Knowledge and Process Management Volume 10 Number 1 pp 3–17 (2003)
Published online in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/kpm.163

■ *Research Article*

Application of Knowledge Management Technology in Customer Relationship Management

Ranjit Bose[1]* and Vijayan Sugumaran[2]

[1]*Anderson School of Management, University of New Mexico, USA*
[2]*School of Business Administration, Oakland University, USA*

Given the important role being played by knowledge management (KM) systems in the current customer-centric business environment, there is a lack of a simple and overall framework to integrate the traditional customer relationship management (CRM) functionalities with the management and application of the customer-related knowledge, particularly in the context of marketing decisions. While KM systems manage an organization's knowledge through the process of creating, structuring, disseminating and applying knowledge to enhance organizational performance and create value, traditional CRM have focused on the transactional exchanges to manage customer interactions. True CRM is possible only by integrating them with KM systems to create knowledge-enabled CRM processes that allow companies to evaluate key business measures such as customer satisfaction, customer profitability, or customer loyalty to support their business decisions. Such systems will help marketers address customer needs based on what the marketers know about their customers, rather than on a mass generalization of the characteristics of customers. We address this issue in this paper by proposing an integrated framework for CRM through the application of knowledge management technology. The framework can be the basis for enhancing CRM development. Copyright © 2003 John Wiley & Sons, Ltd.

INTRODUCTION

CRM is one of the hottest tools in business today. But like total quality management and reengineering before it, CRM has not always lived up to its hype (Brown, 2000; Swift, 2001). Still, companies ignore it at the risk of being left behind. Simply, CRM is a high-tech way of gathering mountains of information about customers, then using it to make customers happy—or at least a source of more business. It is therefore, concerned with understanding and influencing customer behavior (Kotler, 2000).

One CRM trailblazer was the gaming company Harrah's Entertainment, which has successfully combined software and human marketing expertise to get gamblers into its 25 casinos. Harrah's do a thorough, sophisticated analysis of 24 million customers in their database. Harrah's know—how frequently customers come, what they play, and they then provide follow-up with continuous communication over the phone, direct mail and e-mail and on their Web site. It allows Harrah's to be participatory rather than being simply reactive. Their technologists refer to it as CRM but their managers refer it as their loyalty program.

Although CRM is the fastest-growing business tool satisfaction with its use currently ranks quite low (Winer, 2001). Many companies have started to realize that they need both the mountains of

*Correspondence to: Dr Ranjit Bose, Anderson School of Management, University of New Mexico, Albuquerque, NM 87131, USA. Email: bose@mgt.unm.edu

information on millions of customers as well as an appropriate technical infrastructure coupled with marketing expertise to use CRM satisfactorily (Zeithaml, 2001). CRM is not necessarily about automating or speeding up existing operational processes; rather, it is about developing and optimizing methodologies to intelligently manage customer relationships. Thus, it is about effectively managing and leveraging customer related information or knowledge, to better understand and serve customers.

A true CRM solution design requires a complex combination of many best-of-breed components, including analytical tools, campaign management, and event triggers, combined with the many new components such as collateral management, rule-based workflow management, and integrated channel management needed to achieve a one-to-one marketing capability. This capability dictates the need for a single, unified, and comprehensive view of customers' needs and preferences across all business functions, points of interactions, and audiences (Shoemaker, 2001; Tiwana, 2001). Additionally, it requires the existence of interfaces between non-customer contact systems, such as enterprise resource planning systems (ERP), and operational and customer contact systems.

As organizations move towards a comprehensive e-business environment, the business processes supporting the environment become increasingly, highly knowledge-intensive and therefore, an organization's long-term success and growth become dependent on the successful expansion, use, and management of its corporate knowledge across its business processes (Davenport and Grover, 2001; Liebowitz, 2000). CRM is no exception to this trend, it is moving away from being a transaction-oriented, operational system of the past to a more knowledge-oriented, analytical system of the future that provides the means by which a company can maintain a progressive relationship with a customer across that customer's lifetime relationship with the company (Gordon, 1998; Kalakota and Robinson, 2001). This means having the ability to track and analyze a range of customer actions and events over time, using the information and knowledge from operational CRM systems as well as from other enterprise systems such as KM systems (Wiig, 1999).

