Systematic Engineering in Designing Architecture of Telecommunications Business Intelligence System

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Abstract. Nowadays, several solutions can be obtained from business intelligence product vendors for building business intelligence system. However, based on our experience in implementing business intelligence system in telecommunications, many practical challenges and problems are emerging continuously when we use the above products to integrate and mine business intelligence from operational systems and work flows. As a result of survey, 85% of data warehouse projects failed to meet their intended objectives. One of the key reasons, we believe, is located at the design strategy of system architecture whether it is from systematical viewpoint or not. In this paper, based on our work experience in theory and application, we take the process of constructing a business intelligence system as a systematic engineering, and abstracted and advanced a hybrid strategies for constructing software architecture of telecommunications business intelligence system, which implements the BI system based on the four types of models step by step, supports system analysis and design from four levels of analyses, a suite of functionalities and components for decision support, and a knowledge portal for integration and presentation of all analysis and design. As an experimental assessment of the above proposed approach for building hybrid intelligent architecture of BI system, we further presented a prototype of the intelligent operational analysis system (IOAS) for telecommunications operators, which is built on the top of historical heterogeneous data and real telecommunications environment, and has been shown to work online user-friendly and flexibly, support decision making systematically.

1. Introduction

With the ever-increasing globalized competition both from internal and external competitors, and ever-increasing requirements of improved and new telecommunications services emerging from customers, markets and technologies, more and more stubborn problems are being heaped on the tables of telecommunications operators and their services providers, for instance, the increasing telecommunications frauds and churners, and are waiting in lines for decision making. To this end, analysis and mining of business intelligence (BI) from business operational systems in telecommunications [1] has been seen as an effective way in scientific and intelligent management and decision making for telecommunications operators and services providers. Therefore, the construction of data warehouse and the implementation of data mining have been viewed as two underlying and promising steps in building telecommunications business intelligence system.

However, solutions available from present business intelligence vendors, such as IBM [2], Cognos [3], SAS [4], ORACLE [5], MicroStrategy [6] etc either simply focus on building data aggregate supports and implementing data analyses, or only provide data mining methods, rather than providing a suite of functionalities and components for decision support, which can be made without expertise in statistics, data mining, and even computer technologies. As a result of them, 85% of current data warehouse projects fail to meet their intended objectives. 40% don't even get off the ground [7].

With regards to our experience both in research and application in business intelligence system, one of the key reasons of the above problems, we believe, is located at the design strategy of system architecture whether it is from systematical viewpoint or not, which results in whether our system users, who are neither statisticians and data miners nor computer experts, can take it over smoothly and more importantly take it as one integral part of their daily job utilities.

In this paper, in respect of our practical and fruitful work experiences both in theory and applications in telecommunications business intelligence [8, 9], we report our proposed approach for building hybrid intelligent architecture of telecommunications business intelligence system. However, here we do not intend to discuss those details about how to implementing this type of telecommunications business intelligence system. We'd like to discuss some key strategies and components in building this hybrid intelligent architecture from the following aspects: the current problems emerging from the usage of the BI products available, system analysis and design from four types of models and analyses, a suite of functionalities and components for decision support, and a knowledge portal for integration and presentation of all analyses and design. In the end, a prototype of our project of building Intelligent Operational Analysis System (IOAS) is discussed based on the proposed hybrid intelligent strategies and real-time industrial data from China telecommunications industry.

2. What's the Problem of Current BI Products

Currently, functionalities available from business intelligence systems, either abuliding or in use, mainly embody the representations of operational reports, including predefined, OLAP and ad hoc reports, which to some degree fulfills basic and daily requirements of operational analysis and decision making. However, as we have mentioned, 85% of current data warehouse projects fail to meet their intended objectives. From our experience in requirement engineering and design of the BI system, the following questions may give us to some degree answers to the above failure.

What's the functionalities of BI system There are many answers for it from every vendor and provider of BI. However, it emerges and resounds in our mind during the whole process when we try to provide our customers a satisfactory tool for them to mining intelligence and further enhancing their productivity and decision-making level.

How to build a BI system on the top of the complicated operational systems There are many heterogeneous systems existed in the telecommunications operations, for instance, billing system, accounting system, MIS, OA, running and maintenance system. On the other hand, there are built-in work flows and customer relationships located at a telecommunications operator. Therefore, it is a complex process for us to build a BI system. How to build the BI system on the top of these systems and organizations? It is necessary for the BI product and services providers to go deep into the target organizations and set up a step-by-step approach from the requirement engineering, information modeling to analytical decision making, other than the setting of data warehouse and reporting presentations.

