53	4.00	0.00	3.40	0.55
Access Authorization	4.13	0.35	4.00	0.00	4.17	0.41
Timeliness of Information	4.00	0.00	4.00	0.00	4.00	0.00
Accuracy of Information	4.00	0.00	4.00	0.00	4.00	0.00
Meaning of Information	3.50	0.76	3.00	1.41	3.67	0.52
Consistency of Information	3.67	0.52	3.00	0.00	4.00	0.00
Perceived Usefulness	4.13	0.35	4.00	0.00	4.17	0.41
Perceived Ease of Use	3.00	0.93	3.00	0.00	3.00	1.10

As illustrated in Tables 32 and 33, the four participants agree that the divisional DM architecture has provided more effective information processing than transactional systems. From Table 32, the measurement of DWG success is based on systems quality (mean = 3.77), information quality (mean = 3.79), and user acceptance (mean = 3.56). The evidence indicates that divisional IS staff and business functional managers, who have the primary role in DW development decisions, respond with higher mean scores to DW success in comparison to those indicated by corporate DW managers. This pattern of mean differences can be explained by the roles that divisional IS staff and business managers play during system implementation. A more detailed explanation is presented in the cross-case analysis. Table 34 indicates four factors that lead to the success of Organization E's divisional DM architecture.

Table 34: Factors for Divisional DM Success

1.	Ensure that senior management provides sufficient financial support and commitment during the development effort.
2.	Manage users' expectations to obtain user buy-in by promoting the success of the initial project (e.g., business users believe that the data warehouse is important in supporting decision-making processes).
3.	Ensure that DW development team has both the necessary technical and business-related skills.
4.	Clearly define needed data and use appropriate modeling techniques during DW design (e.g., good understanding of data collection and data grouping).

Organizational Structure

Organizational structure is defined as the enduring system of systematic relationships among positions within an organization (Mintzberg 1979). In this study, these relationships focus on expectations about the behavior of position holders using written documentation (formalization), and the degree of decision-making authority allocated to those positions (decentralization). Organization E has been targeted toward a moderate level of formalization with great concern for employee maintenance. Middle management and lower level executives typically have the authority to make important decisions within their functional units.

Table 35: Overall Measurements of Organizational Structure

	Mean	
Formalization	3.00	**Moderately formal**
Decentralization of Decision-making	3.18	**Decision-making occurs between middle and lower management**

Table 36: Individual Measurements of Organizational Structure

	Mean
Formalization	
How frequently does your organization use written fixed rules and business policies?	2.33
How many employees in your organization receive written business policies and procedures?	2.33
How many employees in your organization receive written job descriptions?	3.67
Who receives the organizational chart?	4.00
Decentralization of Decision-making	
What level of your organization typically has the authority to make decisions?	3.00
Which level of your organization typically has the authority for making decisions concerning employee promotions?	3.00
Which level of your organization typically has the major authority for making decisions concerning number of employees assigned to a project?	3.00
Which level of your organization typically has the authority for making decisions concerning hiring a full-time professional employee?	2.33
Which level of your organization typically has the authority for making decisions concerning work methods to be used?	3.33
Which level of your organization typically has the authority for making decisions concerning delivery dates and priority of orders?	5.00

A number of definitions of organizations were described in Chapter 3. For our purposes, an organization is a rational coordination of the activities of a group of people for the purpose of achieving a particular goal. Organization E selected a matrix structure to allow for a joint effort of both functional and divisional structures simultaneously in the same part of the organization. In other words, the matrix structure provides a formal chain of command for both functional (vertical) and divisional (horizontal) relationships. While the vertical structure provides traditional control within functional departments, the horizontal structure provides coordination across departments. This type of arrangement leads Organization E to a moderately formalized (mean = 3.0) and decentralized (mean = 3.18) environment.

The organization offers very few employees the opportunity to use written documentation in describing their tasks, responsibilities, and decision-making authority. During the data collection process, business functional managers indicated that although written documentation was intended to be rational and helpful to the organization, it often created "red tape" that caused more problems than it solved. The researcher measured formalization by asking business functional managers the extent to which they used written rules (mean = 2.3), and policies and procedures (mean = 2.3). However, the communications are well written and the extent to which jobs are explicitly defined (mean = 3.7) complements the organizational chart (mean = 4.0) for the majority of employees within the organization.

With decentralization, decision-making authority is pushed down to the middle organizational levels. As mentioned in the previous cases, decentralization is believed to relieve the burden on top managers, making greater use of middle managers' skills and abilities. Decisions are made closer to the action by well-informed managers, permitting a more rapid response to changes of electrical equipment and electronics markets.

The department heads from autonomous units are responsible for their departmental performance and hold complete strategic and operating decision-making authority concerning employee promotion (mean = 3.0), number of employees assigned to a project (mean = 3.0), the hiring of full-time professional employees, and work methods to be used (mean = 3.3). There seems to be much more decentralizing of authority downward to lower management in the aspects of delivery data and priority of order. Most first-line managers have full authority to direct and control their time frames to complete given assignments (mean = 5.0).

Organization F

Overview

Organization F is a multinational healthcare organization with more than 12,000 employees. The organization manufactures and sells casting, bandaging and support items, wound care management, orthopedic and other medical and consumer healthcare products. A continuous process of supplying new and innovative products is supported by substantial R&D investment to deliver new levels of healing to patients throughout the world. Last year, the organization reorganized its structure around product lines. It is structured in territorial divisions, including the United Kingdom, the U.S., Europe, Africa, Asia, and Australia. Organization F is pursuing a multinational expansion strategy in which its operations are geographically dispersed and highly subdivided by territory. According to its 1999 Financial Report by Hoover's Inc., corporate annual sales were more than $700 million in the U.S., and over $1.7 billion worldwide in annual net income.

In 1998, DWG technology was first introduced to the U.S. operation as a partial assignment of the Y2K conversion project. The orthopedic division was the first division to complete the project. The first divisional, independent DMs were completed in early 1999. In the IT organization, the CIO is an executive director reporting to the president of the U.S. operation, is a single level from the top of the organizational hierarchy and supervises over 80 IT staff. In general, the IT organization is highly decentralized for all three primary IT activities. Five IS directors report to the CIO. All IS activities are performed by divisional IS staff, who report to the same IS management team within their own division. Coordination across these IS units (e.g., data warehousing development, and Systems Information Management (SIM) can be accomplished via hierarchical reporting arrangements. Table 37 illustrates pure decentralized IT governance, where divisional IS has primary decision-making authority for IT infrastructure, IT use, and project management within the guidelines of corporate-wide IT standards and procedures.

Table 37: Pattern of IT-Related Authority

Primary IT Activities	Level of IT Decision Making
IT Infrastructure Decisions (Decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Use Decisions (Decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services)	**Divisional IS: Primary Role** Corporate IS: Minor Role
IT Project Management Decisions (Decisions that emphasize the process of defining, planning, directing, monitoring, and controlling the IT development and deployment at a minimum cost within a specific time and budget)	**Divisional IS: Primary Role** Corporate IS: Minor Role

In addition, during interviews with DW managers, interviewees clearly indicated that since their organization was diversified into different businesses and across several countries, each operating division had to emphasize the unique nature of its particular market and singularly shape its business strategies and operations. As a consequence, IT decision-making responsibilities were located deep within operating divisions to enable each business functional unit to shape its divisional DM architecture for its market situation.

Data Warehousing Implementation

In a conventional approach to DW implementation, the development team interviewed users, collected data, and returned to the IT department to create a new system. Instead of viewing the DW team as the system designer, the DW development team at Organization F strongly recommended that users design their own systems. Stressing user input in DW design was necessary. During the course of DW implementation, they combined two modern approaches: prototyping and joint applications development (JAD) to allow strong participation from both users and technical staff. Using a prototyping approach helped the DW project team reduce the time needed to develop system requirements. The DW project manager indicated that in the past the system development team prepared specifications, which were given to the users to approve. Most users seemed to have difficulty comprehending the specifications. As a result, it may not have been until the testing stage that users first gained an understanding of how the system would or would not work.

In addition, the DW project manager suggested that prototyping should be used to complement, not replace, other methodologies. In this case, JAD was used to allow the project team, users, and sponsors to work together to identify requirements for the system. One problem with JAD at Organization F was that it suffered from the traditional problems associated with groups. People, for example, were reluctant to challenge the opinions of others, particularly their supervisors. A few people usually dominated the discussion, and not everyone participated. The project manager's solution was to allow everyone to participate equally within a given time frame (e.g., 5 minutes per participant).

Figure 16 shows a two-layer DW architecture for Organization F in which the data is integrated and redesigned and then loaded into an divisional DM. This architecture was designed to dedicate resources to a specific product line. Although this approach does not have one large database, it has all of the constructs that qualify it as a true DW environment. Like Organization E, data volume and processing complexity do not require separate physical data stores for information distribution and delivery. In the first data layer, operational data is extracted from transactional systems and directly loaded into the operational data store (ODS) without performing data transformation and cleansing. Each derivation to ODS, at the detailed level, is aligned to address users' needs. Data in ODS is subject-oriented, fully integrated, and updateable to support the tactical decision-making process. According to the DW project manager, ODS data is almost always just one step away from being both dimensional and queryable. That one step consists of cleaning up the key values so that they point to clean dimensions.