Given the important role being played by KM systems in the current customer-centric environment, there is a need for a simple and integrated framework for the management of customer knowledge (Winer, 2001). Surprisingly, there is a lack of a simple and comprehensive framework to integrate the traditional CRM functionalities with the management and application of the knowledge, particularly in the context of marketing decisions (Helmke *et al.*, 2001; Massey *et al.*, 2001; Parasuram and Grewal, 2000). While KM systems manage an organization's knowledge through the process of creating, structuring, disseminating and applying knowledge to enhance organizational performance and create value (Alavi and Leidner, 2001; Davenport and Prusak, 1998; Liebowitz, 1999; Offsey, 1997), traditional CRM have focused on the transactional exchanges to manage customer interactions. True CRM is possible only by integrating them with KM systems to create knowledge-enabled CRM processes that allow companies to evaluate key business measures such as customer satisfaction, customer profitability, or customer loyalty to support their business decisions (Fahey, 2001; Reichheld and Schefter, 2000; Winer, 2001). Such systems will help marketers address customer needs based on what the marketers know about their customers, rather than on a mass generalization of the characteristics of customers.

We address this issue in this paper by presenting an integrated framework for CRM through the application of knowledge management technology. The framework is designed to deliver consistent service across all touch points and channels by providing: (a) a single view of each customer across the entire enterprise and throughout the customer's lifecycle; and (b) an architecture that supports and promotes knowledge-based, analysis-driven interaction with each customer. To test the operational feasibility of this framework, a proof-of-concept prototype has been developed and tested that uses current technologies such as extensible markup language (XML) and intelligent software agents for performing the proposed KM and CRM activities.

Our paper is further organized as follows. First, we present a background literature review on CRM, KM and discuss the uniqueness of our work. We then provide the KM capabilities needed for CRM and the architecture for KM-based CRM. The proof of concept prototype implementation and a demonstration session is then presented. Discussion on the implications as well as limitations of our research and the future research needs are followed by the concluding remarks.

BACKGROUND

Customer Relationship Management

CRM is about managing customer knowledge to better understand and serve them. It is an umbrella concept that places the customer at the center of an organization. Customer service is an important component of CRM, however CRM is also

concerned with coordinating customer relations across all business functions, points of interaction, and audiences (Brown, 2000; Day, 2000).

Delivering consistent service across all touch points gives companies a strong market advantage. When information or knowledge is fragmented within a company, customer feedback is hard to obtain. As a result, customer service suffers and organizations fall back on the mass marketing principle that 'one-size-fits-all'. One-to-one marketing requires a comprehensive view of customers' needs and preferences (Kotler, 2000).

Information technology-driven relationship management by a firm focuses on obtaining detailed knowledge about a customer's behavior, preferences, needs, and buying patterns and on using that knowledge to set prices, negotiate terms, tailor promotions, add product features, and otherwise customize its entire relationship with each customer (Kohli, 2001; Shoemaker, 2001). Offering customers convenience, personalization and excellent service plays a key role in the success and differentiation of many online businesses (Kalakota and Robinson, 2001). CRM focuses on providing and maintaining quality service for customers by effectively communicating and delivering products, services, information and solutions to address customer problems, wants and needs.

Knowledge management

KM is management of a company's corporate knowledge and information assets to provide this knowledge to as many company staff members as possible as well as its business processes to encourage better and more consistent decision-making (Probst *et al.*, 2000). By integrating operational CRM data with knowledge from around the enterprise, companies can make use of the abilities of analytical CRM systems, and with them, make truly customer-centric business decisions. For example, companies can proactively offer products and services that fit a given customer's needs based on what the customer has already purchased, or increase purchase rates by dynamically personalizing content based on Web visitor's profile, or provide customers in the highest value tier with personal representatives who understand their history or preferences.

There is an increased sense of urgency in the institutionalization of comprehensive knowledge management programs due to the fact that the Internet and the World Wide Web are revolutionizing the way enterprises do business (Alavi and Leidner, 1999; Leebaert, 1998; Liebowitz, 2000; O'Leary, 1998). A well-designed KM infrastructure makes it easier for people to share knowledge during problem solving resulting in reduced operating cost, improved staff productivity, cost avoidance, and soft benefits such as increasing the knowledge base, and sharing expertise (Applehans *et al.*, 1999).

