

# A Process Driven Architecture of Analytical CRM Systems with Implementation in Bank Industry

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**Abstract**—Analytical customer relationship management (CRM) systems, which can discover knowledge from huge amount of data, play a crucial role in decision support. However, while most researches in CRM mainly focus on data mining, relatively few research papers on detailed architectures for analytical CRM systems have been published. In this paper, a practical process driven architecture of building analytical CRM systems is proposed. This architecture is based on the typical CRM analysis process and integrates with multilevel secure (MLS) data model to ensure the efficiency and timeliness of provision of right information to the right users. Furthermore, through a case study of a real-world analytical CRM implementation project in the bank industry, an analytical CRM solution using the proposed architecture has been developed and received approvable ratings from our client, which demonstrates the feasibility of this architecture.

**Index Terms**—customer relationship management, System Architecture, multilevel secure, Bank Industry

## I. INTRODUCTION

With gradual market changes from the product-centered stage to the customer-centered stage, customer relationship management (CRM) systems are becoming a major part of company strategy planning. A good CRM system can enhance not only an organization's ability to interact, attract and build one-to-one relationships with customers, but also the ability to gain customer knowledge [1]. The former (operational) functionality is usually accomplished by operational CRM systems, and the latter (analytical) functionality is usually accomplished by analytical CRM systems. By providing a panoramic customer view through profiling and generating customer behavior patterns to predict future actions [1], analytical CRM systems, which analyze customer data generated by operational tools and discover knowledge about customers [2], can help companies

make better decision. However, based on a four-year survey of CRM applications in [1], current CRM systems are dominated by operational applications, and the analytical function of CRM has long been neglected [3].

Furthermore, how to develop an analytical CRM system remains a problem. Although many companies have adopted CRM technology as one of the necessary components of an effective business model, approximately 70% of CRM software installations falter [4]. One of the reasons account for these failures is inappropriate system architecture design without an in-depth understanding of client's needs [5,6]. The development of analytical CRM systems also confronts the same problem.

One solution to the problem described above is to provide practical and detailed system architectures for building analytical CRM systems which integrates with data mining techniques. Some studies [7-11] have been conducted to create excellent CRM applications in different businesses. But most of these researches show more concern about data warehouse and mining techniques rather than system architectures and implementations. Also they did not focus on analytical CRM systems. To the best of our knowledge, architectures and implementations of analytical CRM systems have rarely been studied except in [1] and [12]. Zu et al. described a conceptual analytical CRM design frame based on distributed data warehouse in [12], but they did not provide any case study and user management concern. Xu et al. examined how analytical CRM systems were used to support customer knowledge acquisition and how such a system could be developed [1], but neither system architecture nor case studies were presented.

In order to address these issues, in this paper we propose a practical process driven architecture of building analytical CRM systems. Based on the typical CRM analysis process which sits at the heart of analytical CRM systems, this architecture not only provides an easy

transition from analytical concept in CRM theory to practice, but also ties all modules of analytical CRM systems together in a coherent manner. Furthermore, by integrating multilevel secure (MLS) data model [5] and classifying potential participants of the systems from enterprises' viewpoint, this architecture ensures the provision of right information to the right users. In addition, through a case study of a real-world analytical CRM implementation project in the bank industry, we have developed an analytical CRM system using the proposed architecture. This system has received approvable ratings from our client – a branch of a Chinese major bank.

The remainder of this paper is structured as follows. In Section II we elaborate our proposed process driven architecture of analytical CRM systems. Section III presents our system design and implementation details. Evaluation result of the system is illustrated in Section IV. Some concluding remarks and ideas for future work are given in Section V.

## II. A PROCESS DRIVEN ARCHITECTURE OF ANALYTICAL CRM SYSTEMS

### A. A Process Driven Architecture

CRM analysis using data mining technique sits at the heart of analytical CRM systems, so the central thought of our design is based on the typical CRM analysis process. Fig. 1 shows the process driven architecture of our solution. The architecture is based on a widely used frame [13], which can be divided into two subsystems, back-end and front-end subsystem.