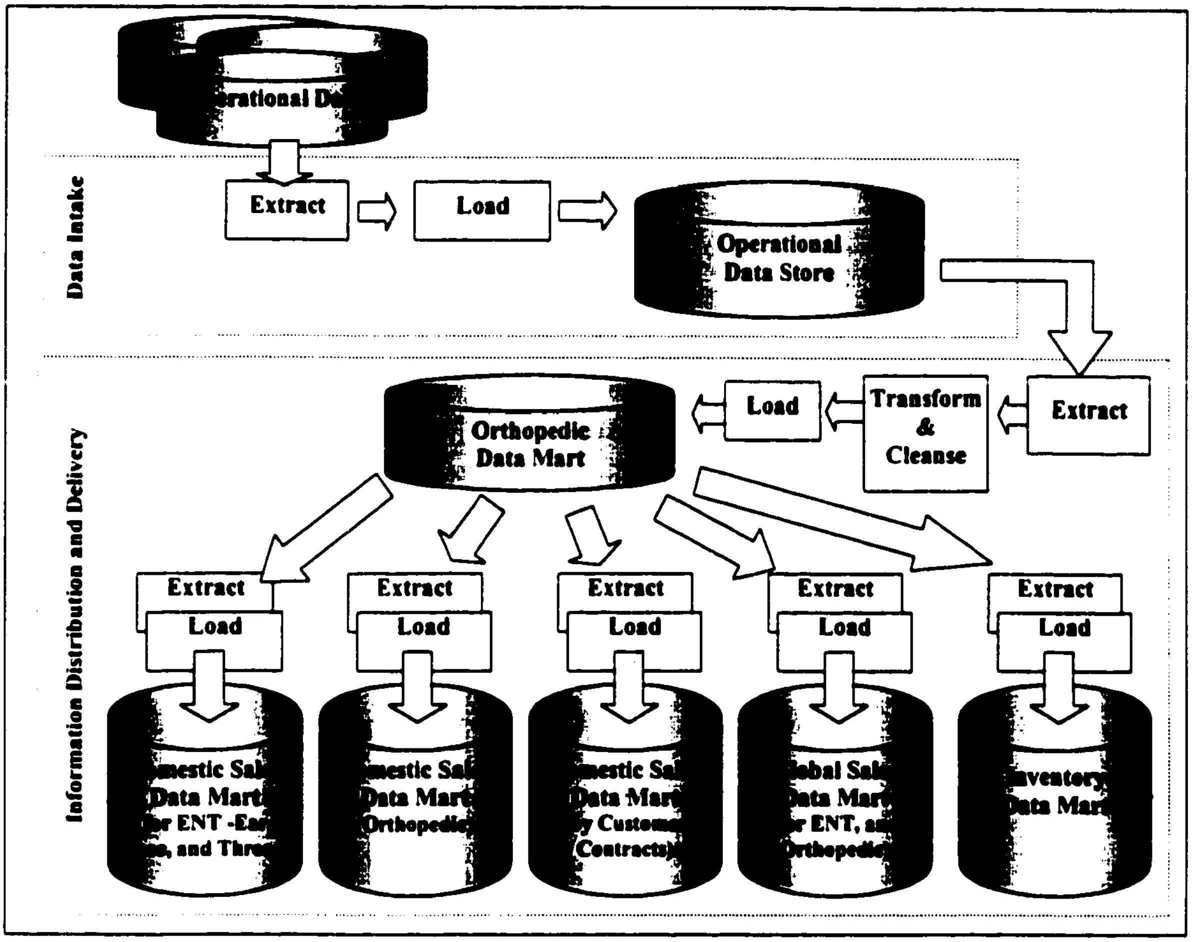

Figure 16: Divisional Data Mart Topology

As a result of the initial cleanup in the first layer, data starts to become queryable because it can be tied via a simple star-join to the primary dimensions of the surrounding business. Additionally, ODS data will be much easier to deal with in the future because some of the data processing needed to tie these records to other data in the second layer (DM) has already done. The second data layer is designed for data distribution and delivery. The DW project manager argues that the DM must not be an independent, quick or dirty, DW. Instead, the divisional DM is a single subject area implemented within the framework of an overall plan. The orthopedic DM is loaded with data extracted directly from ODS. The integration process is performed to capture the ODS data and then identify and resolve data quality issues. Cleansing and integration of data is needed to make it fit the standard enterprise format. Additionally, when data is extracted from a divisional DM, it is used to populate five subsequent DMs whose common dimensions were designed to conform to the equality and roll-up rule. The advantage of conformed dimensions is that all five subsequent DMs do not have to be on the same system and do not even need to be created at the same time. Once all DMs are running, an application spanning all five subject areas can request data simultaneously (in a single query or separate queries depending on implementation). Thus, once the common dimensions have been identified, the development of overall scalable DMs can be managed under this common dimensional framework.

The DW architecture within Organization F was implemented as a by-product of their Y2K project. The DW was the organization's early foray into the client-server environment. The learning curve was part of the overall time it took to build the warehouse. The DW development team ensured that they completely understood their architecture and infrastructures before building their DW technology. This had a positive affected on all aspects of the development project, including resources, timelines, tasks, deliverables, and training needs. Thus, identifying DW architecture and infrastructures should be a separate project from the actual development of the company's DW.

Data Warehousing Success: Organization F discovered the need for DW technology to collect and organize their growing amounts of data to improve sales and remain competitive during its Y2K conversion project. During the initial interview with Organization F's DW staff, respondents indicated that a data warehouse was designed as an accessible storage area, electronically housing an organization's medical and consumer healthcare product information. Properly designed and implemented, such a warehouse is an extremely powerful asset in a company's quest to gain or maintain a competitive advantage. While the concept is simple, the construction is not. To ensure successful construction, DW success variables must be monitored.

Table 38: Overall Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Quality	4.00	0.70	3.94	0.93	4.05	0.49
Information Quality	4.23	0.58	4.44	0.51	4.08	0.58
User Acceptance	4.45	0.69	4.25	0.89	4.58	0.51

Table 39: Sub Components of Data Warehousing Success

	Total		Tech		Users	
	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev.
Systems Reliability	4.40	0.52	4.25	0.50	4.50	0.55
Flexibility	3.80	0.42	4.00	0.00	3.67	0.52
Integration	3.88	0.35	3.75	0.50	4.00	0.00
Access Authorization	3.90	1.10	3.75	1.89	4.00	0.00
Timeliness of Information	4.50	0.53	4.50	0.58	4.50	0.55
Accuracy of Information	4.00	0.67	4.50	0.58	3.67	0.52
Meaning of Information	4.40	0.52	4.50	0.58	4.33	0.52
Consistency of Information	4.00	0.47	4.25	0.50	3.83	0.41
Perceived Usefulness	4.70	0.48	5.00	0.00	4.50	0.55
Perceived Ease of Use	4.20	0.79	3.50	0.58	4.67	0.52

Table 38 summarizes the comparison of DWG success variables. Five participants agree that divisional DM architecture has provided more effective information processing than transactional systems. The measurement of DWG success is based on systems quality (mean = 4.00), information quality (mean = 4.23), and user acceptance (mean = 4.45). The evidence indicates that divisional IS staff and business functional managers who have a primary role in DW development decisions respond with higher mean scores to DW success than those indicated by corporate DW managers. This pattern of mean differences can be explained by the roles that divisional IS staff and business managers play during the system implementation. A more detailed explanation is presented in cross-case analysis. Table 40 indicates four factors that led to the success of Organization F's divisional DM architecture.

Table 40: Factors for Enterprise-Wide DWG Success

1. Establish corporate-wide implementation policies and standards that allow overall scalable DW architecture (e.g., recognize the advantages of utilizing common dimensional data marts).
2. Transform and cleanse operational data to meet the DW quality standards (e.g., generate high-quality output data).
3. Avoid bleeding-edge technology.
4. Maintain a good relationship between user community and the technical team during DW design (e.g., involve users in every stage of implementation).

Organizational Structure

Organizational design is a never-ending subject of discussion among multinational corporation managers. There is no ideal structure to deal with the complex management needs of all large and global-spanning businesses. Organization F, which is geographically dispersed, has formed a divisional structure, specialized by territory, as the most suitable for its environment. This design delegates operational responsibility for geographic areas to line managers, with corporate headquarters retaining responsibility for worldwide strategic planning and control. The organizations successfully using this design shared two significant characteristics: routine bulk of sales revenue that was derived from similar end-use markets and critical local marketing requirements. Variations from market to market in a centrally developed basic product could be dealt with at close range. However, according to a business functional manager, the task of coordinating product variations, transferring new ideas and techniques from one country to another, and optimizing the logistic flow of product from sources to worldwide markets frequently proved difficult for this internal setting.

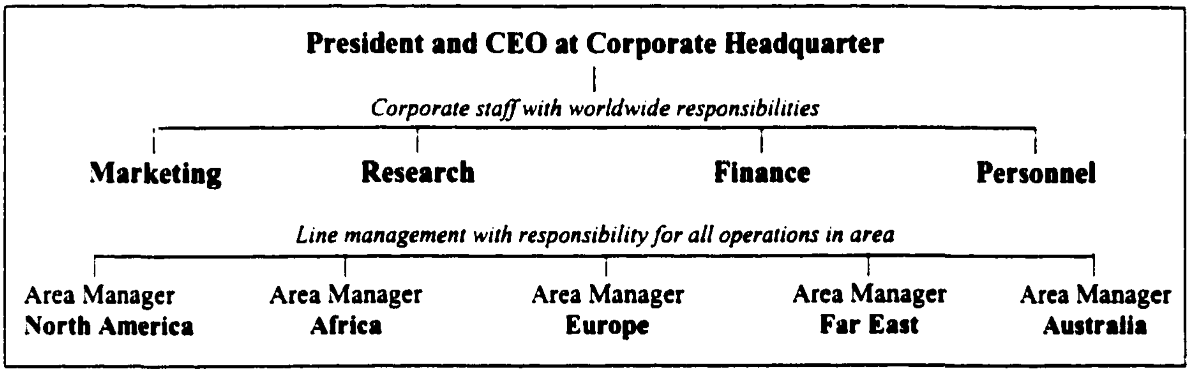

Figure 17: Overview of Organizational Design

As mentioned above, Organization F's approach for assigning divisional responsibility is to group its activities by geographic region. In this structure, all functions in a specific region report to the same division manager. Such a structure focuses its activities on local market conditions, enabling closer coordination of activities in order to meet the needs of customers within each region. For example, competitive advantage may come from the production or sale of a product adapted to a given region. As illustrated in Table 41, a high level of formalization (mean = 4.00) had been selected for frequent use of written documentation in directing and managing its human resources. The location of decision authority is near the lower organizational level (mean = 2.61), causing the organization to feel greater uncertainty from intense global competition.

