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An ontology-based business intelligence application in a financial knowledge management system

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ABSTRACT

Business intelligence (BI) applications within an enterprise range over enterprise reporting, cube and ad hoc query analysis, statistical analysis, data mining, and proactive report delivery and alerting. The most sophisticated applications of BI are statistical analysis and data mining, which involve mathematical and statistical treatment of data for correlation analysis, trend analysis, hypothesis testing, and predictive analysis. They are used by relatively small groups of users consisting of information analysts and power users, for whom data and analysis are their primary jobs. We present an ontology-based approach for BI applications, specifically in statistical analysis and data mining. We implemented our approach in financial knowledge management system (FKMS), which is able to do: (i) data extraction, transformation and loading, (ii) data cubes creation and retrieval, (iii) statistical analysis and data mining, (iv) experiment metadata management, (v) experiment retrieval for new problem solving. The resulting knowledge from each experiment defined as a knowledge set consisting of strings of data, model, parameters, and reports are stored, shared, disseminated, and thus helpful to support decision making. We finally illustrate the above claims with a process of applying data mining techniques to support corporate bonds classification.

1. Introduction

Knowledge is power. Today's business environment has been tougher than ever. Enterprises experience global competitions. Customers demand more on product features and services. Corporate expenses are continuously increasing. To survive in the harsh environment, high-level management needs business intelligent information to efficiently manage corporate operations and support their making of decisions. Support-level staffs need knowledge information to provide better customer services for gaining satisfaction and retaining loyalty. Vast operating data is staggered into various corporate databases and needs consolidating. It has become more important than ever to access and generate valuable knowledge and share information among authorized users within a corporation and/or business partners. Thus, a system of integrating knowledge management and decision support processes is in great demand. As mentioned in (Bolloju, Khalifa, & Turban, 2002), a synergy can be created by the integration of decision support and knowledge management, since these two processes involve activities that complement each other. The knowledge retrieval, storage, and dissemination activities in knowledge management functionality enhance the dynamic creation and maintenance of decision support models, subsequently, enhancing the decision support process. From the system design's point of view, what we need is a new generation of knowledge-enabled system that provides enterprise an infrastructure to capture, cleanse, store, organize, leverage, and disseminate not only source data and information but also the knowledge or value-added information of the firm (Nemati, Steiger, Iyer, & Herschel, 2002).

We present the concept of financial knowledge management system (FKMS), which is a prototype of KM environment specifically for financial research purposes. What the environment generates is groups of knowledge set with strings of data, models, parameters, and reports. Ontology of knowledge management and knowledge sharing is presented. Finally, a realization of decision support and knowledge sharing processes to a corporate bond classification is illustrated. With FKMS, knowledge workers can freely extract sets of financial and economic data, analyze data with different decision support modules, rerun experiments with different sets of parameters, and finally disseminate value-added information (knowledge) through middleware or Internet to remote clients. Not to mention that the knowledge

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generated is being collected, classified, and shared with colleagues, and thus well archived into corporate business intelligence databank.

The remainder of this paper proceeds as follows. Section 2 reasons our motivation for developing FKMS. Section 3 introduces system architecture of FKMS. Section 4 presents the ontology of knowledge management and knowledge sharing, and demonstrates with a case of corporate bond classification problem. Section 5 concludes this paper.

2. Motivation of developing a financial knowledge management system

One of the biggest challenges that most security investment institutions experienced was the lack of an intelligent data mining system to support investment researches decisions. The problems that their system encountered including:

(i) lack of efficiency in managing vast financial data,
(ii) lack of communication and knowledge sharing among analysts,
(iii) lack of a mechanism to resolve synchronization problems when multiple users are accessing data,
(iv) lack of a mechanism to efficiently manage generated research experiments,
(v) lack of an automation to publish its reports to clients via its Web sites or email.