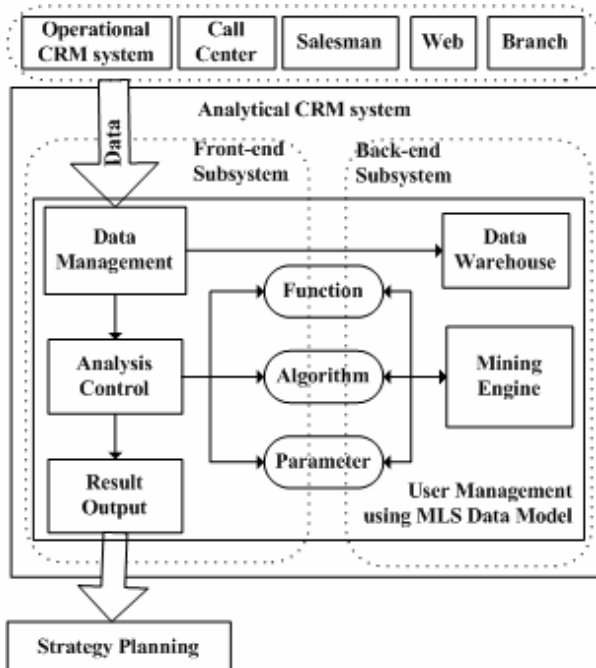


Figure 1. Architecture of analytical CRM systems

The back-end subsystem, which aims at analyzing, reporting and predicting customer behavior by data mining technique, consists of a data warehouse and a

mining engine. The data warehouse can be described as a large repository of corporate data [14]. It gives the companies various data that allows them to discover knowledge about customers. The mining engine analyzes the data stored in the data warehouse in order to support companies to make better decision in resource planning, customer targeting, marketing and other operating processes.

The front-end subsystem involves interactive applications for the potential participants of analytical CRM systems. Its main function is to provide various modules for users to control data warehouse and mining engine, that is, to control analytical processes, which is the main concern of our process driven architecture. In order to control data warehouse and to collect "islands of data", we design a data management module to combine data warehouse with various data resources. This module is a data management tool that gives system users instant access to information. Specifically, it can also extract, clean, filter, transform, and manage large volumes of data from multiple, heterogeneous systems, creating a historical record of all user interactions. These functions are considered to be integrated in the data warehouse in [15]. However, based on a research about system users' expectations and needs, we separated these functions from data warehouse in our architecture, because users need to perform data processing directly.

In addition, in order to control mining engine, we design an analysis control module in the front-end subsystem. After users select the data source in data management module, they should select the analytical function which they want to perform. The back-end system will established the corresponding model and analysis process. Then users need to set some necessary parameters which specify the integrity constraints of the selected algorithm. In our proposed architecture, when an analysis occurs, information such as values of different parameters would be passed to mining engine. After the engine compares current status with predetermined status set, it triggers some corresponding events, and the condition of these events will be evaluated. Only if the condition is evaluated to be true, the analysis process will move on. Finally, users will obtain a visualization of analysis result in order to understand customers more quickly and to make better decisions.

On the other hand, a major component of analytical CRM systems is the provision of right information to the right users at all levels [11]. In our proposed architecture, this issue is addressed using a MLS data model.

### B. MLS Data Model

MLS was first introduced to CRM systems by Jukić et al [5]. It groups users as well as data into a finite number of access levels, and each user is only assigned to one access level. Access to data is solely determined by the access levels of users and data [16].