Table 41: Overall Measurements of Organizational Structure

	Mean	
Formalization	4.00	**Highly formalized**
Decentralization Decision Making	2.61	**Decision-making occurs between top and middle management**

Ten individual survey items for further measurement of two structural variables are listed in Table 42. By dividing employees and resources along divisional lines, highly formalized techniques were used to decide which jobs across organizational divisions were standardized based on written documentation. Standardizing behavior can reduce variability and promote coordination because employees understand what task is to be performed. In addition, Organization F did not overlook the economics of formalization. The greater the formalization, the less discretion is required from a job incumbent. Various written documents used included fixed rules (mean = 4.00), business policies and procedures (mean = 4.00), and job description (mean = 5.00).

Table 42: Individual Measurements of Organizational Structure

	Mean
Formalization	
How frequently does your organization use fixed written rules and business policies?	4.00
How many employees in your organization receive written business policies and procedures?	4.00
How many employees in your organization receive written job descriptions?	5.00
Who receives the organizational chart?	3.00
Decentralization of Decision Making	
What level of your organization typically has the authority to make decisions?	3.00
Which level of your organization typically has the authority for making decisions concerning employee promotions?	1.67
Which level of your organization typically has the major authority for making decisions concerning number of employees assigned to a project?	2.33
Which level of your organization typically has the authority for making decisions concerning hiring a full-time professional employee?	2.00
Which level of your organization typically has the authority for making decisions concerning work methods to be used?	3.33
Which level of your organization typically has the authority for making decisions concerning delivery dates and priority of orders?	3.33

The organization was concerned that extreme autonomy of operating units at local subsidiaries could conceivably have the undesirable result of over fragmentation of the business. If the local subsidiary units became too independent, the parent business might lose its identity, and even its control over the units. Business functional managers agree that moderate centralization is absolutely necessary. The objective is to make each subsidiary unit a manageable business by itself. Since increased size increases the number and difficulty of decisions demanded of top management at headquarters, the need for mild centralization is more urgent for regional managers at local sites. By providing support services and acting as an external monitor, regional managers are responsible for their divisional performance and hold local strategic and operating decision-making authority concerning employee promotion (mean = 1.67), number of employees assigned to a project (mean = 2.33), the hiring of full-time professional employees at the local site (mean = 2.00), work methods to be used (mean = 3.33), and delivery of data and priority of order (mean = 3.33).

Conclusion

This chapter presents an array of topics related to the multiple case research methodology and design that were applied to this study. The topics include research methodology, key variables, research design, details of questionnaire development and testing, use of expert interview and content analysis, and survey administration. Thorough coverage of these topics provides a essential foundation for this study and indicates the rigor used in producing the multiple case study results.

CHAPTER 5

RESULTS: CROSS-CASE ANALYSIS

This study seeks to explain whether or not the outcome differences in DW topology can be explained by differences in an organization's choice of structures. It is important to know whether the organizational structure lends itself to successful implementation of the data warehouse. The purpose of this chapter is to present an analysis of the cross-case study results that outline the statistical procedures employed in analyzing the data and research findings.

To prove research hypotheses, the sample organizations were selected based on the DWG approach and overall organizational structure design. Six large organizations from various industries participated: air freight and transportation, higher education, marketing information services, retail, electrical equipment and electronics, and health care products and supplies. Organizations A through C have implemented an enterprise-wide DWG approach. Organizations D through F have adopted a divisional DM approach that serves the specific needs of business functional units. Overview results in cross-case analysis are presented in Table 43. Three organizational types were assigned evenly to each group. In addition, three structural variables – formalization, decentralization of authority, and IT decision-making – are presented with summary scores to demonstrate the difference in observations.

Table 43: Overview Results in Cross-Case Analysis

DW Imp. Approach	Organization	Org. Type	Organizational Structure: Formalization	Organizational Structure: Decentralization of Authority	Organizational Structure: IT Decision-Making
Enterprise-Wide DWG Approach	A	Functional	Very Highly 4.89	Moderately Decentralized 3.29	**Hybrid towards Centralization**
	B	Divisional	Highly 4.25	Highly Centralized 2.25	**Centralization**
	C	Matrix	Highly 4.0	Highly Decentralized 3.94	**Centralization**
Divisional DM Approach	D	Functional	Highly 3.75	Moderately Decentralized 3.25	**Hybrid towards Decentralization**
	E	Matrix	Moderately 3.0	Moderately Decentralized 3.18	**Decentralization**
	F	Divisional	Highly 4.0	Moderately Centralized 2.61	**Decentralization**

Mintzberg (1979) suggests that organizational structure is a fact of life for anyone who comes in contact with organizations. In one way, organizations are like human fingerprints: each has its own unique internal structure. Since the 1970s, researchers have been searching some common organizational structures. Inherent in this search is the belief that every organizational structure contains a complex clustering of elements that are internally cohesive and where the presence of some elements suggest the reliable occurrence of others (Miller and Friesen 1984). The researcher expects that these structural elements, such as degree of formalization, decentralization of authority, and IT decision-making, are likely to influence the organizational preferences in adopting DW topology.

Discussion and Findings

As described in Chapter 2, data warehouse topology is defined as the conceptual as well as logical layout and connectivity of a DWG technology that can be identified as a layer based on its types of data rather than by its physical placement. The researcher describes each topology from a broader perspective of the entire organization. This offers a consistent approach in examining corporate data architecture across the organization. Some organizations believe that an enterprise-wide DW architecture is the environment that can provide better management visibility and more insight than the traditional IS used to support day-to-day operations. However, others argue that the DM environment is a preferred option for different areas of business in implementing DW architecture to fulfill their business needs. This leads to the application of DW topology at the departmental or divisional level. Thus, the scope of DW topology in this study is enterprise-wide in preference, but it may be restricted to a department or division if needed.

The results of the analysis of the interview data are summarized in Figure 18. Two survey instruments with research survey were developed to measure three structural variables that are assumed to make a significant contribution to successful selection of DWG implementation approach. The three variables are recorded as a primary source of data for the testing of the research hypotheses. The research findings indicate that formalization and IT decision making have positive effects on successful selection of a DWG approach. Decentralization, on the other hand, presents unstable relationship to the DWG approach. A more detailed explanation and illustration of this variable is described in the following section.

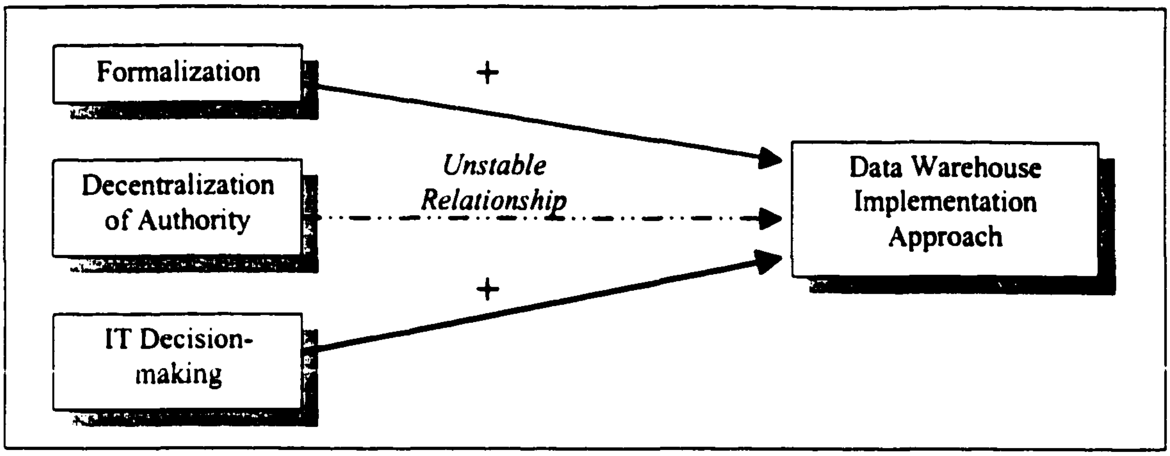

Figure 18: Interview Results on Organizational Structure

In addition, the researcher discovered that the integration of DW architecture into the existing system's architecture is not always straightforward and simple. In this study, current transactional system architectures may be extremely sophisticated at some organizations, both by design and lack of design. In most cases, there have been some type of constraints set in implementing the DW architecture, which is used to explain the relationship between organizational structure and DW topology. These constraints can be a variety of technical, integration, strategic, or political considerations that introduce limitations as to how the DW architecture can be implemented within these organizations. More detailed information is presented in each individual case analysis.

Findings for Hypothesis 1

Hypothesis 1 predicts that organizations with a higher degree of formalization are likely to implement more a centralized data warehousing approach.

The findings for hypothesis 1, based on the interview data, are summarized in Table 44. Results of this study support the notion that there is a greater degree of formalization in organizations with an enterprise-wide DWG approach than in ones using a divisional data mart approach.