The KM framework we present (shown in Figure 1) consists of the following four major processes: (a) knowledge identification & generation, (b) knowledge codification & storage, (c) knowledge distribution, and d) knowledge utilization & feedback. The *knowledge identification & generation* process includes recognition and creation of new knowledge. It focuses on determining the relevant customer, process and domain knowledge needed to successfully carry out CRM activities and acquiring or generating this knowledge by monitoring the activities of customers and other players in the industry.

The *knowledge codification & storage process* involves converting knowledge into machine-readable form and storing it for future use. In particular, it

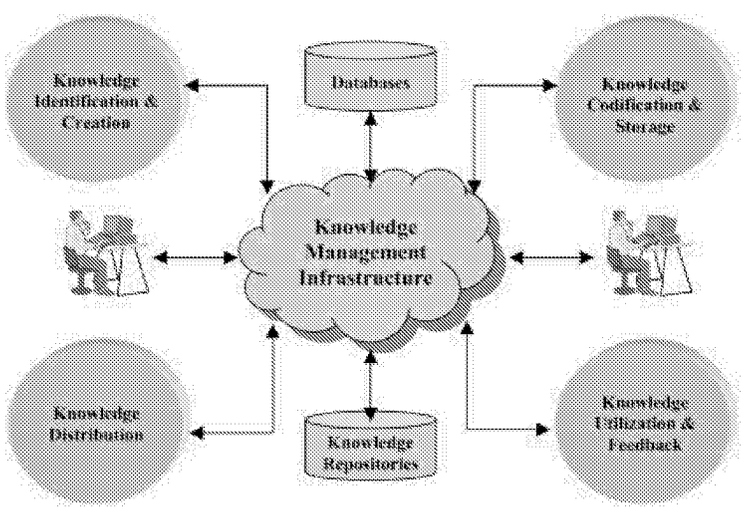

Figure 1. Knowledge management framework

deals with archiving the new knowledge by adding it to a persistent knowledge repository that can be used by all the stakeholders. This process consists of mapping the knowledge to appropriate formalisms, converting it to the internal representation and storing it in the knowledge repository. Current technologies such as XML and the Universal Description, Discovery and Integration (UDDI) formalism can be used for internal representation and storage. These approaches facilitate easy search and retrieval of relevant knowledge from the repositories, and enables the stakeholders to apply this knowledge in decision-making (David, 1999).

The *knowledge distribution* process relates to disseminating knowledge throughout the organization and handling requests for specific knowledge elements that would be useful in working through a specific problem scenario. Knowledge dissemination can employ either 'push' or 'pull' technologies depending upon the organization's culture and infrastructure.

The *knowledge utilization & feedback process* comprises knowledge deployment and providing feedback. This process enables the stakeholders to identify and retrieve relevant knowledge needed for solving a particular problem. Utilization of this knowledge in the context of a specific problem may result in additional knowledge, which can be abstracted out and stored in the knowledge repository for future use. Stakeholders can provide feedback regarding the quality of knowledge stored in the repository as well as how easy or difficult it is to search for relevant knowledge. They can also identify new types of knowledge that need to be gathered based on strategic objectives and the changes that are taking place within the environment.

This research attempts to integrate relevant enabling technologies (Devedic, 1999; Fowler, 2000; Sycara *et al.*, 1996; Wu, 2001) into an environment that would support organizational knowledge creation, use, and management. Two such enabling technologies that we discuss are intelligent agents and XML, which are briefly discussed below.

Intelligent agents and KM

Intelligent agents are useful in automating repetitive tasks, finding and filtering information, and intelligently summarizing complex data (Murch and Johnson, 1999). Just like their human counterparts, intelligent agents can have the capability to learn and even make recommendations regarding a particular course of action (Hess *et al.*, 2000; Maes *et al.*, 1999). Intelligent agents can act on behalf of human users to perform laborious and routine tasks such as locating and accessing necessary information, resolving inconsistencies in the retrieved information, filtering away irrelevant and unwanted information, and integrating information from heterogeneous information sources. In order to execute tasks on behalf of a business process, computer application, or an individual, agents are designed to be goal driven, i.e. they are capable of creating an agenda of goals to be satisfied. Agents can be thought of as intelligent computerized assistants.