The access levels are illustrated in Fig. 2. Based on a comprehensive study of potential participants of the analytical CRM system, we divide the users into four groups from enterprises' viewpoint as follows:

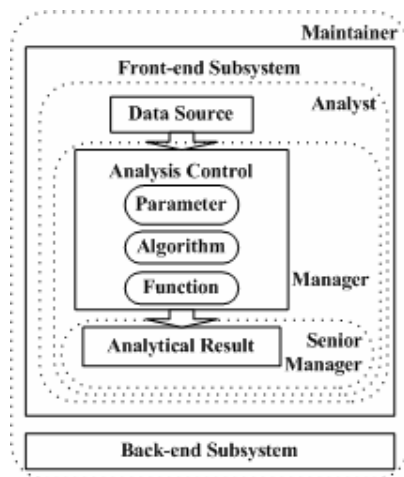


Figure 2. Access levels of different users (the broken panes indicate access ranges of different users)

- *Senior manager*, who only concerns about the result of analysis without taking account of the process of analysis;
- *Manager*, who mainly concerns about the result of analysis but sometimes will analyze data by himself;
- *Analyst*, who is responsible for data analyses;
- *Maintainer*, who knows all the details about the system.

The difference between analysts and managers during analysis is that the analytical process is simplified for managers. For example, when performing customer segmentation using data mining techniques, managers only need to set the number of customer classes, but analyst may need to set many parameters about the mining algorithm itself, such as number of iterations, so that the algorithm can achieve better analytical results. From a software development viewpoint, this architecture matches well with recent technologies such as Java, because different module can be realized using component methods.

### III. SYSTEM DESIGN AND IMPLEMENTATION

#### A. The Business Entity Example

The business example is a branch of a major Chinese bank which has about 500,000 customers. The management made a comprehensive study of the previous and the recent performance of the bank and reached a conclusion that the bank needed serious change to survive in the increasingly competitive marketplace locally and globally. However, one problem is that the managers are not provided with sufficient analytical reports to make right decisions at the right time. The proposed solution to all the above challenges and needs is applying a carefully designed and developed analytical CRM system, in order to discover knowledge from mass data and support better decisions.

#### B. Analytical functions and processes

In our analytical CRM system, main analytical functions are: 1) Customer segmentation, which segments clients into groups and especially identifies the most profitable customers. 2) Churn analysis, which estimates the propensity of customers to cease doing business with a company in a given time period. 3) Cheat detection, which inspects the cheat propensity of customers. 4) Cross-sell, which recognizes cross-sell opportunities and picks up a set of customers whom the company would like to target with new products.

Our architecture is designed to be process driven, and all the modules are organized based on the typical CRM analysis process. So after logging in the system, users will be led to complete the analytical process along with the skips of web pages. For example, after users select a data source, the web page will jump to the analytical function page so that users can select an analytical function to perform. Then users have the freedom to choose various algorithms and set corresponding parameters. The system will execute the algorithms under constraints set by users and finally output analytical results.

#### C. Back-end Subsystem

The back-end subsystem consists of a data warehouse and an analytic engine. By storing and organizing data fundamental to the analytical CRM system, the data warehouse enables the system to provide real-time information and allows users to search for any desired data within the system. All the data, including information about customers, products, transactions, makes no difference to the analytic engine. We designed the schema related to analytical engine for the data warehouse in Fig. 3.

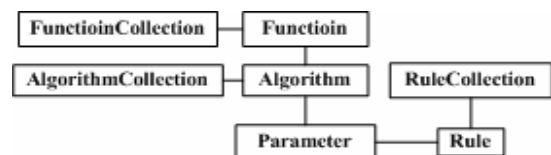


Figure 3. Schema related to analytical engine

Functionality of the system depends on the relationships between different fields of the database [9]. We designed a unique identifier for each field of the database. These identifiers and the relationships between data tables can minimize the complexity, the size, and the overall maintenance of the system. They also allow an easy addition of new algorithms.

#### D. Front-end Subsystem

As a front-end for an analytical CRM system to interact with users from the bank, it is important for its web site to focus on the bank's specific needs and present an image that matches the bank's existing website. This provides an easy transition from the bank's corporate website to the analytical CRM system.

The general color scheme and layout is shown by the screen shot of analysis control main page, which sits at the heart of the front-end subsystem, Fig. 4.

