Winter 12-10-2002

A Bi-Directional Approach for Developing Data Warehouses in Public Sectors

Monica Lam

Russell K.H. Ching

A Bi-Directional Approach for Developing Data Warehouses in Public Sectors

Monica Lam lamsm@csus.edu
Russell Ching chingr@csus.edu
Management Information Science Department
California State University, Sacramento
6000 J Street, Sacramento, CA 95819-6088, USA

Abstract

Data warehouse is proclaimed as the latest decision support technology. As data warehouses require a significant amount of organizational resources to develop, more research have been devoted to identifying the critical success factors and the formulas for assured investment return from data warehouses. This study proposes a bi-directional development approach for data warehouses in public sectors. The primary rationale for the proposed approach is the fundamentally different organizational goals of public sector organizations from private sector organizations. Whereas the ultimate goal of private sector organizations is profit making, public sector organizations have a set of conflicting goals including different social and political objectives. The star schema as a dimensional data model for data warehouse is not totally suitable for data warehouses that demand the analyses of both quantitative and qualitative measures. Using the data warehouse in the College of Business Administration at the California State University, Sacramento as a case study, we illustrate how the QQ (Quantitative and Qualitative) data schema accommodates the need of capturing both quantitative and qualitative information. In addition, we show the bi-directional top-down/bottom-up initiative, the formal/informal information collection, and the enterprise data warehouse/subject data mart architecture for the data warehouse.

1. Introduction

Inmon [13] defined data warehouse as a subject oriented, integrated, non-volatile, and time variant collection of data for decision support. In the past decade, we have seen the concept and technology of data warehousing evolving from a visionary idea to the mainstream of decision support in corporate culture. It was estimated that the investment in data warehousing will grow from US$8.8 billion in 1996 to US$113.5 billion in 2002 [30]. About 85-90% of the Fortune 500 companies have either adopted or plan to adopt data warehouses [25]. The International Data Corporation (1996) reported an average return on investment of 401% in 62 data warehouses, with an average 1.7-year payback period. On the other hand, the failure rate of data warehouses is also very high. While the exact figures are not available, the initial failure rate of data warehouse is estimated to be one-half to two-thirds [31][30]. Following the development path of introduction, proliferation (or growth), control, and maturity, data warehousing is currently in the stage of proliferation. The accumulation of success and failure experience is generating a wealth of guidance on the application of data warehousing in organizations.

The public sectors are usually slow in adopting new information technology because of their complex organizational structure and project approval process. The past diffusion of information technology follows the path from private sectors to public sectors. In terms of supporting semi-structured or unstructured decision making, the public sectors are as needy as, if not more than, the private sectors. We have seen the application of decision support systems in the areas of resource allocation [15][19][26], admission policies [8], scheduling [9], hazardous waste management [24], and auditing [30], Data warehousing, the latest development of decision support tools, has been gradually adopted as a problem solver for strategic issues in public sectors. Given the fundamental differences in organizational goals and structure between public and private sectors, the development of data warehouses in public sectors may require different methodologies, tools, and skills. This study attempts to identify the suitable methodology in the planning and design phase of data warehouse in public sectors. The rest of the paper is organized into the following five sections. Section 2 provides a literature review on the data warehousing for the past few years. Section 3 identifies some organizational characteristics in private and public sectors. Section 4 presents the bi-directional approach for developing data warehouses in public sectors. Section 5 illustrates the bi-directional approach using a business school case study. The last section concludes the paper by suggesting some future research directions.

2. Data Warehousing in the Literature

Among the seventeen data warehousing research studies we identified from the literature in the past few years, seven are explorative case studies [23][7][21][[1][18][25], three are survey studies [6][31][28], three are theoretical analysis without empirical data [20][2][29], two are data warehousing for auditing purposes [11][22], and two are Web-based data warehouses [5][12]. The distribution of our reviewed articles indicates case study as a popular research method in this proliferation stage of data warehouse development. Researchers are observing the development of different data warehouses in different organizations, collecting data about the success and failure factors, accumulating

experience about the planning imperative, design methods, implementation tactics, and operational procedures for data warehouses. We will see the accumulation of case knowledge leading to the development of consolidated theories for the control stage of data warehousing in the coming decade. This section will review some of the recent findings about data warehousing in the literature.