XML and KM

Extensible Markup Language or XML is emerging as a fundamental enabling technology for content management and application integration (Balasubramanian and Bashian, 1998; Goldfarb and Prescod, 1998). XML is a set of rules for defining data structures and thus making it possible for key elements in a document to be characterized according to meaning. XML has several valuable characteristics. First, it is a descriptive markup language rather than a procedural markup language. Hence, it is possible to represent the semantics of an XML document in a straightforward way. Second, it is vendor independent and therefore highly transportable between different platforms and systems while maintaining data integrity. Third, it is human legible. It is also worth noting that XML has its roots in SGML (Standard Generalized Markup Language) and adheres to many of its principles.

XML enables us to build a structure around the document's attributes, and RDF (Resource Description Framework) allows us to improve search mechanisms using the semantics of annotations (Decker *et al.*, 2000; Rabarijaona *et al.*, 2000). XML makes it possible to deliver information to agents in a form that allows for automatic processing after receipt and therefore distribute the processing load over a federation of agents that work cooperatively in problem solving. The set of elements, attributes, and entities that are defined within an XML document can be formally defined in a document type definition (DTD).

We contend that by combining intelligent agent and XML technologies, one could envision a knowledge management environment that supports all phases of the knowledge life cycle, namely, creation, organization, formalization, distribution, application, and evolution.

Our contribution

We present an integrated framework, that aims for knowledge-enabled CRM processes, and which supports and promotes consistent, knowledge-based, analysis-driven interaction with each customer. Majority of today's CRM systems are focused primarily

on call centers' operations (Brown, 2000; Massey *et al.*, 2001; Orzec, 1998). Several software vendors are active in this field and are offering initial versions of their products. Examples include Macromedia (ARIA and LikeMinds product lines), Vignette, Engage, IBM (i.e. net commerce), Mathlogic, Microsoft (i.e. Site Server Commerce), NetGenesis, and E. piphany. The analytical CRM system that we propose is just emerging (Swift, 2001). It is designed to provide business intelligence by encompassing knowledge management practices and by leveraging the knowledge gathered from cross-functional customer touch points such as call center, Web access, e-mail, and direct sales.

The ability to leverage the knowledge from customer-facing systems for back-office analysis has recently been proven to be directly proportional to a company's success in enhancing customer loyalty (Reichheld and Schefter, 2000). Without this ability, the environment remains disconnected, and many important business questions cannot be easily answered. For example, a customer service representative scheduling a follow-up communication with a customer may not be able to discern that customer's value score to determine the level of service that should be provided, or an account representative may have no idea whether a key business customer has responded to certain key promotions, or a customer support analyst may try in vain to measure complaint history against sales revenue for a given product.

Analytical CRM systems can incorporate several different types of analytical tools for support personnel. For example, tools for predictive modeling (e.g. behavior prediction uses historical customer behaviors to foresee future behaviors, using sophisticated modeling and data mining techniques) to provide lists of customers most likely to respond to a given marketing campaign, or purchase-pattern recognition, or enabling marketing and sales staff to compare customers with like behaviors so they can position new products to an optimal audience (Berry and Linhoff, 1997; Bose and Sugumaran, 1999; Fraternali, 1999). The keys to different types of analyses, and especially to the actions that result, are (a) knowing a firm's best customers and its unprofitable customers, so it can lure the right ones back, and (b) understanding that CRM has to work for customers, not just the company.

KNOWLEDGE MANAGEMENT CAPABILITIES NEEDED FOR CRM

In order to implement knowledge-enabled CRM processes, companies need to provide and support several categories of knowledge management capabilities through the deployment and integration of currently available technologies (Gold *et al.*, 2001). The capabilities prescribed in this research are primarily intranet and extranet based.

The capabilities framework, presented in Figure 2, is designed around enterprise knowledge portals. Using a portal architecture allows for a common interface to knowledge from different knowledge sources such as documents, applications, and data warehouses (Applehans *et al.*, 1999; Caldwell *et al.*, 2000). The capabilities framework is designed to accelerate the penetration of knowledge management within organizations because the users, who most likely are familiar with the portal concept through the use of Internet portals such as Yahoo, will expect that the interface component of the architecture to offer similar capabilities for knowledge management, such as search engines and automatic document summarization, across an enterprise-wide collection of documents.

At a high level the framework can be explained as comprised of two parts. First, it is designed to leverage existing knowledge and to enable creation of new knowledge through a continuous learning process denoted by the knowledge learning loops. And second, the rectangular labeled boxes denote the KM capabilities and a few currently available techniques or technologies that can provide them. A brief description of each of the capabilities is provided below.