Though data for financial applications are simple data, the data typically includes time series information and the relationships among the financial instruments are complex. For example, consider a derivative security objects. The derivative security object often shares underlying securities with other derivatives. Underlying securities can come from many classes of instruments, from a simple currency to an interest rate swap to a hedge. As the securities become more complex, the problems of data management and knowledge discovery become more difficult. Consider a security portfolio, the portfolio construction is a process of quantitative analysis over massive amounts of data. The data cube and ad hoc analysis techniques are an invisible solution to support this process. A system that efficiently supports financial application thus would provide support for: (i) temporal objects, (ii) object management, which is the efficient storage and manipulation of complex data, (iii) knowledge discovery, the capability of extracting information as rules for decision making. The (i) and (ii) result in financial data modeling using object-oriented techniques, whereas the (iii) is merely data mining techniques.

3. System architecture

The architecture of the FKMS is a layered structure as shown in Fig. 1. The object-oriented design gives the system flexibility and expandability. FKMS consists of five layers: the resource layer, the data conversion layer, the data storage and management layer, the knowledge/trend/pattern layer, and finally the user process layer. Various sources of data are converted into the time series database according to predefined schema. With OLAP tool, users can easily define various periodical reports with report generator and generate sets of data cubes for analysis. The resulting data cubes are stored and managed in the FKMS that various valuation models, data mining techniques or statistical modules can be applied to. In addition, Web pages represented by the XML can be sent to major corporate clients (as a message), as well as posted on the enterprise information portal with Web-enabled modules and messaging tools. Finally, thousands of files generated by the analysts are well managed and monitored for knowledge sharing and as for internal performance evaluations.

The data cubes are stored in a traditional relational database management system (RDBMS); users can easily divert the data cubes via ODBC or JDBC for analytical applications at the knowledge/trend/pattern layer. The selected analytical applications are either designed or programmed by users, or the off-the-shell software such as Excel, Matlab, IMSL, SAS, SPSS, or S-Plus. A use case diagram in Fig. 2 depicted the function requirement for FKMS implementation.

3.1. Resource layer

Various resources of data are used by analysts when they write research reports or run valuation models. Typical examples of these data resources are financial databases from foreign data vendors such as Bloomberg, Data Stream, First Call, or from domestic data vendors like the TEJ and the SFI, as well as other reports from competitors, and some periodically published data on the Web sites. While some data are static, meaning that they are periodically released, some are dynamic, which means that they are not periodic. On the other hand, the format of data can be classified as structured, semi-structured, and unstructured. We focus on the management of structured data, as their format is clearly defined so that data operations or manipulations can be deployed.

3.2. Data conversion layer

A data warehouse should always provide its users with accurate, consistent, and real-time data. It should be flexible to support all corporate operations and changes. Corporations usually manage

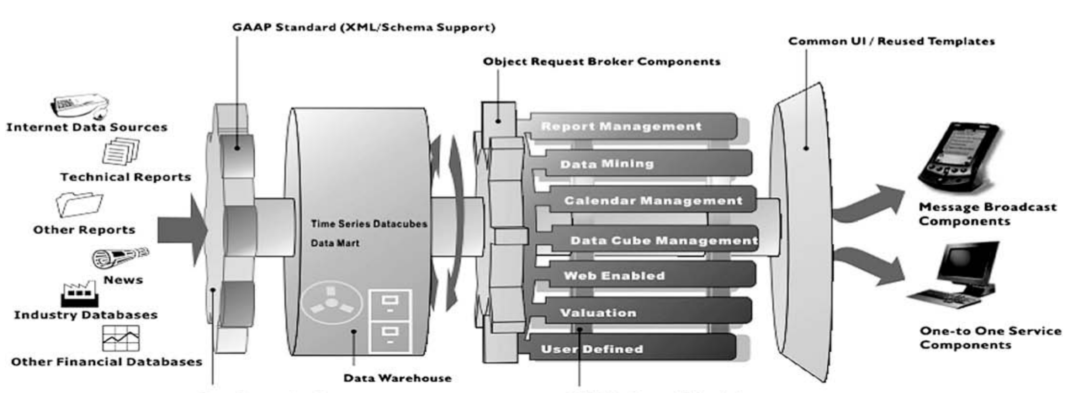

Fig. 1. The system architecture of financial knowledge management system.