Table 44: Interview Results on Formalization

	Organization with					
	Enterprise-Wide DWG Approach			Divisional DM Approach		
	A	B	C	D	E	F
	Mean					
Formalization	**4.89**	**4.25**	**4.00**	**3.75**	**3.00**	**4.00**
How frequently does your organization use fixed written rules and business policies?	4.50	4.00	3.33	2.50	2.33	4.00
How many employees in your organization receive written business policies and procedures?	5.00	4.50	3.67	5.00	2.33	4.00
How many employees in your organization receive written job descriptions?	5.00	4.50	4.00	3.50	3.67	5.00
Who receives the organizational chart?	5.00	4.00	5.00	4.00	4.00	3.00

In this study, formalization is the organizational design concept that represents the amount of written documentation used to direct and control DW activities, such as data accessibility, integrity, and security. Organizations tend to formalize their behavior to reduce variability, and ultimately manage, predict, and control it effectively. Another primary motive for doing so is to coordinate activities (Bjork 1975).

The results of this data analysis provide compelling evidence that formalization played an important role for three of the organizations (A through C) in their choice of a DWG implementation approach. An enterprise-wide DWG approach is positively related to formalization, as the variability of data consumers' behaviors from various departments across the organization must be formally coordinated organization-wide. Davis and Olson (1985) indicate that user-developed systems need less formal documentation than public systems that are used across organization. The high level of formalization is essential for quality assurance procedures such as system revision and future modification. Thus, centralized IT resources cannot convey a full spectrum of benefits without controlling this variability. Furthermore, empirical surveys (Cronan and Means 1984; Gordon and Narayanam 1984) confirmed that formalization enhances coordination and communication between IT staff and users, or among IS developers of specific systems.

In addition, evidence indicates that the following two organizations (D and E) chose a divisional data mart approach for their data architecture when less formalization was required. However, the results of this cross-case study do not fully support this line of reasoning for Organization F. The degree of formalization in this organization is not clearly determined by the positive relation with their choice of a DWG approach. An alternative explanation, which does correspond to the data, suggests that a higher degree of formalization can be explained by the type of organization. As described in Chapter 4, Organization F's approach for assigning divisional responsibility is to group its activities by geographic region. The implementation of this type of approach allows the organization to better manage the greater uncertainties stemming from intense global competition. Because of its headquarters in a foreign country, a geographical, responsibility structure allows the location of decision authority to move down toward the lower organizational levels. This movement in decision authority enables the organization to more concisely coordinate local activities to meet customer needs within each region.

With the support of previous empirical studies (Gordon and Narayanan 1984; Zeffane 1989; Zumd 1982), researchers confirm that information technology can be considered to be positively related to formalization when the variability of employees' behaviors needs to be controlled. By sharing a centralized DW architecture, organizations with high formalization in place are likely to succeed in this environment. It requires data consumers across the organization to follow more formalized rules, policies, and procedures. It enables reference to the rules and procedures in a metadata repository. Thus, frequent use of an enterprise-wide DW requires frequent reference to the organizations' predefined rules and procedures.

According to T-Test analysis *(see appendix A)*, there is enough evidence to support the above hypothesis. With 95% confidence, there is a significant difference in means regarding degree of formalization for the organizations using two DWG approaches *(p-value of 0.0387)*. Therefore, the researcher would like to conclude this finding by indicating that there is a greater degree of formalization in organizations with an enterprise-wide DWG approach than in ones using a divisional data mart approach. However, Huge, and Aiken (1970) offer important comments. They indicate that formalization, defined as the degree of job codification, was found to be inversely related to the rate of program change. It presumably discourages new suggestions, new patterns of behavior, and incentive to search for better ways of performing tasks. However, it is important to note that research relating formalization to successful implementation of changes, rather than initiation of these changes, yields opposite conclusions. That is, formalization is regarded as a necessary component for implementing change.

Finding for Hypothesis 2

Hypothesis 2 predicts that organizations with a higher degree of centralization in decision-making authority are likely to implement a more centralized data warehousing approach.

In chapter 3, prior research has shown that more highly centralized decision-making authority near the top organizational levels has a stronger effect on the centralized DWG approach. Table 45 summarizes the results of this study that show an unstable relationship between decentralization of authority and DW topology.

Table 45: Interview Results on Decentralization of Authority

	Organization with					
	Enterprise-Wide DWG Approach			**Divisional DM Approach**		
	A	**B**	**C**	**D**	**E**	**F**
	Mean					
Decentralization of Authority	**3.29**	**2.25**	**3.94**	**3.25**	**3.18**	**2.61**
Which level of your organization typically has the authority to make decisions?	3.33	2.00	5.00	3.00	3.00	3.00
Which level in your organization typically has the authority for making decisions concerning employee promotions?	2.33	2.00	4.00	3.50	3.00	1.67
Which level in your organization typically has the primary authority for making decisions concerning number of employees assigned to a project?	3.67	2.00	3.67	3.50	3.00	2.33
Which level in your organization typically has the authority to make decisions concerning hiring a full-time professional employee?	3.33	2.00	4.00	2.50	2.33	2.00
Which level in your organization typically has the authority to make decisions concerning work methods to be used?	4.00	3.50	4.33	3.50	3.33	3.33
Which level in your organization typically has the authority to make decisions concerning delivery dates and priority of orders?	3.00	2.00	2.67	3.50	5.00	3.33

Decentralization of authority does not appear to play a dominant role in describing the selection of a DWG approach. From the results of T-Test analysis *(see Appendix A.)*, there is not enough evidence to indicate that decentralization of authority is a leading factor in selecting DWG implementation approaches *(p-value of 0.731)*. With a 95% level of confidence, the researcher cannot statistically conclude that organizations with a higher degree of centralization in decision-making authority are likely to implement a more centralized data warehousing approach. In addition, Davis and Olson (1985) support the idea that centralization and decentralization of authority can be applied independently to the functions within information systems, including system operations, application system development, and overall planning and control. Furthermore, many organizational literatures have presented this instability in research results. In the first school of thought, researchers argue for decentralization of authority. They believe that using centralized IS allows upper management, who were once reluctant to delegate authority, to now feel more confident about decentralizing decision-making using centralized information systems (Blua and Shoenheerr 1971; Klatzky 1970; Pfeffer and Leblebici 1977). Information from the systems will allow upper management to determine if the performance of subordinates deviates from acceptable standards. On the other hand, opponents of this perspective claim that the large information-handling capacity of computers would facilitate re-centralization of decision-making authority which previously was delegated because of information processing limitations of managers (Simon 1977; Whisler 1970a, 1970b). In turn, this re-centralization provides the support needed to eliminate weakness of decentralized structures, such as suboptimization and high cost of coordination.

At this point, the schism between these two camps, both of which are grounded on plausible theoretical reasoning, appears to be too great to be reconciled, and it poses an obstacle for predicting the relationship between decentralization of authority and selection of DW topology.

Findings for Hypothesis 3

Hypothesis 3 predicts that organizations with higher levels of centralized IT authority are likely to implement a more centralized data warehousing approach.

The survey data in Table 46 provides corroborating evidence from the interview findings for this hypothesis. Overall, the follow-up interview data provides support for hypothesis 3. The evidence from Organizations A through C seems to support the common-sense notion that IT decision-making for the three primary IT activities with wider spans of control is better accomplished with the centralized, enterprise-wide DWG approach. When divisional IS staff is increased their authority within their own division as IT authority distributed across organization, divisional data mart approach appears to play a role in DW architecture design. In Organization D through F, business functional units have essentially created divisional data marts for their data architecture.

Table 46: Interview Results on IT Decision Authority for Three Primary IT Activities

DW Imp. Approach	Organization	Level of Infrastructure Decisions	Level of IT Use Decisions	Level of Project Management Decisions	Degree of IT Decision-Making
Enterprise-Wide DWG Approach	A	Corporate IS	Divisional IS	Corporate IS	**Hybrid towards Centralization**
	B	Corporate IS	Corporate IS	Corporate IS	**Centralization**
	C	Corporate IS	Corporate IS	Corporate IS	**Centralization**
Divisional DM Approach	D	Corporate IS	Divisional IS	Divisional IS	**Hybrid towards Decentralization**
	E	Divisional IS	Divisional IS	Divisional IS and Line Management	**Decentralization**
	F	Divisional IS	Divisional IS and Line Mgmt	Divisional IS and Line Mgmt	**Decentralization**

Table 46 shows the first three organizations (Organizations A through C) maintain a higher degree of centralization of IT decision-making authority by using an enterprise-wide DWG approach than the last three organizations (Organizations E through F) that use a divisional DM approach. This indicates that the separation of authority is obviously essential for understanding the control of IT resources and for differentiating strategic choices in DW implementation. Although those with formal authority may have the clout, others within the organization may have created strong power bases that allow them to have even greater influence over decisions.

Pfeffer (1981) suggests the evidence to support this notion. He indicates that decision authority is a structural phenomenon that is created by division of labor and departmentation. Horizontal differentiation inevitably creates some tasks that are more important than others. To use IT resources within each organization, those groups or departments performing the more critical tasks, or who are able to convince others within the organization that their tasks are more critical, will have a natural advantage in the IT decision-making authority (Caufield 1989; Miller et al 1991).

Based on the prior literature (DeSanctis and Jackson 1994; Earl 1989), large companies with decentralized IS decision-making authority are least likely to invest in horizontal mechanisms for corporate/division collaboration. Companies with such IS contexts are likely to be organizations with highly autonomous business units. This will lead to the successful implementation of a divisional DM architecture. In contrast, large organizations with centralized IS governance are likely to invest in horizontal mechanisms for corporate/division collaboration in order to achieve IS cost efficiencies through economies of scale and standardized infrastructures (Brown and Magill 1998). In such a setting, the organizations tend to adopt an enterprise-wide DW architecture.