Presentation involves personalizing both the access to and displaying of the results of user interactions with the system. It is designed to let every organizational user know where to go to find the organization's knowledge through a single browser-based point of entry to all information that the user may need. Personalization provides the ability to customize what types of information are relevant to a user and how that information is presented.

The *personalization* function helps personalize content and services to deliver tailored content or information to users based on several user criteria or preferences. The primary capabilities of this function include the creation of personalization profiles of individual users or groups or departments or divisions, providing personalized navigation, providing personalized notification, and the ability to personalize the content categorization. Personalization is often accomplished by using software agents, commonly called spiders, to get the information and handle user profiling.

The *collaboration* function is designed to connect people with people through communities of

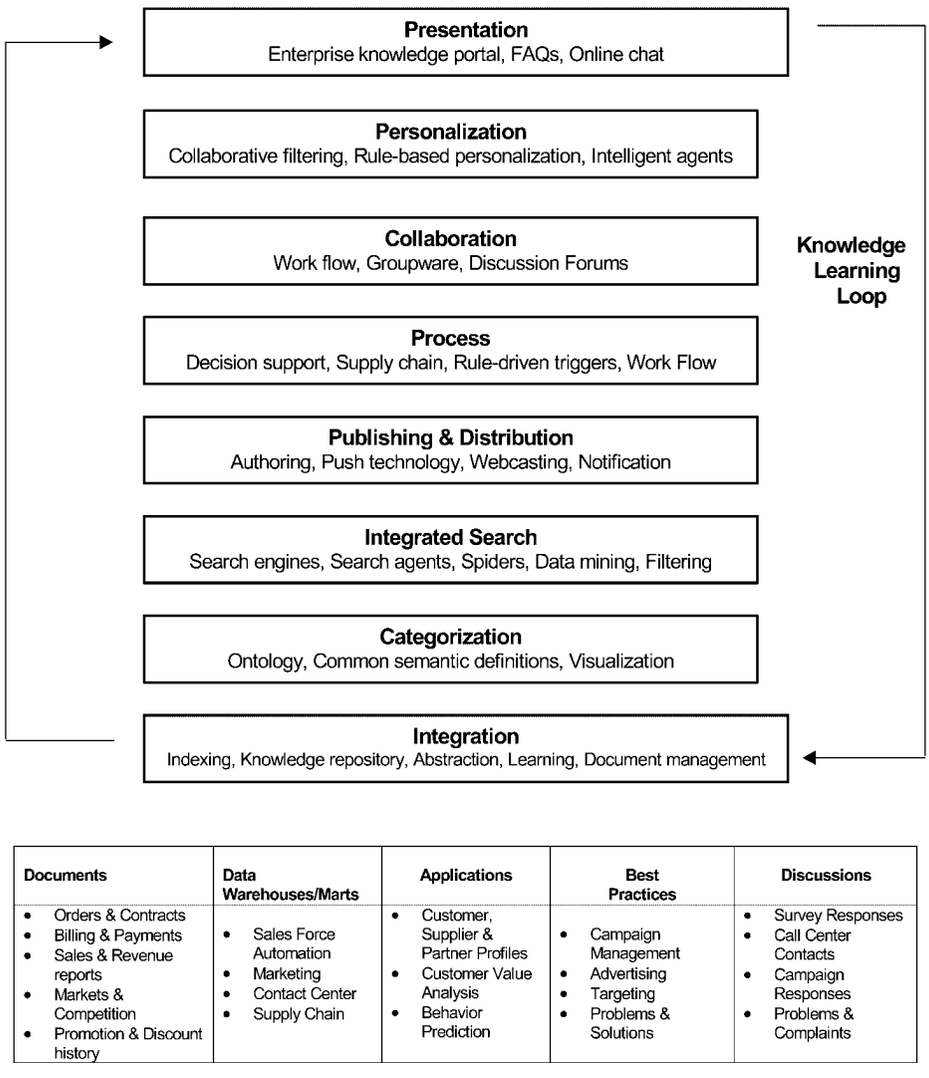

Figure 2. Knowledge management capabilities for CRM

practices; to preserve discussions; and to stimulate collaboration by integrating the knowledge repositories and collaboration applications such as workflow.