For case studies, Sammon & Finnegan [23] investigated the data warehousing practice of four corporate users. Using semi-structured interviews and document analysis, they identified ten critical success factors for data warehousing. The ten factors are business-driven initiative, executive sponsorship and commitment, funding commitment based on realistically managed expectations, project team with access to cross-functional project management and implementation experience, attention to source data quality, flexible enterprise data model, effective data stewardship, long-term plan for automated data extraction methods and tools, knowledge of data warehouse compatibility with existing systems, and hardware/software poof of concept. Cooper et. al [7] described how the data warehouse technology transformed the First American Corporation from a traditional banking to a customer centric system. The VISION data warehouse at First American Corporation was designed to provide data and analysis to allow the management to know the client better, provide what the client needs, help the client achieve goals, and offer the client preferred channels. First American Corporation managed to re-align the organizational structure with new information technology infrastructure and strategy, which is proved to be a critical factor in enabling the organization to reap benefits from the data warehouse.

Quaddus & Intrapairot [21] reported the end-user adoption and usage process of data warehouse in the Siam Commercial Bank, a major commercial bank in Thailand. They found that the policies of "increase level of training" and "decrease training delay" can significantly accelerate the diffusion of data warehouse usage. Ang & Teo [1] investigated the data warehouse developed for the Housing and Development Board in Singapore. This is the only case study in public sectors among the seven case studies. The management issues of concern in this case study include identifying the development process, choosing development options, adopting incremental change approach, overcoming resistance, choosing project leader, providing formal and systematic training, and scalability and maintenance. This case study did not focus on developmental differences between private and public sector data warehouses. Marks and Frolick [18] presented the development process of a data warehouse in a home service company. The most important lessons learned from the case study are clear mission, effective business analysis, and top management support. Watson et. al [30] had the question of why some organizations realized more benefits from data warehouses than others. They traced the development of data warehouses in a large manufacturing company, the Internal Revenue Services, and a financial services company. Their findings show that a successful data warehousing process constitutes the steps of articulating a vision, communicating the vision throughout the organization, and institutionalizing the changes required by the vision. Shin [25] studied the project management issues of a data warehouse project in one of the biggest insurance companies in the US. The study identified the following essential practices for the successful data warehouse project management: (1) process involvement by business units and prospective end-users; (2) manageable project scope; (3) packaged tools for data staging; (4) marketing the new system throughout the project to business customers and target users; and (5) metadata-centric system design and implementation based on conformed dimensions and facts.

For survey studies, Chen et. al [6] developed a questionnaire to investigate the concept of user satisfaction with data warehouses. They identified data accuracy, format, and precision; support provided to end-users; and fulfillment of end-users needs as the three major factors for data warehouse satisfaction. The advice is to provide training and support to end-users, in order for end-users to understand the meaning of data in the data warehouse. Wixom and Watson [31] were interested in the role of implementation in data warehouse success. Their study was a cross-sectional survey from 111 organizations using paired mail questionnaires on implementation factors and success of warehouses. They found that the link between implementation and warehouse success is weak. However, there are significant correlations between data quality and perceived net benefits, and between system quality and perceived net benefits. Watson et al. [28] carried out a survey to explore the topics of sponsorship, architecture, use, costs, and benefits in data warehouse. The 47 usable responses indicate that about 40% of data warehouses were sponsored by vice-president of a business unit, 36% were used in marketing and sales, 32% were of data warehouse only architecture; 58% of the surveyed organizations had an average number of 18.5 users in the information system units, 52% had an average number of 150.5 users in the marketing and sales unit, 41% had an average number of 48.4 users in the finance units, 43% used a prototype approach to develop data warehouses; and 66% of the end-users believed that the data warehouses met their objectives.

Another research direction in data warehouse is to develop theoretical models to describe, explain, and predict the generic phenomenon of data warehousing. Murtaza [20] presented a framework for developing enterprise data warehouses. The framework consists of the stages of business requirements, data sourcing, target architecture, access tool selection, and administration. Ballou & Tayi [2] constructed an integer programming

model to maximize the total value from all projects for improving the data quality in data warehouse environments. The model considers the factors of current data quality, required data quality, anticipated data quality, priority of organization activity, cost of data quality enhancement, and the utility of value added from data improvement projects. Watson et. al [29] described the benchmark variables including data, architecture, stability of the production environment, warehouse staff, users, impact on users' skills and jobs, applications, costs and benefits, and organizational impact for the stages of initiation, growth, and maturity in data warehousing. There are other specific research topics such as incorporating the Web elements into data warehousing [5][12] and the role of data warehouses in auditing [11][22].