How to support decision making In addition, aiming at decision support, how does a business intelligence system present the analytical results from reports and mining to decision-makers user-friendly and help them make decisions directly without additional transformation or expert involvement? Again, how to do system integration of data mining with other presentation knowledge into a unified and user-friendly knowledge portal? How to deliver data mining applications and their analytical results to our customers who are neither statisticians nor data miners or even are not computer experts? Can it adapt, update or control the operational systems and network switches online to step into a well-ordered situation based on analytical results, and emerge decision-making hints to its non-expert users directly from the results actively? Furthermore, on the theoretical side, can a business intelligence system benefits from the theory of cybernetics, and be built as a loop-closed system which synthesizes data analysis, problem prevention, prediction and control in order to support automatic or human-involved feedback management and decision?

3. Functionalities of Hybrid Intelligent BI System

With regards to the functionalities and modules of business intelligence system, there are many literatures especially from those commercial companies like IBM, Cognos, SAS, etc. However, as we discussed in section 2, there are still many problems emerge from the current looks of business intelligence products when we use them in the real world.

In this section, we'll discuss what functionalities and modules we believe are required by our non-expert system users.

System goals To this end, based on the above idea of building a business intelligence system as a closed loop system, the concepts of four models and four-step analysis, and the strategy of heterogeneous information integration, we hope a hybrid intelligent business intelligence system embed and support decision making, prevention, alarm and control, and their feedbacks to system operators in order to provide more systematical and comprehensive decision-making supports.

As for alarm signals, detected, analyzed or predicted in either events or by thresholds, alert information and actions will be issued or triggered to related systems or system operators of the telecommunications operational systems for controlling or preventing of unusual and negative activities by electronic or human-involved way; contrarily, normal daily or periodical reports and signals will be used for decision support and customer relationship management.

Data integration As discussed above, there exist several information systems which support the business operations of a telecommunications operator. Before we build up data warehouse and data marts, a worthwhile step we recommend to do is to extract data into an operational data store from these heterogeneous distributed information resources.

Then, local primitives of each source are extracted, analyzed, and further extended and mapped to the shared terms. In order to support user-friendly user profiles, another term base and user-global primitives match mechanism are required. The three levels of ontologies: user views, shared vocabulary, local terms, are extracted, described and refined in XML DTD, IBM DB2 metadata base and an ontology knowledge base.

The formation and refinement of these three ontologies are carried on the top of domain specific requirement engineering and system analysis using the previously discussed operation model and its customer models, and with the proceeding of ETL, and the building of ODS and data warehouse and marts. Data warehouse and marts are built and updated on schedules with the mutual efficiency of common global ontology and metadata, and the subjects and specials in the data model.

As a result of the hybrid ontology-based resource integration in telecommunications, an integral and user transparent linkage is built from user interaction interfaces to specific local sources, which hides complexities of heterogeneous resources, and provides non-expert level of work environment for the system users to analyze and mine business intelligence from complicated and colorful operational world.

Data processing Three main types of data processing, including detection, analysis and prediction, are conducted on the top of the preset data subjects and specials in the warehouse and marts. For each subject or special, there are generally four levels of analysis available, namely predefined analysis, ad hoc analysis, OLAP analysis and data mining analysis, according to requirements of specific problem. The analytical results can be used for alarm and prevention or for decision support according to what they have activated in the preset specification.

Decision supports In order to support non-expert user-friendly decision making, a technical report builder and a decision report builder are designed for producing technical reports (mainly for technical analysts and operation analysts), decision-making reports (mainly for department or middle level managers) and final decision support reports (mainly submitted to general manager for some significant decision or permission). These builders provide dynamic convenience and practical utilities for generating user-friendly reports, which explicate the analytical results of all above four levels of analyses in domain specific terms and easily understandable style. All reports are generated on the top of report templates in XML.

Respective users, in terms of their specific responsibilities and operational branches, use these analytical results for production dispatching, customer relationship management, operation control or prevention, and so on.

It is worthy of mentioning here that the above operations are conducted automatically or human-computer cooperated as for different environment or policy limitations. In some case, for example, we can only implement control, prevention and production dispatching by human interventions through the human computer interactive interfaces. This is another key aspect we advanced that it is very important to integrate hybrid intelligence from human qualitative intelligence to computer quantitative intelligence as required [10].