Other Findings: Data Warehousing Success

Currently, a researcher may choose from a large number of information system success measures. This has tended to create some confusion, as many researchers and practitioners have had little guidance in identifying success constructs and measures. Adding to the confusion is the poor theoretical grounding of the information systems success instruments. As noted by Shirani, Aiken, and Reithel (1994), most of the existing instruments were developed through interviews, questionnaires, and from scales derived from other scales. They note that though this approach has intuitive appeal, a sound theoretical basis for their inclusion is often missing.

After reviewing the IS success theoretical literature, general systems theory, and several IS success instruments, the researcher in this study has identified three variables which appear to be the core dimensions for measuring data warehousing success: systems quality, information quality, and technology acceptance from users' perspectives. The definition of an information systems success construct underlies the development of a cumulative MIS research tradition by allowing for cross-study comparisons and study replications. Table 47 illustrates the comparison of IT staff and users' perspectives of data warehousing success for all six organizations.

Table 47: Comparison of IT Staff and Users' Perspectives of DWG Success

DW Imp. Approach	Org.	Systems Quality			Information Quality			Technology Acceptance		
		Total	Tech	User	Total	Tech	User	Total	Tech	User
Enterprise-Wide DWG Approach	A	3.69	**4.04**	**3.33**	3.56	**4.21**	**2.92**	3.58	**4.08**	**3.08**
	B	3.74	**3.79**	**3.67**	3.59	**3.70**	**3.44**	4.65	4.58	4.75
	C	4.19	**4.38**	**4.13**	4.47	**4.88**	**4.32**	4.17	**4.25**	**4.13**
Divisional DM Approach	D	4.00	**3.94**	**4.07**	3.60	4.00	3.25	4.56	**4.50**	**4.63**
	E	3.71	**3.75**	**3.78**	3.79	**3.5**	**3.9**	3.56	**3.5**	**3.58**
	F	4.00	**3.94**	**4.05**	4.23	4.44	4.08	4.45	**4.25**	**4.58**

Table 47 indicates that the majority of DW managers (DW technical staff) rated their systems with higher means for all three variables than the ones from DW business functional managers and divisional IS units (DW users) when an enterprise-wide DW architecture was implemented within their organizations (in above shaded areas). With the exception of Organization B, similar patterns with higher means occurred when the DW technical staff responded concerning perceived ease of use and perceived usefulness in comparison to the responses from DW users. During the follow-up interviews with Organization A, respondents indicated that the central IS unit has the technical competence to provide higher technical expertise to support a larger, more complex DW architecture. In general, a central IS can specialize and thus develop sufficient expertise to evaluate technologies. It can also function as a research unit for DWG technology by providing the necessary skills needed for leading edge pilot projects, which can not be undertaken by divisional IS units.

Unlike the results of DW success for an enterprise-wide DW architecture, DW business functional managers provided higher response rates to systems quality and user acceptance (shown in above shaded areas) when data architecture was implemented in a divisional DM environment. Such support by DW users produced an opposing disposition toward data warehousing success. This provides strong support for end user computing. Respondents from Organization E indicate that the functions of their system were defined to meet a set of users' specific needs. The researcher believes the users seem to understand the problem areas better than corporate IS units. They also argue that the IS specialists, on the other hand, are experts in the technology, but not in the problem areas. By allowing divisional IS staff to develop their own divisional data marts, there is no need for communication with the corporate IS unit. Therefore, with divisional DM development, no communication gap exists.

Within this context, the evidence obtained from the six organizations suggests consistency with the prior research in Chapter 2. In light of this evidence, an enterprise-wide DW architecture allows for an integrated and complete view of the organization's information. Its projects involve high complexity in development. In most cases, the unique architecture required for a customized DW, divisional data mart structure, must be built upon a set of business subject requirements that are derived from the individual needs of the organization. The analysis results in this study provide strong support that even if the implementation process is presented as being successful, a DW development team needs to ask a wide range of questions in building it. Regardless of the type of DW topology, DW designers need to pay as much attention to the business requirements, data definitions, and flow of data as they do to choosing hardware and software. Nevertheless, DW construction requires a sense of anticipation about future ways to use the collected records. DW developers need to be aware of the constantly changing needs of their company's business and the capabilities of the available and emerging hardware and software requirements.

Table 48 summarizes factors leading to the success of DW architecture for six sample organizations that emphasize the construction of new warehousing projects. It is important to know that the above factors are not "critical success factors." According to Rockart (1979), critical success factors are the factors that are critical to success in performing the functions or making decisions. They are the key areas of the job where things must go right in order for the organization to flourish. For the current DW studies, researchers (Haley 1997; Little 1998) may choose from a large number of DW critical success factors measures. This has tended to create some confusion, as many DW researchers and practitioners have had little guidance in identifying success constructs and measures.

Table 48: Factors for DWG Success across Six Organizations

1. Ensure that upper management provides sufficient support and commitment during the DW development efforts.
2. Ensure that executive officers encourage the use of the DW architecture once it is built.
3. Ensure long-term commitment from DW development team that understands the users' needs.
4. Ensure that DW development team has both the necessary technical and business related skills.
5. Establish a good partnership between users and DW developers.
6. Transform and cleanse operational data to meet the DW quality standard.
7. Ensure that needed data exists and can be obtained from internal and external data sources.
8. Ensure that the metadata provides a clear roadmap for all data in the warehouse.
9. Establish corporate-wide standards and procedures regarding data quality, access, exploitation, and presentation.
10. Select DW hardware and software to meet the project's requirements.
11. Use an appropriate DW development methodology and modeling technique to build the data architecture.
12. Match query tools with different users' access skills, preferences, and requirements.
13. Manage user expectations to obtain user buy-in by promoting the success of the initial project.
14. Provide appropriate user training and support programs.
15. Include users in the meetings that determine users' needs during the design of data subject areas.
16. Constantly adapt the system to meet changing business requirements over time.
17. Clearly define needed data and use appropriate modeling techniques during DW design.
18. Avoid bleeding-edge technology.

Since they do not follow the rigorous standards set by Rockart (1979), the factors in Table 48 should not considered to be DW critical success factors. As noted by Shirani, Aiken, and Reithel (1994), most of the existing instruments were developed through interviews, questionnaires, and personal experience and from scales derived from other scales. They note that though this approach has intuitive appeal, a sound theoretical basis for their inclusion is often missing. To take this lack of theoretical basis into account, the researcher refers to them as "factors for success" rather than critical success factors.

This chapter presents an analysis of the cross-case study of six large organizations in order to determine whether the outcome differences in DW topology can be explained by differences in an organization's choice of structures. The research findings indicate that formalization and IT decision making have positive effects on successful selection of a DWG approach. Decentralization, on the other hand, does not appear to play a dominant role in describing the selection of a DWG approach.

In the next chapter, a discussion and conclusion of this study are presented and future research directions are suggested.

CHAPTER 6

DISCUSSION AND CONCLUSION

In this chapter, the research contributions, which indicates that formalization and level of IT decision-making authority were found to significantly affect the differences in outcome of DW topology, are first described. In the second section, the limitations of the study are described. Lastly, directions for the future research are offered.

Contributions of the Research

The subject of the impact of organizational structure on IT effectiveness has been a topic of considerable interest by many researchers in MIS and organization theory. Research in this area has focused on whether IT affects an organization and its structure or an organizational structure affects the use of IT. A more meaningful approach that truly evaluates the usefulness of IT within an organization is needed. Especially in dramatically changing business environments, DW technology and its architecture are introduced and used to fulfill wide areas of business needs. The approach that provides meaningful DW implementation to support the organization's business goals and objectives will be the framework that relates DW technology with the organizational structure, and contexts effectively. This study tries to improve an explanation of the relationships among those structural variables by studying practicing data warehousing professionals.

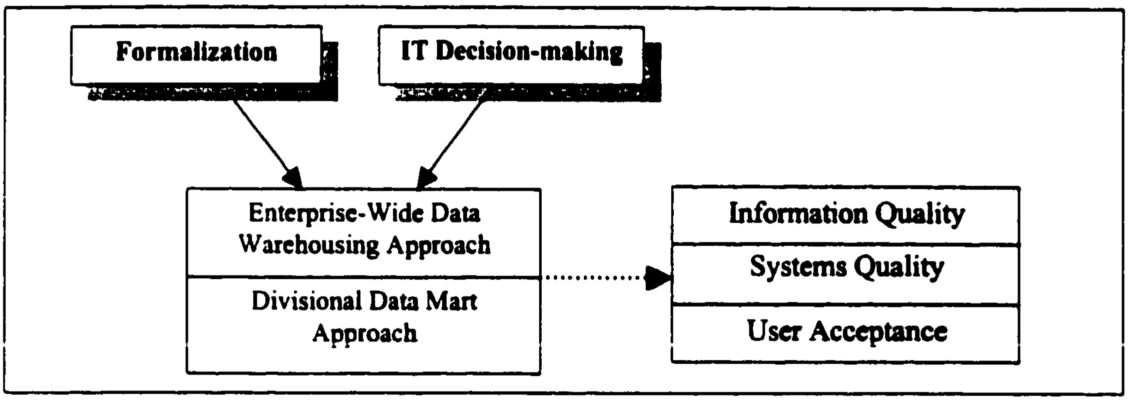

Figure 19: Proposed Model for Data Warehouse Architecture Decisions

As stated in Chapter 1, this dissertation had two objectives. The first objective was to determine whether a potential relationship exists between organizational structure and the choice of warehouse topology. Another objective was to utilize the research findings to develop organizational variables that can differentiate DW topologies. As shown in Figure 19, data analysis indicated that two structure variables could explain the outcome differences in DW topology. They indeed lend themselves to successful implementation of the data warehouse. Three organizations (A through C) with a higher degree of formalization demonstrated that they had implemented successful centralized DW architecture using an enterprise-wide DWG approach. In other words, these three organizations had developed an enterprise data model, collected enterprise-wide business requirements; they also decided to build centralized DWs for users across the organizations with subset data marts that can be populated to satisfy specific subject areas as needed.