By MLS data model, users view their personalized page and connect to information that applies to them from the moment they log in. The analysis control main page, shown in Fig. 4, highlights the algorithms and detail description of the algorithms. We used tables to separate different blocks of information and to keep lists in line. When performing one analytical function, if users are not sure about which algorithm to choose, they can use the default algorithm which show better result than other algorithms in the past analyses. If users choose one algorithm, details about this algorithm such as description will be shown in the algorithm detail table, so that users could see whether they choose the right algorithm. Users also have the freedom to view the details about one specific analytical process or delete analytical record. They can use the view button to see the historical analytical results.

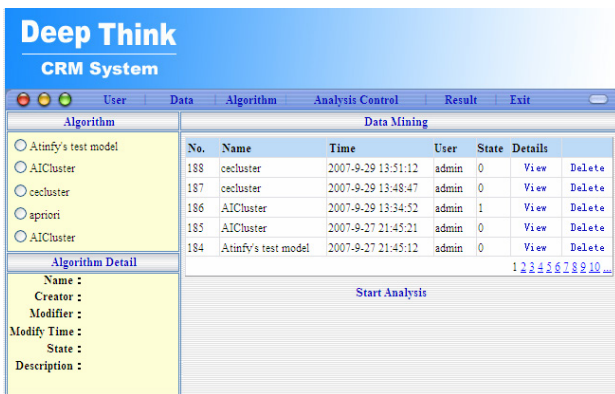


Figure 4. View of analysis control main page

APPENDIX A APPENDIX TITLE

IV. EVALUATION

In order to evaluate the system, we conducted a usability testing in order to evaluate how easy the system was to use. Testers were given seven tasks associated with these functionalities to accomplish and were asked to rate, on a 1 to 5 scale (with 5 being the easiest), how easy the task was to complete. The average ratings are shown in Fig. 5.

If a rating of 4 or higher is considered to be user-friendly, this test result produced positive results. Five out of the seven functionalities received approvable ratings in our result.

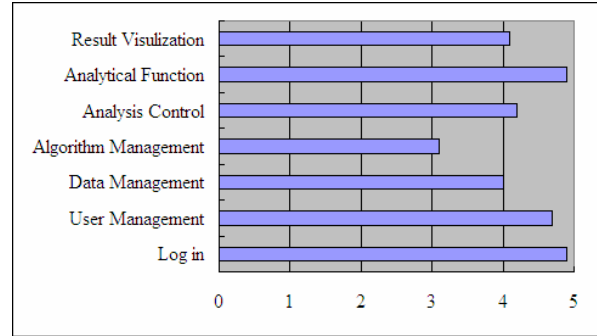


Figure 5. Bar graph of Usability Test Results

The high rating of analytical function shows that the analytical functions provided by our system meet our client’s analysis requirements. Furthermore, although most analytical CRM systems show no concern about user classification from enterprises’ viewpoint, the rating of user management using MLS model supports our classification of potential participants of this system and proves the ability of this system to provide right information to the right users. In addition, although all the testers use this system for the first time, the high ratings of analysis control and result visualization shows that performing analyses is very easy for most testers, which demonstrates the user-friendly of our system, while most other CRM systems are criticized for complicated analytical processes according to [6].

On the other hand, based on conversations with testers, we found that the reason for poor rating of algorithm management is that testers are not familiar with the algorithms we provided. According to this feedback, we will provide detail description of each algorithm in this system to users in the future.

V. CONCLUSION AND FUTURE WORK

Deregulation, globalization and diversification have made the battle for customers more intense than any other time. However, relatively few research papers on the detailed system architectures and implementation technologies for analytical CRM systems have been published. Analytical CRM systems can discover knowledge from huge amount of data and play a crucial role in decision support. In this paper, we propose a practical process driven architecture of building analytical CRM systems. Based on the typical CRM analysis process which sits at the heart of analytical CRM systems, this architecture not only provides an easy transition from analytical concept in CRM theory to practice, but also ties all modules of analytical CRM systems together in a coherent manner. In addition, through integrating multilevel secure (MLS) data model and classifying potential participants of the systems from enterprises’ viewpoint, this architecture ensures the provision of right information to the right users. Furthermore, through a case study of a real-world analytical CRM implementation project in the bank industry, we have developed an analytical CRM system using the proposed architecture. This system has received approvable ratings from our client.