The above review of the data warehouse literature in the past few years shows that only a few studies [1][11] have investigated the role of data warehouses in public sectors. It is the purpose of this study to develop an appropriate development approach for data warehouses in public sectors.

3. Organizational Characteristics in Private and Public Sectors

Table 1 summarizes the relevant organizational characteristics for data warehouse development in private and public sectors. One important difference is the organizational goals. Private sector organizations have the ultimate goal of making profit, which can be translated into increasing the share values of investors. On the other hand, public sector organizations (such as federal and state agencies, public educational institutes, and charity organizations) are non profit making, and have multiple social and political objectives. In other words, private sector organizations' goals can be readily quantified whereas public sector organizations' goals have to be measured both qualitatively and quantitatively.

Another difference is the organizational structure. Private sector organizations tend to have clear lines of authorities and responsibilities. Since the goal of profit-making is quantifiable, it is easier to pinpoint the problematic areas when the organizations cannot meet the goals. The numbers speak for themselves showing whether the sales departments do not make enough revenue, the production departments over-spend on raw materials, or the marketing departments do not reach enough potential buyers. If the current structure is not contributive to profit making, private sector organizations are more willing to change the structure. Since structural change is permissible, it is less likely for private sector organizations to rely on informal structure to work around problems. On the other hand, since public sector organizations have to achieve multiple or conflicting objectives, the structure is designed to have a check and balance effect. The lines of authorities and responsibilities are more likely to be overlapping and vaguely defined. The obscure lines of responsibilities make it difficult to trace the contributions of different organizational units to the organizational goals, which further make it difficult to justify any structural changes for improving organizational effectiveness. As it is difficult to have structural change, ineffectiveness and inefficiencies may be ignored or solved by informal working structure.

As for management style, any styles that can promote profit making will usually be encouraged in private sector organizations. Public sector organizations tend to have management styles that balance different social and political objectives. People who achieve managerial or leadership positions in public sector organizations have very good diplomatic skills but they are reluctant to give commitment and be change agents. As for the working personnel, private sector organizations motivate employees by relatively well-defined monetary reward systems. Private sector employees know very well what they have to do in order to be rewarded. In public sector organizations, personnel are more likely to work by the books in order to avoid being blamed. The reward systems are usually determined by and distributed over different authorities such as the labor union and a multi-level set of ruling units. Public sector employees are in a worse position than their private sector counterpart to control their career destinies. As for change management, since private sector organizations have more competitors, they tend to have more environmental sensors to detect threats and opportunities. They tend to have more formalized systems to respond to crises and carry out required changes. Private sector organizations, on the other hand, usually avoid changes unless they are mandated by top management or their survivals are threatened. In summary, public sectors organizations have quantitative and qualitative objectives, overlapping and vague lines of responsibilities and authorities, top management focusing on balancing, working personnel focusing on maintenance, and intrinsic persistence on status quo. These relative characteristics affect the application process of data warehousing technology. The next section discusses a bi-directional approach for developing data warehouses in public sectors.

4. A Bi-Directional Development Approach for Data Warehouses in Public Sectors

The literature suggests different system development life cycles for data warehouses [17][16][10][4][27][3], and most include the stages of initiation, information requirement, architecture design, data sources, data modeling, end-user interface, implementation, testing, training, and maintenance. Each step has its own methodology, tools, and skills. The bi-directional development approach for data warehouse proposed in this study focuses on the stages of initiative, information requirement, architecture design, and data modeling. Figure 1 summarizes the suggestions of the bi-directional

approach for data warehouse development in public sectors.

For the initiative stage, the bi-directional approach suggests the simultaneous top-down and bottom-up for planning and justification of data warehouses. The hybrid approach can reduce the strong opposition to changes in public sector organizations. The bottom-up direction may be triggered by end-users' dissatisfaction with the current level of information quality and information processing procedure. The top-down direction may be stimulated by external forces that threaten the survival, legitimacy, or status of the organization. The congruency of the two directions provides a fertile ground for data warehouse success. If the data warehouse initiative is mandated by top management without support by end-users, the data warehouse adoption process will be difficult to diffuse. To the extreme, the end-users may sabotage the data warehouse. A data warehouse proposed solely by end-users may not be able to get the multi-level top management's attention in highly bureaucratic public sectors.