On the other hand, two organizations (D and E) with lesser degrees of formalization chose to implement their data architecture with divisional DM approaches. This implies that business priorities prompted them to develop individual data marts because the nature of the subject determines the scope or the coverage of the information to be extracted into data marts. With less formalization, divisions or departments can develop their own data marts as inexpensive alternatives to enterprise-wide approaches, which take significantly less time and money to build.

In addition, evidence obtained from three organizations (A through C) suggests that, consistent with the predictions of hypothesis 3, highly centralized IT decision authority would reflect a dominating enterprise-wide DWG implementation approach. In the last three instances observed within the case sites (D through F), the dominating divisional data mart architecture resulted in a decentralized IT decision mode. The interviews made it clear that the mode of IT decision-making primarily influences the selection of DW architecture. Interviewees constantly stressed that since their organization was diversified into different businesses and across several countries, each operating division had to focus on the unique nature of its particular market. As a consequence, IT decision responsibility was being located deeply within operating divisions, so as to enable each business functional unit to shape its divisional data mart architecture for its market situation.

The organization consists of a relatively permanent structure exhibiting a hierarchy of authority, specialization, and some degree of formalization and centralization. Variations in organizational structure depend in part on the organization's goals and environment. The researcher intends to explain concepts of organizations and management as they relate to DW architecture design. This study was driven by a strong desire to provide empirical evidence that could form the basis for guidelines for the practitioner. In this study, evidence shows that enterprise-wide DW architecture as well as divisional data mart architecture can be effective. However, we cannot assume that every data architecture is an effective choice for every organization, especially from users' perspectives. Furthermore, the trade press continue to remind us that the choices of DW architecture must support the organization's goals and missions (Berson and Smith 1997). The predictive model in Figure 19 is a step toward sharing with the practitioner community our findings on "what support" in terms of the key variables for DW architecture decisions.

This study assimilates past research and current findings into a framework that can be used by researchers and managers. Future research should attempt to verify the revised framework by including more measures from organizational effectiveness and structure. Further, the researcher believes that there will be a great potential for additional research in identifying an even more comprehensive framework as DWG technologies continue to grow.

Limitations and Issues

Although the results obtained from this study are valid and are expected to provide a significant contribution to the areas of MIS and organization theory, caution must be used in interpreting the findings. Thus, results of this study must be considered in light of three limitations.

First, since the study participants, six selected organizations, were not randomly selected from the population of organizations that had implemented DWG technology, drawing inferences to that population is tenuous. As Pettigrew (1988) noted, while cases may be chosen randomly, random selection is neither necessary nor preferable. Given the limited number of cases that can usually be studied, it is suitable to select cases, which are likely to replicate or extend emergent theory. In this study, it was almost impossible to form an adequate sampling frame for a random sample without investigating the whole population. In addition, certain organizations with DWG technology refused to participate in this study. Within the DW development team and users participating in this study, there was self-selection by the DW project leader as to DW managers and business functional managers. Systematic biases in this "selection" of participants, therefore, cannot be ruled out. In light of the similarity of the DW development tasks throughout the population, however, one would not expect the research results to be significantly different if all organizations with DWG technology had participated in this study.

The second limitation concerns the study's sample size. This research shares a weakness common to other research at the work group level. The more reliable and generalizable variables should be used to measure a technology variable, specifically DWG technology. However, Hersen and Barlow (1976) suggest that when a multiple case design is implemented, a replication in results is more preferable than a sampling logic. In this study, it is evidence that replication is indeed occurred to all three cases (from each DWG approach) when similar results are obtained. The researcher also selected each organization carefully to support holistic design. Three organizations from each DWG approach group (enterprise-wide DWG approach and divisional data mart approach) served in a manner similar to multiple experiments.

The third limitation concerns our ability to generalize the research findings to organizations that implement DW technology in other industries. As described in Chapter 4, only six industries were selected. To what extent this study's findings would be significantly influenced by the inclusion of other industries must be explored in future research.

Future Research

Several suggestions for future research were presented in the discussion of the hypotheses results. The measures used here were designed for only six specific organizations. Measures with greater breadth will be desirable to increase the level of consistency. Future researchers will need to determine whether the relationships shown here hold true for other industries. In addition, multinational organizations should be considered to examine the relations, especially related to their global strategies. For example, an examination of the relationship between their global competitive strategies and the DWG implementation approaches (topologies) for multinational corporations (MNCs) should be considered. Global strategy, for example, can be conceptualized into two aspects: product-related strategy and market-related strategy.

As a broader set of industries are added to this study, different organizational variables should be considered to develop a causal link between variables. Research studies that consider DWG technology and organizational structure measures before and after DWG technology implementation in a number of organizations should indicate whether it is indeed the changes in DW architecture which is driving the change in structure..

Assuming that a wide body of significant research findings can be developed to indicate the best fit of DWG approach for a given organizational setting, one more major effort will be possible. By adding studies of organizational strategy to the variables studied in this work, it may be possible to develop an even more complete picture of how DW architecture design should be. Several researchers (Burns and Wholey 1993; Daft and Weick 1989; Egelhoff 1991; Smith, Dykman and Davis 1985) suggest that organizations are information-processing systems. Understanding the effects of the DWG technology as well as the use of DWG products may provide the insights and mechanisms needed to build and test a complete model of DW architecture. This model supports an organization's goals with maximum returns on its investment.

For over 40 years, researchers and writers from the academic environment and business have been interested in techno-structure models. Studies have been conducted at all levels of the organization and have used multiple definitions of technology. Just as information technology has changed over the years, so have some trends in the results of research comparing information technology and organizational structure, as illustrated in Table 49. This change in the trend of results again points to the need for a less specific, technology-independent method for evaluating information.

Table 49: Overview of IT and Organizational Structure Research

Author	**Year**	**Formalization**	**Decentralization of Authority**	**IT Decision-Making**
Smith et al.	1992	+	-	
Zefanne	1992	+	-	
Daft	1992		+	Decentralized
Huber	1990		-	
Ahituv	1989	N	+	Decentralized
Cash, et al.	1988		+	Decentralized
Storey	1987	+	+	
Carter	1984		N	
King	1983		+	Decentralized
Zmud	1982	+	+	
Ein-Dor and Segev	1982		+	Decentralized
Robey	1981		N	
Olson, and Chervany	1980	N	+	Decentralized

Prior research efforts have not resolved the controversies that are associated with techno-structure research. Especially for the last 20 years, the results of analyzing the impact of the introduction of IT on organizational structure have not fully revealed the relationship between IT and structure. Prior research, however, has provided a foundation on which additional research can be built. Nevertheless, several critical issues have been identified that will enhance future studies when the researchers ensure each issue is addressed in the study effort. These critical issues for future research may include: clear definitions of technology and organizational structure variables, precise measure of the technology-structure interactions, and identification of the level of organization.

The researcher would like to end this study by indicating that with the increasing trend toward a divisional DM approach, it is imperative that IS managers must evaluate the importance of the key organizational variables in designing effective DW architectures. The findings of this study emphasize the need to design DW architectures that are congruent in order to realize greater effectiveness. Formalization and level of IT decision-making authority were found to significantly affect the differences in outcome of DW topology. Specially, a higher degree of formalization and a highly centralized IT decision authority reflected a dominating enterprise-wide DWG implementation approach. Therefore, the congruent structures identified in this study provide IS managers with a benchmark against which they can compare the design of their own DW architectures.

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APPENDIX A.

RESULTS OF T-TEST: PAIRED TWO SAMPLE FOR MEANS ANALYSIS

T-Test: Paired Two Sample for Means for Formalization between Two DW Implementation Approaches

Enterprise-Wide DWG Approach	Divisional DM Approach
4.50	2.50
5.00	5.00
5.00	3.50
5.00	4.00
4.00	2.33
4.50	2.33
4.50	3.67
4.00	4.00
3.33	4.00
3.67	4.00
4.00	5.00
5.00	3.00

Analysis:

	Variable 1	*Variable 2*
Mean	4.38	3.61
Variance	0.33	0.85
Observations	12	12
Pearson Correlation	-0.0856	
Hypothesized Mean Difference	0	
Df	11	
t Stat	2.3475	
P(T<=t) one-tail	0.0193	
t Critical one-tail	1.7959	
P(T<=t) two-tail	**0.0387**	
t Critical two-tail	2.2010	

T-Test: Paired Two Sample for Means for Decentralization between Two DW Implementation Approaches

Enterprise-Wide DWG Approach	Divisional DM Approach
3.33	3.00
2.33	3.50
3.67	3.50
3.33	2.50
4.00	3.50
3.00	3.50
2.00	3.00
2.00	3.00
2.00	3.00
2.00	2.33
3.50	3.33
2.00	5.00
5.00	3.00
4.00	1.67
3.67	2.33
4.00	2.00
4.33	3.33
2.67	3.33

Analysis:

	Variable 1	*Variable 2*
Mean	3.16	3.05
Variance	0.90	0.54
Observations	18	18
Pearson Correlation	-0.2876	
Hypothesized Mean Difference	0	
Df	17	
t Stat	0.3493	
P(T<=t) one-tail	0.3656	
t Critical one-tail	1.7396	
P(T<=t) two-tail	**0.7311**	
t Critical two-tail	2.1098	

APPENDIX B.