Knowledge portal Furthermore, in our solution, in order to provide unified certification and authorization, information and knowledge presentation and services, system componentization and reconstruction, a unified aggregation point of information, applications, views and services, referred as active knowledge portal, is in study, which brings top and bottom sources together into a single view and is customized for user friendliness.

The portal lodges many centers, like certificate center, security center, control center, model center, warehouse center, decision center, and knowledge center. This one-stop interface combines certification and authentication, ontology and metadata management, data auditing, presentation logics of ETL tools, ODS system, data warehouse and presentation applications on the top of underlying multiple distributed sources.

These centers serve as the human computer interfaces, more importantly, they act as the digital nerve center of the business intelligence platform, which can reconstruct system modules, and logical flow, views and services, reconfigures user permissions and interface mechanisms for different departments and customers. For example, the four above mentioned underlying models are finally organized in the model center; however, the customer credit evaluation system and operational specification assessment are situated in the knowledge center.

System framework As an aggregation result of all the above discussions both in this section and the previous three, a hybrid intelligent architecture of BI system integrates all

intelligence and presents us a comprehensive suite of functionalities and components in mining business intelligence from telecommunications industry. With the flow of the data and information stream from bottom up, business intelligence gestates and emerges from the final refinement among multiple levels of processing. Finally, automatic or human-involved events, views, services, alarms and/or actions are activated, which direct the activities of decision-makers in the telecommunications operator with the accompanying analytical reports and decision-support reports.

4. System Design: Four Types of Models

In this and the following section 4 and 5, on the basis of the above hybrid structure, we discuss the business intelligence system analysis and design for telecommunications operators. We abstracted and proposed a system design approach of four types of models, business intelligence analysis of four steps analyses, finally a hybrid intelligent framework of the telecommunications business intelligent system is presented.

Successful planning and implementation of business intelligence, especially in cases of telecommunications-like enterprises, from our experience in this field, is recommended to be based on four types of hardcore models: domain-specific operational and its customer models, telecommunications business intelligence system model, data model and algorithm models, we'll discuss them respectively in the following sub-sections. Among all these four models, the domain-specific operational and customer model serves for foundation of implementing business intelligence system.

4.1 Domain-specific Operational and Its Customer Models

The role of domain-specific operational and its customer models is to define main services and product types, enterprise operational workflow, information gathering, distribution and usage strategies, decision making flow chart in a specific operator, main customer types and feature distribution, management and service flow of customer relationships, operational regulation and rules both from internal and industrial associations and government, problems and bottleneck emerged from production, management and policy, etc.

Before startup of analysis and design of telecommunications business intelligence, a collection of domain operation and its customer models matching with the reality of a particular telecommunications operator and its customers should be clarified and testified in respect of the above strategies. The output of domain operation and customer model includes flow charts, structure diagrams, entity relation diagrams of production, management, services, customers and products distribution.

4.2 Telecommunications BI System Model

In the second place, based on the above groundwork of operational and customer models, a BI system model can be set up as the framework of designing and implementing telecommunications business intelligence. System model tells telecommunications business intelligence system architects about what functionalities this system has, how many layers exists from data ETL to analysis, presentation and decision support, how to integrate multiple operational applications, data sources, human computer interaction, what kinds of system output are expected, and also system framework and computing model,

implementation methods and design patterns, system specification, metrics and terminology, mechanisms of metadata management, universal certification, auditing and control. System analysis and simulation are required before finding a suitable system model.

4.3 Data Warehouse Data Models

With this blueprint of business intelligence system in telecommunications constructed on top of operational and system models, it is time to customize data models for data warehouse and data marts now, which can be arranged regarding subjects and special topics, analysis measures and dimensions. For instance, the customer subject and the sales subject exist in the data warehouse, and churn and fraud specials in data marts. A comprehensive entity relation model diagram and an overall subject and special field diagram are produced, which covers all subjects and specials, sub-subjects and sub-specials, measures, members and dimensions, etc.

4.4 Analytical Algorithm Models

Furthermore, with the requirements from problem solving, and subjects and specials analyses in data warehouse and data marts, algorithm models of data analysis in regard to statistics analysis and mining can be specified in respect of problem domain and method selection. Algorithm library is organized to support analysis requests of subjects and measures, and of prediction, clustering and classification, etc.