For the information requirement stage, the bi-directional approach suggests both the formal and informal channels for requirement identification. As public sector organizations have informal structure performing significant tasks, it is important to collect information requirements from informal channels. Formal channels include interviews, on-site observations, analyses of reports, tables, manuals, and other published strategic papers. Informal channels are unrecorded complaints, grievances, hidden agendas, personal contacts, gossips, and casual discussions.

For the stage of architecture design, the bi-directional approach recommends a combined architecture of enterprise data warehouse and data mart. A pure enterprise data warehouse approach develops one and only one comprehensive data warehouse to support all decision activities in all departments for the organization. A pure data mart approach develops many independent and small data warehouses supporting different organizational units or decision subjects. Given the multiple and conflicting objectives in public sector organizations, the pure data mart approach will not be able to give an overall view of the organizational truth to leaders performing balancing acts. On the other hand, the pure enterprise data warehouse will be too time consuming and complicated to build. The combined approach will first generate a high-level blueprint for the enterprise level data warehouse, then set the priorities for different data marts, and build the most visible, least risky, and most valuable data mart as a proof of concept project. This bi-directional approach has the effect of building the data warehouse incrementally without losing sight of how the data mart pieces will fit together as a seamless entity.

For the stage of data modeling, the bi-directional approach proposes a new data modeling technique QQ schema (first Q for quantitative and second Q for qualitative), capturing both quantitative and qualitative bottom line measures for public sector organizations. The star schema as a dimensional data model for data warehouses [17] is designed to store quantitative data such as sales figures, costs, and budget variances in the center fact table surrounding by multiple dimension tables. Any qualitative data have to be stored in dimension tables, which are used as headers and sub-headers in multidimensional analyses and reports. Once data are stored in dimension tables, they cannot be sliced and diced as in the fact table because dimension tables are usually not inter-related. Given that public sector organizations are not purely figure-driven, it is important to have both qualitative and quantitative measures in the tables that support strategic and tactical analyses. The next section will illustrate the bi-directional development approach using a case study for a business school data warehouse.

5. A Case Study Illustrating the Bi-Directional Development Approach for Data Warehouse

This section describes the data warehousing experience at the College of Business Administration (CBA), California State University at Sacramento (CSUS) in the United States. The data warehouse project started in the Fall of 2001 and is on-going. The CBA at CSUS has about 130 full-time and part-time faculty members, 4000 undergraduate students, and 380 graduate students in Fall 2001. The CBA has four academic departments including Accountancy, Management, Management Information Science, and Organizational Behavior and Environment.

5.1 Top-down and bottom-up initiative for data warehouse

The CBA at CSUS received her re-accreditation from AACSB International (The Association to Advance Collegiate Schools of Business, formerly American Assembly of Collegiate Schools of Business) a few years ago. Amongst the turmoil of leadership transitions from 1995 to 1997, the CBA managed to collect her efforts, engage her faculty members, address issues of AACSB concerns, and finally earned the re-accreditation. The re-accreditation process has taught the administration and faculty members who were involved in the process a lesson of the critical role of information under the new AACSB accreditation guidelines.

Under the California State University System, faculty members have to submit activity reports for the purposes of salary merit increase, tenure and promotion, and post-tenure review. The re-accreditation process also required faculty members to fill in questionnaires for

satisfaction and curriculum surveys, as well as submit faculty data sheets listing their intellectual contributions and professional activities. In total, a faculty member can be requested to submit up to 5 different reports in one year. Many reports have overlapping data that can be consolidated. Faculty members expressed their frustration over filling in multiple reports for the same information. The administration also felt the painful process of collecting data from different sources to satisfy different information requests from the AACSB and other external bodies. In Spring 2001, the Academic Office of the University announced funding availability that was earmarked for strategic information technology and requested proposal for the funding. One proposal for a data warehouse project was submitted from the Management Information Science Department. The Dean of the CBA gladly and enthusiastically approved the data warehouse proposal. The initiative process of the CBA data warehouse is bi-directional, supported by end-users and endorsed by top management.