A COPY OF COVER LETTER

Date

Company's Address

Dear *Data Warehouse Manger*:

I would like to thank you for giving us the opportunity to learn more about *Organization 's Name* data warehousing technology. Attached are the questions that we would like you and your data warehouse users to answer in order to share your experience with us. When participants have completed the survey, please send the questionnaires directly to us (with contact phone
number) for review. If further discussion is needed, we will contact each individual directly.

In general, this initial step is to obtain primary information regarding your data warehouse implementation and organizational structure. This requires two DW managers (yourself and another DW staff) to share data warehousing experience and three DW primary business functional mangers to evaluate the organizational contexts. The purpose of this survey is:

1. to determine whether a potential relationship exists between organizational structure and the ability to implement data warehouse (DW) topology;
2. to utilize the available research to develop organizational variables that can differentiate data warehouse topologies; and
3. to find out whether data warehouse topology is a significant factor affecting the implementation of data warehousing.

We hope that the findings of this study will provide us with a better understanding of the essential attributes leading to the success of a DW implementation. We will send the final finding to you free of charge. No attempt will be made to identify responses by any individual or company. If you have any questions, please feel free to contact me at 901/678-3259.

Thank you so much for your cooperation.

Sutee Sujitparapitaya

APPENDIX C.

A COPY OF QUESTIONNAIRE FOR DATA WAREHOUSING MANAGERS

Questionnaire

To be completed by a data warehousing manager

This survey is completely anonymous. No attempt will be made to identify responses by any individual. Your replies are an important part of my research. Please answer all questions as candidly and completely as possible. Thank you for your time.
Note: *Data Warehouse or Data Mart is abbreviated as DW/DM.*

Company/Organization: ____

Job Title: ______________________________ Year(s) in this position __________

Department: ____

Please answer the following question regarding the organizational context.

BG1. What is your current job function? ______________________________
____
____

BG2. What is the approximate no. of IT staff in your company? ______________.

BG3. What is the approximate no. of IT staff that maintain your DW/DM (production stage)? ________.

BG4. What is your department's annual IT budget for Data Management and DW/DM software and tools? *(select only one)*

[ ] Less than $100,000 [ ] $100,000 to $499,999 [ ] $500,000 to $999,999
[ ] $1 Million to $10 Million [ ] $10 Million or more

BG5. Are you aware of the DW/DM objectives for your business unit?
(Note: DW objectives are defined as statements of what is to be accomplished from your company's DW/DM, and act as guidelines for the direction in which DW/DM is to be developed)
If **NO**, why not
a. They have not been formulated
b. I was not involved in creating them.
c. I recently joined the unit.
d. I am not a member of the senior management team.
e. They have not been communicated to me.

If **YES**, please state the three most important your company's DW/DM objectives.
a. ______________________________
b. ______________________________
c. ______________________________

BG6. Are you aware of your company's current (1-2 year) business objectives?
(Note: Organizational objectives are specific performance targets, directing efforts toward what is to be accomplished through the organization's activities)
If **NO**, why not
a. They have not been formulated
b. I was not involved in creating them.
c. I recently joined the unit.
d. I am not a member of the senior management team.
e. They have not been communicated to me.

If **YES**, please state the three most important business objectives.
a. ______________________________
b. ______________________________
c. ______________________________

OS1. How many levels is the CIO (or the highest IS executive) below the top of the organizational hierarchy? *(select only one)*
[ ] One [ ] Two [ ] Three [ ] Four [ ] Five or more

OS2. How many persons report directly to the CIO (or the highest IS executive)? ______________

Please answer the following question regarding <u>the DW/DM</u> in your company.

DW1. Which of the following ***best describes*** your company's DW/DMs? *(select only <u>one</u>)*

[ ] *Enterprise-wide data warehousing:* Data is extracted from transactional (production) systems into a centralized data warehouse, and then business units may extract data into their departmental data marts as needed. (Transactional Systems → Enterprise-wide Data Warehouse → Data Marts).
Additional information: ____________________

____

____

[ ] *Incremental data mart:* Data is extracted directly from transactional systems into incremental data marts (Transactional Systems → Data Marts).
Additional information: ____________________

____

____

DW2. How ***successful*** have DW/DM development projects been from a technical perspective? *(select only <u>one</u>)*

[ ] Highly successful
[ ] Successful but can be improved
[ ] Moderately successful
[ ] Marginally successful
[ ] Unsuccessful

DW3. What ***systems development techniques*** have you used in your DW/DM project? *(select only <u>one</u>)*

[ ] Modern structured analysis (focuses on processes)
[ ] Information engineering (focuses on data and strategic planning)
[ ] Prototyping (focuses on a small-scale prototyping solution)
[ ] Joint application development (focuses on a facilitating group meeting with both technicians and users)
[ ] Other (please specify) ____________________

____

DW4. From your experience, what are the ***benefits*** that have resulted from having a DW/DM?

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________

DW5. From your experience, what are the ***problems*** that you have encountered in DW/DM projects?

a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________

Rating Scale Questions

*Please use the **5-point scale** provided, to rate their level of applicability in your work environment.*

1	2	3	4	5	DK
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree	Do not know or No Experience

Systems Quality

Systems Reliability (Dependability and consistency of access and uptime of systems)

____ SQ1. Users can count on DW/DM to be "up" and available when they need.

____ SQ2. DW/DM is subject to dependability and consistency of access.

Flexibility (Ability to adjust to changes)

____ SQ3. DW/DM can flexibly adjust to new demands or condition.

____ SQ4. DW/DM is versatile in addressing data needs as they arise.

Integration (Ability to integrate systems and data from different data sources across organization as needed)

____ SQ5. DW/DM effectively integrates data from a variety of data sources within organization.

____ SQ6. Existing technology was accessed before DW/DM implementation.

Authorization (obtaining authority to access data necessary to do the job)

____ SQ7. Getting authorization to access data that would be useful to users is easy.

____ SQ8. Users have the right authority to access data that would be useful in their job.

Information Quality

Timeliness (Information that users use and would like to use is current enough to meet their needs)

____ IQ1. Data from DW/DM is current enough to meet users' needs.

____ IQ2. Users have more up-to-date information now from DW than they had from transactional systems.

Accuracy (Information that is correct, reliable, and certified free of error)

____ IQ3. Data from DW/DM is more correct than that from transactional systems.

____ IQ4. Users have more accurate data now from DW than they had from transactional systems.

Meaning (Ease of determining what information on a report or file means)

____ IQ5. The exact definition of data from DW/DM is easier to find than that from transactional systems (well-formatted, well-presented, well-organized).

____ IQ6. Users can easily interpret and understand data from DW/DM.

Consistency (Information can be compared and consolidated without inconsistencies)

____ IQ7. Data from DW/DM is more consistent to users than one from transactional systems.

____ IQ8. Users have more consistency of data now from DW/DM than they had from transactional systems.

User Acceptance

Perceived Usefulness (Users believe that using DW/DM would enhance their job-related performance)

____ UA1. DW/DM addresses users' job-related needs better than when only transactional systems were available.

____ UA2. Users find DW/DM useful in their job.

Perceived Ease-of-Use (Users believe that using DW/DM would be free of effort)

____ UA3. Users find that it is easy to get DW/DM to do what they want to do.

____ UA4. Users find DW/DM easy to use.

Checklist Questions

EI1. Please indicate the types of applications by activities that are supported by your company's DW/DM. *(Select **all** that apply)*

	Reporting[a]	Managed[b] Query	EIS[c]	OLAP[d]	Data[e] Mining	Other[f]; please specify ______
Accounting and financial management	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Management information systems	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Production planning and quality control	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Public relations and advertising	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Sales and marketing	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Purchasing and materials management	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Hiring and managing human resources	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Education and training	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Marketing research	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Note:

(a) *Reporting Tools allow users to generate production as well as management reports (Example: COBOL, Information Builders, Inc.'s FOCUS, Seagate Software's Crystal report).*

(b) *Managed Query Tools provide users with a metalayer to reduce the complexities of SQL and database structure. (Example: IQ Software's IQ Objects, Andyne Computing Ltd.'s GQL, IBM's Decision Server, Speedware Corp.'s Esperant, and Oracle Corp.'s Discoverer/2000).*

(c) *Executive Information Systems allow users to build customized, graphical decision support applications that give managers and executives a high-level view of the business. (Example: Pilot Software, Inc.'s Lightship, Platinum Technology's Forest and Trees, Comshare, Inc.'s SAS/EIS).*

(d) *OLAP tools allow users to navigate through the hierarchies and dimensions in an intuitive way to view corporate data. (Example: Arbor Software Corp.'s Essbase and Oracle's Express, MicroStrategy, Inc. DSS Agent, Information Advantage, Inc.'s DecisionSuite, Cognos' PowerPlay, Brio Technology, Inc.'s BrioQuery).*

(e) *Data mining provides insights into corporate data using a variety of statistical and artificial-intelligence (AI) algorithms to analyze the correlation of variables in the data. (Example. Data Mind Corp.'s DataMind, Pilot's Discovery Server, SAS).*

Fill in the Blank Questions

EI2. Please indicate the number of users who are currently accessing data (either from directly accessed DW/DM or from DW access tools): __________ users

EI3. How many applications in total does your company's DW/DM support? *(Example: 4 for DSS, 2 for EIS, and 3 for data mining would equal to 7)*

____

OA2. Please indicate the factors that you believe contribute to the success of your company's DW/DM implementation? *(List **all** applicable factors)*

____
____
____
____
____
____
____
____
____

APPENDIX D.