It is worthy of noting here that the hypothesis, assessment and modification of modeling are based on processes and principle of human computer cooperation. Hypothesis contributed by domain experts and knowledge engineers is testified, clarified and modified by all involved experts and domain analysts connecting to a sample data source. Then, after testing of this model, it is published to system architects to do system design and implementation.

Up to now, with all these four types of models securing most key points from problem requirements to problem-solving, it is relatively easier to start up implementation of telecommunications business intelligence system. Figure 1 shows the relationship of the above models.

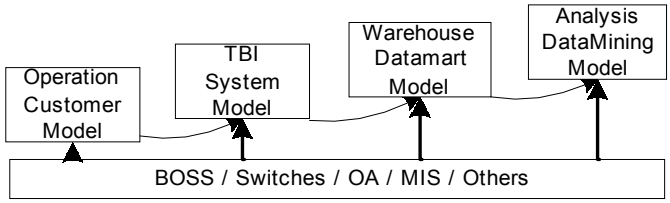

Fig.1 Four types of models

5. Four Steps of Business Intelligence Analyses

With regards to practical functionality and promotion to telecommunications enterprise operations and management from the theory of business intelligence, data analyses act as a key and leading actor. In order to deal with different levels and aspects of requirements from the aspects of decision makers and product analysts, for each data warehouse and data mart subject and special, four types of analyses can be served, i.e. predefined analysis, ad hoc analysis, OLAP analysis and data mining analysis, based on aggregate data from

telecommunications business operational support systems (BOSS), switches system, office automation systems (OA), management information systems (MIS) and other external systems and resources, which are shown in Figure 2.

Predefined analysis Predefined analysis is carried out mainly based on predefined requirements using historical data, aggregate of historical data, middle-granularity data in terms of statistics preparation, etc. Predefined analysis serves for the most daily services and the largest part of fixed reports for operational analysis and decision making.

Ad hoc analysis However, as a flexible and dynamic application, ad hoc analysis presents reports generation mechanism in run time for producing online reports based on sub-subjects or sub-specials under one subject or special, or crossing multiple subjects or specials.

OLAP analysis Furthermore, OLAP analysis denotes online multidimensional, relational and hybrid types of analysis processing.

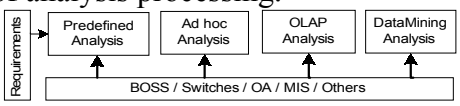

Fig.2 Four steps of analyses

Data mining analysis As an in-depth analysis and decision support technology, data mining takes on significant roles in developing and deploying business intelligence. Due to system complexities and colorful potentials in decision support, a hybrid data mining system integrating multiple mining algorithms on basis of different computing principles, is acceptable and to the point.

6. IOAS: A Prototype Based on Real Time Industrial Environment

On the basis of our proposed hybrid intelligent strategies for building telecommunications business intelligence system, we have testified and constructed a prototype of this type of system--IOAS: intelligent operational analysis system. This system is tested and implemented as per industrial requirements, situations, business intelligence specification, and real-time data [11,12] from China telecommunications operators.

6.1 Powerful Integration and Extensions to Business Intelligence Products Available

In the IOAS, which is built in web services technology and n-tier system structure, six subjects of data warehouse and another six specials of data marts have been testified and established in the data warehouse center after the transformation of data preparation [13]. Unified certification and single signon is lodged in the knowledge portal, four levels of analyses are integrated flexibly and efficiently. To the users, complexities from multiple heterogeneous information resources, ETL tools, ODS system, data warehouse system, presentation reports and tools, are shielded and hidden under the one-stop interface.

Furthermore, this platform combines some knowledge development tools and models builders. For instance, a knowledge development platform manages system parameters, domain experts knowledge, three levels of ontologies, customer relationship, customer credit and evaluation; a technical report builder generates analysis reports for technicians and analysts; a decision-support report builder produces decision-support reports for middle-level and high-level decision makers; a data model builder organizes model reconstruction and maintenance; the predefined report builder predefines reports; human

computer cooperative center provides human computer cooperated control mechanism to fulfill feedbacks from analytical results to operational systems automatically or human-involved, and so on.

With these tools, compared with the solutions of simply integrating the BI products presently available from vendors, this business intelligence platform presents much stronger power to deal with operational decision making user-friendly, practically and systematically, after the extensions to the universal concepts and services available from those business intelligence systems available from IBM, Cognos and so on.