5.2 Formal and informal information requirements

The CBA Dean and the principal investigator of the data warehouse project compiled a list of interviewees for identifying information requirements. The interviewee list included all department heads, all CBA institute directors, the chairperson of Academic Council, the directors of undergraduate and graduate programs offices, and other key decision makers in the College. The question list consisted of the following items:

i. What tasks in your job involve decision making? What tasks do you need to perform in order to support your immediate supervisor's decision making activities?

ii. Which tasks you identified in question 1 have very important effect on your overall job performance?

iii. Do you feel that you have or can obtain enough, timely, and relevant information to carry out the tasks you identified in question 1?

iv. If your answer to question 3 is no, what other information do you need?

v. If your answer to question 3 is no, how would you like to improve the information acquisition methods?

vi. Do you feel that you have enough analysis methods to carry out the tasks you identified in question 1?

vii. If your answer to question 6 is no, what other analysis methods do you need?

viii. Do you feel that the current decision making process for the tasks in question 1 is efficient and effective?

ix. If your answer to question 8 is no, how would like to improve the decision making process?

The information collection process took about three months. There are two factors that facilitated the information collection process. First, being a faculty member and involved in the re-accreditation process, the principal investigator has first-hand knowledge about the information needs of the college. Second, the principal investigator's peer status to the interviewees certainly enhances the trust and open communication during the information collection process. In many occasions, after going through all the formal questions, informal discussions added a lot of insightful requirements to the data warehouse. For example, one department head supported the data warehouse wholeheartedly because it can level the information grounds for all decision makers. That department head had the concern of being unable to access data directly and carry out analyses. Since data can be manipulated and presented in a certain way to support a certain proposition, having access to the same data allows other decision makers to verify the analyses or to present alternative analysis results. The same organizational truth from a data warehouse can streamline the data collection process and avoid locally optimized decisions. The above concern makes it important to allow decision makers to build their customized reports, in addition to pre-defined system reports for general purposes. The information collection process for the CBA data warehouse has been benefited from both the formal and informal channels.

5.3 Data warehouse and data mart architecture

The information collection process identified three major subjects for data warehouses, namely, faculty, students, and alumni. For each subject, there are various decision making activities to support. The subject faculty was determined to have the highest priority for implementation. The development strategy is to launch one data mart with high visibility and return as soon as possible, in order to generate confidence from end-users and top management. However, the conceptual blueprint for the enterprise data warehouse will be finished before the first data mart implementation. This is to ensure that the design of each data mart can be consolidated together into the enterprise data warehouse. Individual data marts need to have the suitable conformed dimensions serving as the overlapping tables across different fact tables. Though conformed dimensions can be added later, it will be less disruptive to the warehouse operations if they are built-in rather than added-back. The concurrent design for data warehouse and data marts can produce faster result but not at the expense of losing the overall data warehouse requirements.

5.4 Quantitative and qualitative (QQ) data schema

Figure 2 presents a partial QQ data schema for the faculty subject data mart for the CBA data warehouse.

The center of the data schema has two fact tables, one for numbers and the other for text, which are essential information to keep track of for faculty. Surrounding the fact tables are dimension tables including faculty, publication/professional organization, and time. The attribute *CategoryID* representing the classification of each record i.e., instructional development, applied scholarship, basic scholarship, or consulting activities in the Qualitative Fact Table. The relationship cardinality between the two fact tables is (0,*) and (1,*) meaning that one record from the qualitative table is associated with 1 or many records from the quantitative table; and one record from the quantitative table is associated with 0 or many records form the qualitative table. The QQ data schema is proposed in this project to support the storage and manipulation of both quantitative and qualitative measures.

6. Conclusion

This study proposes a bi-directional approach for data warehouse development in public sectors. The approach focuses on the stages of initiative, information requirement, architecture design, and data modeling for the development process. The initiative stage combines the top-down and bottom-up directions. The information requirement utilizes both formal and informal channels. The architecture design adopts both enterprise data warehouse and subject data marts. The data modeling extends the star schema to capture both qualitative and quantitative measures for organizations that are not purely profit-driven. The bi-directional approach was illustrated using a case study in the College of Business Administration at the California State University, Sacramento. The data warehouse at CBA has been benefited from the bi-directional approach. The data warehouse project is on-going and we expect to expand and fine-tune the bi-directional approach as more experience is accumulated in the future.