Usability test results revealed that the algorithm management needed to be modified. We plan to enhance the next-phase system with feedback obtained. Also more thorough sets of usability analysis will be performed to ensure that this system meets all requirements of our client. In addition, we perceive that this solution is suitable for implementing analytical CRM system for other industries. But the number of analyzed cases limits generalization. Therefore our proposed solution has to be further validated in empirical research, for example, using additional case studies.

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#### REFERENCES

- [1] M. Xu, J. Walton, "Gaining customer knowledge through analytical CRM", *Industrial Management & Data Systems*, vol. 105, No. 7, 2005, pp. 955-971.
- [2] C. Trepper, "Match your CRM tool to your business model", *Information Week*, vol. 74, 2000.
- [3] Y. Xu, D. C. Yen, B. Lin, D. C. Chou, "Adopting customer relationship management technology", *Industrial Management and Data Systems*, vol. 102, No. 8, 2002, pp. 442-452.
- [4] M.H.A. Tafti, "Analysis of Factors Affecting Implementation of Customer Relationship Management Systems", *Proceedings of IRMA, Idea Group Publishing, Seattle*, 2002.
- [5] N. Jukić, B. Jukić, L. Meamber, G. Nezlek, "Improving E-Business Customer Relationship Management Systems with Multilevel Secure Data Models", *Proceedings of the 35th Hawaii International Conference on System Sciences*, pp. 2256- 2265, 2002.
- [6] M. Starkey, N. Woodcock, "CRM systems: Necessary, but not sufficient. REAP the benefits of customer management", *Journal of Database Marketing, Henry Stewart Publications*, Vol. 9, No. 3, pp. 267-275, 2002.
- [7] M.Geib, A. Reichold, L. Kolbe, W. Brenner, "Architecture for Customer Relationship Management Approaches in Financial Services", *Proceedings of the 38th Hawaii International Conference on System Sciences*, 2005, pp. 240.
- [8] W. Fan, R. Luck, K. Manier, J. Pierce, L. Pool, S. D. Patek, "Customer Relationship Management for a Small Professional Technical Services Corporation", *Proceedings of the 2004 Systems and Information Engineering Design Symposium*, 2004, pp. 243-248.
- [9] I. Singh, "Specification and Design of a CRM system for SMEs", MSc Information Systems, 2002-2003.
- [10] C. Feng, W. Cong, L. Jie, "Agent-based On-line Analytical Mining in CRM System", *IEEE Proceedings of Networking, Sensing and Control*, 2005, pp. 4-12.
- [11] A. Tiwana, *The Essential Guide to Knowledge Management – E-Business and CRM Applications*. Prentice Hall, Atlanta, 2001.
- [12] Q. Zu, D. Chen, Y. Cheng, M. Zhang, "An Analytical CRM Design Frame Based on Distributed Data warehouse", *2nd International Conference on Pervasive Computing and Applications*, 2007, pp. 68 – 71.
- [13] D.K.W. Chiu, W.C.W. Chan, G.K.W Lam, S.C. Cheung, F.T. Luk, "An Event Driven Approach to Customer Relationship Management in e-Brokerage Industry", *Proceedings of the 36th Hawaii International Conference on System Sciences*, 2003
- [14] J. Dyché, *The CRM Handbook: a business Guide to Customer relationship management, Addison-Wesley Professional, Boston*, 2002.
- [15] W. Eckerson, H. Watson, "Harnessing Customer Information for Strategic Advantage: Technical Challenges and Business Solutions", special report, *The Data Warehousing Institute, Chatsworth, CA*, 2000.
- [16] G. Pernul, A. M. Tjoa, W. Winiwarer, "Modeling Data Secrecy and Integrity", *Data & Knowledge Engineering*, vol. 26, No. 3, 1998, pp. 30-37.