6.2 Unified Portal and Single Signon

Finally, as an Internet-oriented platform, a unified portal and single signon combining all or most relevant products or applications is worthwhile. However, how to make the portal rich and colorful, and intelligent and active is still a challenge to most of the commercial business intelligence products available. In our project, we propose a concept of active knowledge portal, which combine several centers, including data warehouse center, control center, knowledge center, model center, and decision center, etc. Interacting with these centers, users either technologists or decision-makers, can not only interact with these applications through one-stop interface, but also surf on a knowledge developing and servicing platform.

6.3 Experimental Environment and Screen Shots of IOAS

Figure 3 presents some screen shots of this system. We are sorry that this prototype is in Chinese for we built it as a demo for a China telecommunications operator. However, you can get to know what have been done with this project through my introduction.

In this IOAS, IBM DB2 Universal database is used as database server, DB2 Data Warehouse server stored six subjects and six specials, ontologies and knowledge base are kept in XML and DB2 database, Cognos is used for OLAP, ad hoc and predefined reports presentation, IBM Intelligent Miner mines business intelligence from huge amount of telecommunications data. Under the IOAS, Informix, Oracle, Sybase, SQL Server are used in the telecommunications business operational systems for storage of operational data.

This platform is organized according to subjects and specials in the data warehouse and marts (shown in the left hand side of the interfaces), and functionality modules needed for system integration and management. These subjects and specials and their related measures, attributes and members are abstracted and matched from the above several heterogeneous distributed resources according to knowledge and ontologies on top of user profiles, shared vocabulary and local primitives. Measures, dimensions, attributes and members in the integrated presentations of the four steps of analyses shown on the one-stop site are in user profiles rather than in local original data views, users can easily launch analysis and observations without the worries of underlying heterogeneity, authorization and information management.

Fig.3 the telecommunications Intelligent Operational Analysis System

7. Conclusions and Future Works

Business intelligence, as a new power to raise productivity and economic benefit for enterprises with huge amount of operational data, has attracted more and more attention from industries and academia. Solutions for implementing telecommunications business intelligence are proposed by more and more vendors from database fields, statistics software providers and some emergent application providers.

However, according to our research and comparison, most of them simply consider something as it stands, and cannot deal with those complexities user-friendly, flexibly and systematically we mentioned. As a matter of fact, what the telecommunications operators need is a user-friendly and decision-support solution integrating management and information of telecommunications operations, which can help them solve problems emerged beforehand, during the events and afterwards.

On the other hand, based on our studies and experimental design, as a new superior decision support technology, it is possible to integrate heterogeneous information resources, which shield complexities and expertise jargon from detailed data structures and attributes; it is also possible to design a unified and user-friendly knowledge portal, which covers global certification and authorization, views, services and applications; again, it is possible to provide online and universal mechanisms for synthesizing data preparation, multiple levels of data analysis, data mining, and data presentation available for different purposes intelligently; and finally, it is also promising to provide users a unified and loop-closed mechanism, which can be used to support user-friendly, intelligent and well-ordered decision making.

In particular, according to our practical experience, a practical step during the process of implementing business intelligence system is to construct a collection of domain ontologies and models, this is much useful especially when the targeted problem is very complicated. In our minds, these domain ontologies and models involve all related main aspects in terms of the heterogeneous information integration, four types of models we mentioned above. However, the generic emphasis of data model doesn't tackle other

significant issues relevant to operational mechanism, customer relationship, system infrastructure, etc. Here, we emphasize the other three types of models as the base for building comprehensive telecommunications business intelligence system.

We further presented a loop-closed system architecture of telecommunications business intelligence platform, which synthesizes data analysis, problem prevention and prediction and analytical results presentation as needed.

Our prototype of IOAS, on the basis of the above hybrid intelligent strategies for building telecommunications business intelligence system, connecting to real-time telecommunications data and operational workflow from telecommunications operators, has proven that our proposed system architecture strategy is possible and feasible, which itself, as a standalone and full support scheme, has further been proven to be beyond those specific business intelligence solutions from IBM, SAS, Cognos and so on, in user-friendliness, unified certification, integration of heterogeneous resources, synthesis of multiple levels of analyses, and system function reconstruction and user permission reconfiguration.

Our future works include but are not limited to the following aspects:

(1) focusing our main attention on some key points in establishing practical and active business intelligence platform for telecommunications operators;

(2) expanding and reifying our current research and experiments of hybrid intelligent telecommunications business intelligence from theoretical and experimental;

(3) transferring our research results in theory to implement the hybrid telecommunications business intelligence platform in related telecom operators based on our current practices and achievements.

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