References

[1] Ang, J., Teo, T. S. H. (2000). Management issues in data warehousing: insights from the housing and development board. *Decision Support Systems*, 29, 11-20.

[2] Ballou, D. P., & Yayi, G. K. (1999). Enhancing data quality in data warehouse environments. *Communications of the ACM*, 42:1, 73-78.

[3] Barquin, R. C., & Edelstein, H. A. (eds.). (1997). *Planning and Designing the data Warehouse.* Prentice Hall PTR.

[4] Bischoff, J., & Alemander, T. (1997). *Data Warehouse: Practical Advice from the Expert.* Prentice Hall.

[5] Chen, L. D., & Frolick, M. N. (2000). Web-based data warehousing. *Information Systems Management*, 17(2), 80-86.

[6] Chen, L. D., Soliman, K. S., Mao, E., & Frolick, M. N. (2000). Measureing user satisfaction with data warehouses: an exploratory study. *Information & Management*, 37, 103-110.

[7] Cooper, B. L., Waston, H. J., Wixom, B. H., & Goodhue, D. L. (2000). Data warehousing supports corporate strategy at First American Corporation. *MIS Quarterly*, 24(4), 547-567.

[8] Elimam, A. A. (1991). A decision support system for university admission policies. European *Journal of Operational Research*, 50, 140-156.

[9] Foulds, L. R., & Johnson, D. G. (2000). Slotmanager: a microcomputer-based decision support system for university timetabling. *Decision Support Systems*, 27, 367-381.

[10] Gill, H. S., & Rao, P. C. (1996). *The Official Guide to Data Warehousing*. Que.

[11] Granof, M. H. (1999). Governmental accounting and reporting: a data warehousing approach. *The Government Accountants Journal*, 48(2), 30-38.

[12] Huang, Z., Chen, L. D., & Frolick, M. N. (2002). Integrating web-based data into a data warehouse. *Information Systems Management*, 19(1), 23-34.

[13] Inmon, W. H. (1996). *Building the Data Warehouse.* Wiley Computer Publishing.

[14] International Data Corporation. (1996). *Financial Impact of Data Warehousing*. IDG.

[15] Kwak, N. K., & Lee, C. (1998). A multicriteria decision-making approach to university resource allocations and information infrastructure planning. *European Journal of Operational Research*, 110, 234-242.

[16] Kimball, R. (1996). *The data Warehouse Toolkit: Practical techniques for Building Dimensional Data Warehouses*. John Wiley & Sons, Inc.

[17] Kimball, R., Reeves, L., Ross, M., & Thornthwaite, W. (1998). *The Data Warehouse Lifecycle Toolkit*. Wiley Computer Publishing.

[18] Marks, W. T., & Frolick, M. N. (2001). Building customer data warehouses fro a marketing and service environment: a case study. *Information Systems Management*, 18(3), 51-56.

[19] Milton-Smith J., Schmidenberg, O., & Klass, D. (1999). Strategic planning, strategic goals and group decision support systems: a business school case study. *International Journal on Technology Management*, 17(1/2), 173-194.

[20] Murtaza, A. H. (1998). A framework for developing enterprise data warehouses. *Information Systems Management*, 15(4), 21-26.

[21] Quaddus, M., & Intrapairot, A. (2001). Management policies and the diffusion of data warehouse: a case study using system dynamics-based decision support system. *Decision Support Systems*, 31, 223-240.

[22] Rezaee, Z., Sharbatoghlie, A., Elam, R., & McMickle, P. L. (2002). Continuous auditing: building automated auditing capability. *Auditing*, 21(1), 147-163.

[23] Sammon, D., Finnegan, P. (2000). The ten commandments of data warehousing. *The Data Base for Advances in Information Systems*, 31(4), 82-91.

[24] Sen, T. K., Moore, L. J., & Hess, T. J. (2000). An organizational decision support system for managing the DOE hazardous waste cleanup program. *Decision Support Systems*, 29, 89-109.

[25] Shin, B. (2002). A case of data warehousing project management. *Information & Management*, 39, 581-592.

[26] Tyagi, R., Moore, L. J., & Taylor, B. W. III. (1988). A decision support system for funds management in a public university. *Operations Research*, 36(6), 864-881.