The *process* function allows users to participate in relevant business processes in the context of their own roles. Through this function, users have access to knowledge management applications such as knowledge or evidence based decision support system applications that enable increased responsiveness to customers and partners.

The *publishing and distribution* function provides the means and a platform for users to easily capture and distribute the particular kinds of knowledge assets they need to monitor without requiring them to learn complex programming syntax. Software agents are used extensively for this function (Aguirre *et al.*, 2001). These agents are designed in such a way that users can set up and control them. The users can specify in them the type of knowledge he or she wants to publish, distribute, and receive. The frequency (by time and/or quantity) and method (by e-mail or Web page) are important parameters that should be set up by the users.

The *integrated search* function is designed to reduce the information overload and usefulness of search results to the users. Integrated searches across all repositories are performed by default but users can also identify the repositories they want to search such as Web pages, e-mails, and discussions. This function should also provide the ability to automate indexing and to crawl frequently to keep the index current.

The *categorization* function allows users to browse, create, and manage knowledge categories.

It establishes a process and guidelines for authoring and publishing knowledge categories by the users. Business groups or departments or divisions are made responsible for creating and managing their own subject area taxonomies.

The *integration* function ensures seamless and consistent navigation among and between the above functions and knowledge sources such that all individuals can use the organization's combined knowledge and experience in the context of their own roles.

ARCHITECTURE FOR KM-BASED CRM SYSTEMS

CRM projects usually fail because they force a lot of changes quickly on business units and the resulting applications often don't serve customers any better. They also fail to integrate the disparate data sources or provide the right kind of information to the right people at the right time (Parasuram and Grewal, 2000). Hence, CRM applications should have the capability to not only gather and make available relevant information in a timely fashion, but also provide tools for analyzing and sharing the information in a meaningful way and allow managers to act quickly. Knowledge management systems deal with these kinds of issues, particularly, identifying and creating knowledge elements from various sources, codifying, storing and disseminating knowledge, and utilizing this knowledge in problem solving (Nissen *et al.*, 2000). Hence, we contend that a KM-based CRM system would provide precisely the kinds of capabilities needed for a CRM system to be effective in managing lasting partnerships with valuable customers. We envision a KM-based CRM system with components that facilitate the easy gathering and assimilation of customer related information as well as organizational processes and industry practices. We propose an architecture for a customer centric CRM system, shown in Figure 3, that combines the traditional knowledge management capabilities as well as the CRM activities needed for successful CRM initiatives. The proposed architecture consists of four major components: (a) internal and external data sources, (b) knowledge acquisition, (c) knowledge repositories, and (d) knowledge utilization. These components are briefly described in the following paragraphs.

(a) Data sources: Effective customer relationship management requires different types of information from a variety of sources. For example, transaction information may be contained in operational databases, whereas standard operating procedures may be stored in official documents. Data sources may be both internal and external to the organization and the CRM