A COPY OF QUESTIONNAIRE FOR BUSINESS FUNCTIONAL MANAGERS

Questionnaire

To be completed by:

a) a manager of end user computing or

b) a person responsible for an application that uses data from data warehouse or data mart

This survey is completely anonymous. No attempt will be made to identify responses by any individual. Your replies are an important part of my research. Please answer all questions as candidly and completely as possible. Thank you for your time.
Note: *Data Warehouse or Data Mart is abbreviated as DW/DM.*

Company/Organization: ____

Job Title: ________________________________ Year(s) in this position ___________

Department: ____

Please answer the following question regarding <u>organizational context</u>.

BG7. What is your current job function? ____

____

____

BG8. What is the approximate number of employees in your company? *(select only <u>one</u>)*
[ ] Less than 250 [ ] 250 to 499 [ ] 500 to 999 [ ] 1000 to 4999 [ ] 5000 or more

BG9. Are you aware of your company's current (1-2 year) business objectives?
(<u>Note</u>: Organizational objectives are specific performance targets, directing efforts toward what is to be accomplished through the organization's activities)
If **NO**, why not
a. They have not been formulated
b. I was not involved in creating them.
c. I recently joined the unit.
d. I am not a member of the senior management team.
e. They have not been communicated to me.

If **YES**, please state the three most important business objectives.
a. ____
b. ____
c. ____

BG10. Are you aware of the DW/DM objectives for your business unit?
(<u>Note</u>: DW objectives are defined as statements of what is to be accomplished from your company's DW/DM, and act as guidelines for the direction in which DW/DM is to be developed)
If **NO**, why not
a. They have not been formulated
b. I was not involved in creating them.
c. I recently joined the unit.
d. I am not a member of the senior management team.
e. They have not been communicated to me.

If **YES**, please state the three most important your company's DW/DM objectives.
a. ____
b. ____
c. ____

OS3. What is your current <u>organizational structure</u>? *(select only <u>one</u>)*
[ ] Simple Structure (shallow hierarchy, simple supervisor)
[ ] Functional Structure (deeper hierarchy, organized around occupational skills)
[ ] Divisional Structure (deeper hierarchy, self-contained product groups)
[ ] Matrix Structure (dual focus on product and/or function)
[ ] Network Structure (basic functions coordinated on a contract basis)

OS4. How many levels is the head of your functional area below the top of the organizational hierarchy? *(select only <u>one</u>)*
[ ] One [ ] Two [ ] Three [ ] Four [ ] Five or more

OS5. How many persons report directly to the head of your functional area? ____________________

Rating Scale Questions

OS6. How frequently does your organization use written fixed rules and business policies? *(select only __one__)*

1	2	3	4	5	DK
Very Seldom	Seldom	Moderate	Frequently	Very Frequently	Do not know or No Experience

OS7. What level of your organization typically has the authority to make decisions? *(select only __one__)*

1	2	3	4	5	DK
Top Management (Centralized)	Between Top and Middle Management	Middle Management	Between Middle and Lower Management	Lower Management (Decentralized)	Do not know or No Experience

OS8. How are tasks subdivided in your organization? *(select only __one__)*

1	2	3	4	5	DK
Highly Vertical (No Task Subdivision)	Between Highly Vertical and Moderate	Moderate	Between Moderate and Highly Horizontal	Highly Horizontal (Highly Subdivided)	Do not know or No Experience

OS9. How many employees in your organization receive written business policies and procedures? *(select only __one__)*

1	2	3	4	5	DK
None	Very Few Employees	Some Employees	Many Employees	All Employees	Do not know or No Experience

OS10. How many employees in your organization receive written job descriptions? *(select only __one__)*

1	2	3	4	5	DK
None	Very Few Employees	Some Employees	Many Employees	All Employees	Do not know or No Experience

OS11. Who receives the organizational chart? *(select only __one__)*

1	2	3	4	5	DK
Very Top Executives	Top Two Levels of Executives	Top Two Levels and most Division or Department Heads	All Supervisors and Project Managers	All Levels of Management	Do not know or No Experience

OS12. Which level in your organization typically has the authority for making decisions concerning __employee promotions__? *(select only __one__)*

1	2	3	4	5	DK
Very Top Executives	Division or Functional Managers	Department Heads	First-Level Managers/ Supervisors	Employees Themselves	Do not know or No Experience

OS13. Which level in your organization typically has the major authority for making decisions concerning __number of employees assigned to a project__? *(select only __one__)*

1	2	3	4	5	DK
Very Top Executives	Division or Functional Managers	Department Heads	First-Level Managers/ Supervisors	Employees Themselves	Do not know or No Experience

OS14. Which level in your organization typically has the authority for making decisions concerning hiring a full-time professional employee? *(select only **one**)*

1	2	3	4	5	DK
Very Top Executives	Division or Functional Managers	Department Heads	First-Level Managers/ Supervisors	Employees Themselves	Do not know or No Experience

OS15. Which level in your organization typically has the authority for making decisions concerning delivery dates and priority of orders? *(select only **one**)*

1	2	3	4	5	DK
Very Top Executives	Division or Functional Managers	Department Heads	First-Level Managers/ Supervisors	Employees Themselves	Do not know or No Experience

OS16. Which level in your organization typically has the authority for making decisions concerning work methods to be used?*(select only **one**)*

1	2	3	4	5	DK
Very Top Executives	Division or Functional Managers	Department Heads	First-Level Managers/ Supervisors	Employees Themselves	Do not know or No Experience

OS17. How many persons typically report to first-line supervisors (e.g. first-level managers)? *(select only **one**)*

1	2	3	4	5	DK
1-5	6-10	11-20	21-30	More than 30	Do not know or No Experience

Please answer the following question regarding <u>the DW/DM</u> in your company.

Rating Scale Questions

OS18. *Please use the **5-point scale** provided, to rate their level of applicability in your company's DW/DM.*

1	2	3	4	5	DK
Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree	Do not know or No Experience

Systems Quality

Systems Reliability (Dependability and consistency of access and uptime of systems)

____ SQ9. You can count on DW/DM to be "up" and available when you need.

____ SQ10. DW/DM is subject to dependability and consistency of access.

Flexibility (Ability to adjust to changes)

____ SQ11. DW/DM can flexibly adjust to new demands or conditions.

____ SQ12. DW/DM is versatile in addressing data needs as they arise.

Integration (Ability to integrate systems and data from different data sources across organization as needed)

____ SQ13. DW/DM effectively integrates data from a variety of data sources within organization.

____ SQ14. Existing technology was accessed before DW/DM implementation.

Authorization (obtaining authority to access data necessary to do the job)

____ SQ15. Getting authorization to access data that would be useful to you is easy.

____ SQ16. You have the right authority to access data that would be useful in your job.

Information Quality

Timeliness (Information that you use and would like to use is current enough to meet your needs)

____ IQ9. Data from DW/DM is current enough to meet your needs.

____ IQ10. You have more up-to-date information now from DW/DM than you had from transactional systems.

Accuracy (Information that is correct, reliable, and certified free of error)

____ IQ11. Data from DW/DM is more correct than that from transactional systems.

____ IQ12. You have more accurate data now from DW than you had from transactional systems.

Meaning (Ease of determining what information on a report or file means)

____ IQ13. The exact definition of data from DW/DM is easier to find than that from transactional systems (well-organized, well-formatted, well-presented).

____ IQ14. You can easily interpret and understand data from DW/DM.

Consistency (Information can be compared and consolidated without inconsistencies)

____ IQ15. Data from DW/DM is more consistent than that from transactional systems.

____ IQ16. You have more consistency of data now from DW/DM than you had from transactional systems.

User Acceptance

Perceived Usefulness (You believe that using DW/DM would enhance your job-related performance)

____ UA5. DW/DM addresses your job-related needs better than when only transactional systems were available.

____ UA6. You find DW/DM useful in your job.

Perceived Ease-of-Use (You believe that using DW/DM would be free of effort)

____ UA7. You find that it is easy to get DW/DM to do what you want to do.

____ UA8. You find DW/DM easy to use.

Fill in the Blank Questions

DW6. How ***successful*** have DW/DM development projects been from a user perspective? *(select only __one__)*
[ ] Highly successful
[ ] Successful but can be improved
[ ] Moderately successful
[ ] Marginally successful
[ ] Unsuccessful

DW7. From your experience, what are the ***benefits*** that have resulted from having a DW/DM?
a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________

DW8. From your experience, what are the ***problems*** that you have encountered in DW/DM projects?
a. ____________________
b. ____________________
c. ____________________
d. ____________________
e. ____________________
f. ____________________
g. ____________________

OA2. Please indicate the factors that you believe contribute to the success of your company's DW/DM implementation? *(List __all__ applicable factors)*

APPENDIX E.

A COPY OF FOLLOW-UP QUESTIONS

Follow-up Questions
(Data Warehousing Manager or Business Functional Manager)

Company/Organization: ______________________________
Name: ______________________________
Telephone: ______________________________

Question 1: IT Governance
If Corporate IS played a primary or unilateral role in a particular decision, and that divisional IS and line management had a minor or no role in that decision, then corporate IS is identified as centralization.

a) Long-term hardware decisions about mainframes, microcomputers, and networks, including capacity, specific vendors, brands, technologies – (new and upgrade)

b) Long-term microcomputer decisions, including capacity, specific vendors, brands, technologies – (new and upgrade)

c) A long-term application decisions, including user tools, reporting tools. (new and upgrade)

d) Project management decisions

Question 2: Please describes your company's data warehouse architecture.

Question 3: Please describes your company's organizational structure.

Question 4: Please describes your company's business driven (things that are strategically important in achieving Business Goals) and DW driven (things that DW offers to help organization achieve Business Goals).

Question 5: What does quality mean for your DW efforts?