[27] Vidette, P., Klauer, P., & Brobst, S. (1998). *Building a Data Warehouse for Decision Support.* Prentice Hall PTR.

[28] Watson, H. J., Annino, D., Wixom, B. H., Avery, K. L., & Rutherford, M. (2001a). Current practices in data

warehousing. *Information Systems Management*, 18(1), 47-55.

[29] Watson, H., Ariyahandra, T., & Matyska, R. J. Jr. (2001b). Data warehousing stages of growth. *Information Systems Management*, 18(3), 42-56.

[30] Watson, H. J., Goodhue, D. L., & Wixom, B. H. (2002). The benefits of data warehousing: Why some organizations realize exceptional payoffs? *Information & Management*, 39, 491-502.

[31] Wixom, B., & Watson, H. J. (2001). An empirical investigation of the factors affecting data warehousing success. *MIS Quarterly*, 25:1, 17-41.

Table 1 Organizational Characteristics in Public and Private Sectors

	Private Sectors	**Public Sectors**
Organizational Goal	• Profit making as the most important goal	• Non-profit making • Multi-objectives • Political and social values
Organizational Structure	• Clear line of responsibility and authority • Less informal structure • Easier to change structure and replace personnel	• More overlapping and redundant line of responsibility and authority • More informal structure • More difficult to correct structural problems
Management Style	• Promote the style that can improve profit	• Emphasize on the diplomatic style that can balance different political and social values
Personnel	• Motivated by clearly-defined monetary reward systems • Responsibilities well defined and understood	• Motivated by avoiding being blamed • Reward and responsibility systems not clearly defined
Change Management	• Use more environmental sensors • More likely to have a formal plan for change • Drastic changes and measures possible	• Less willing to change unless imposed by top management or survival is threatened • More difficult to have drastic changes and measures

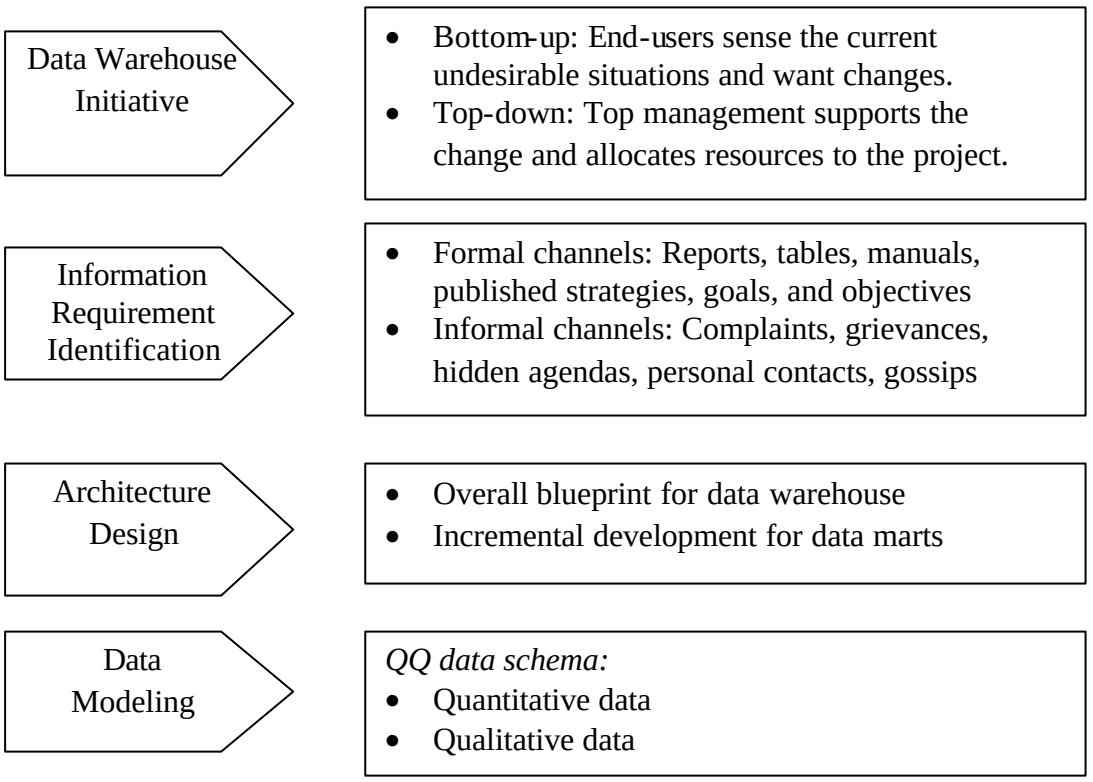

Figure 1 Bi-Directional Approach for DW Development in Public Sectors

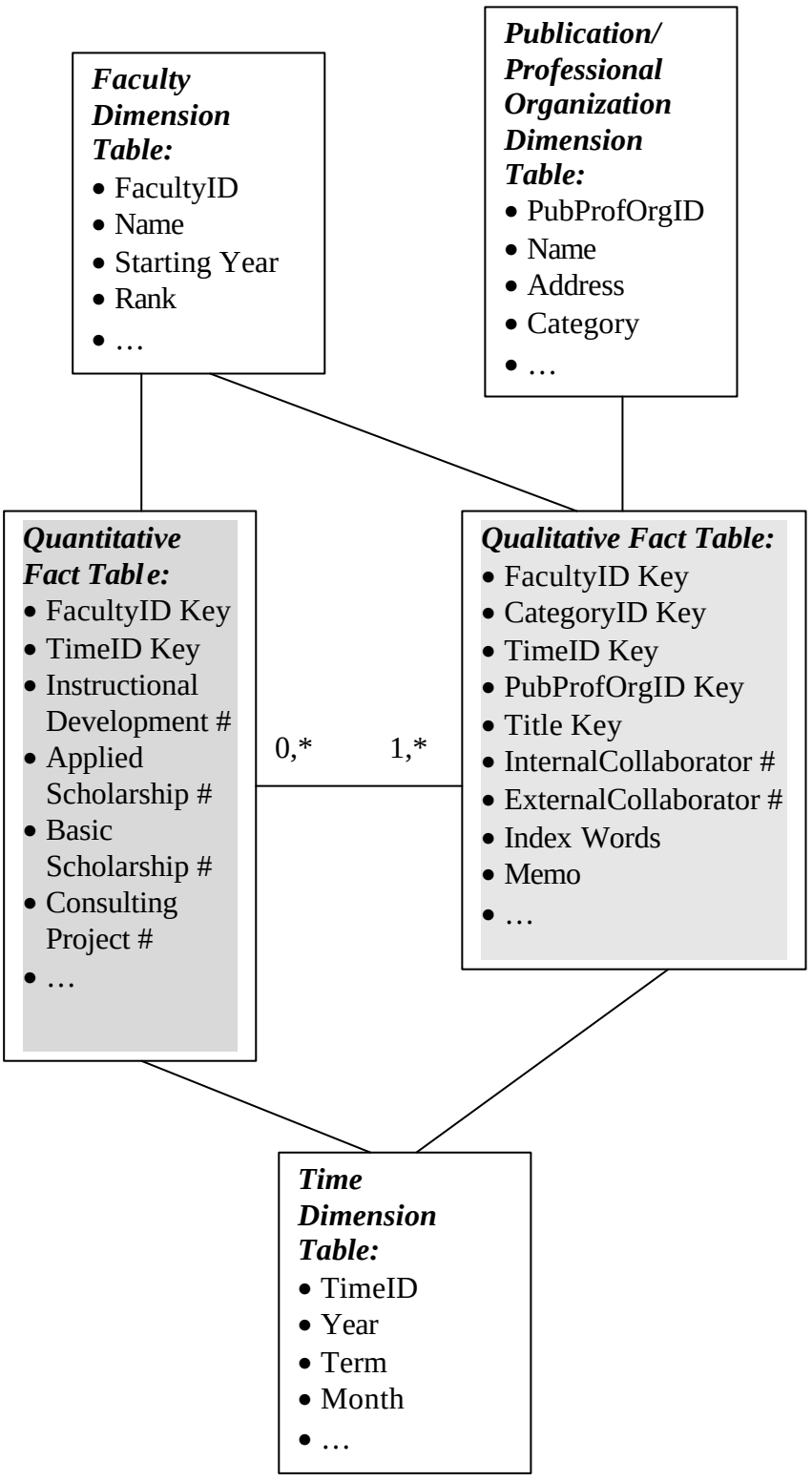

Figure 2 The QQ Data Schema – Faculty Subject