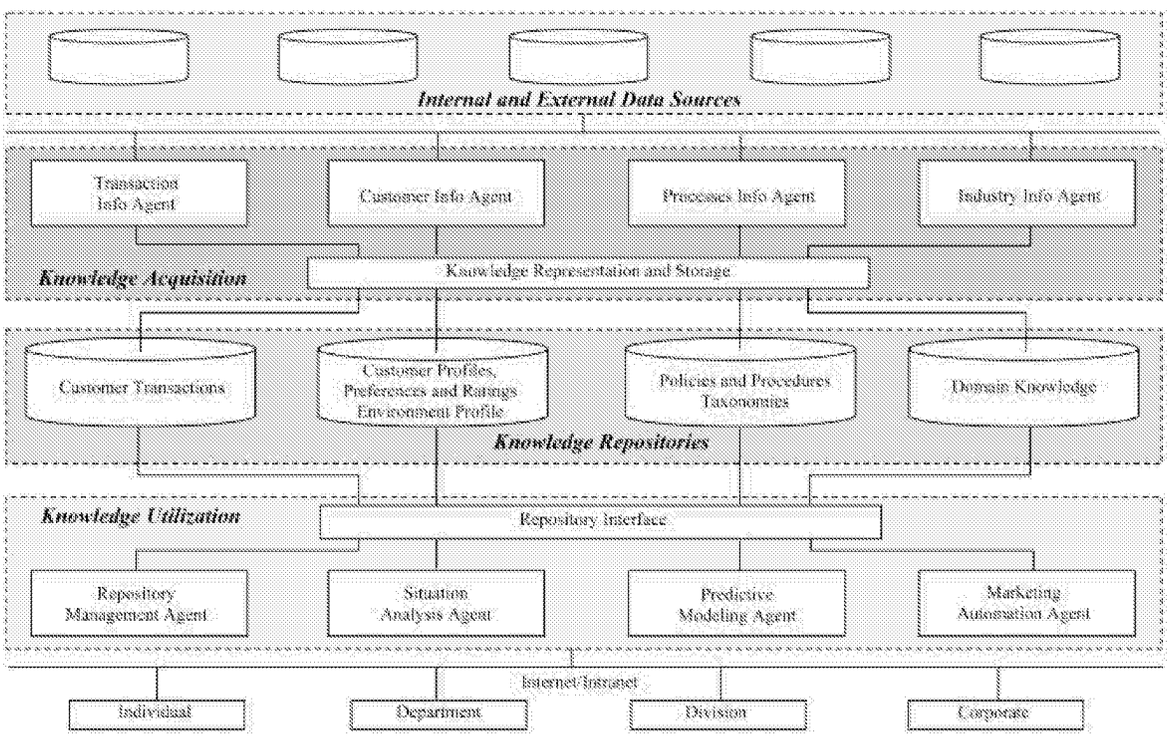

Figure 3. KM-based CRM analytics system architecture

system should have mechanisms to access and retrieve relevant data. For example, the CRM system should be capable of gaining access to not only transaction and customer related information, but also organizational processes and industrywide domain information that would be useful in problem solving and strategic decision making activities. Thus, the CRM system should have an open architecture that is capable of interacting with a wide variety of data and knowledge sources.

Data needed for CRM analytics is very diverse and may be unstructured and difficult to manage (e.g. emails, call reports on PDAs etc.). Emerging information technologies can bridge the gap by: (a) defining standard data formats, such as XML for data presentation or Open Database Connectivity for database-to-database exchanges, (b) ensuring data integrity through proven and published processes, (c) establishing data migration processes, such as storing procedures for graphical data, and (d) choosing CRM analytics tools that support Web browser access.

(b) **Knowledge acquisition component:** This component is responsible for the early phases of knowledge management life cycle, which involves identifying, acquiring and storing relevant knowledge that would be useful in managing customers and products and making meaningful decisions regarding customer service and product service offerings. For example, keeping track of customer histories and characteristics would be essential in determining who, and how best to serve the cliental given various options. The knowledge acquisition component consists of different agents that are geared towards acquiring and synthesizing information related to various aspects of customer relationship management. These agents are: (1) Transaction Info Agent, (2) Customer Info Agent, (3) Process Info Agent, and (4) Industry Info Agent. The Transaction Info Agent is responsible for gathering and assimilating information regarding what products a particular customer has bought over a period of time. This information is obtained by interacting with the transaction databases that exist within the organization. The Customer Info Agent gathers information related to customer preferences and characteristics and keeps track of customer profiles. It is primarily responsible for generating a comprehensive picture of every customer and determining the value of each customer. The Process Info Agent deals with collecting information related to various organizational processes, policies and procedures that have been established and their applicability to different situations. Mostly, standard operating procedures are described in documents, which are not readily accessible to users. This agent creates a repository of these processes and policies for everyone to access. The Industry Info Agent is structured to access data sources outside the organization to gain an understanding of the latest developments that are taking place in the industry and making this knowledge available to decision makers.

(c) **Knowledge repositories:** This component consists of repositories that contain knowledge elements generated by humans as well as the agents that are part of the knowledge acquisition component. These repositories are continually updated as new information becomes available. There are four major repositories that are maintained, namely, (a) Customer Transactions, (b) Customer Profiles, (c) Policies and Procedures, and (d) Domain Knowledge. The Customer Transaction repository contains particulars about all the transactions related to customers. For each purchasing transaction, information about the products and services that the customer bought, discounts that were provided, date of purchase, etc. are maintained so that the customer representative can search and retrieve one or more transaction records for a particular customer. The Customer Profiles repository contains the complete background of each customer including customer history and preferences. It also contains customer ratings and as a result a service representative can quickly assess the value of a particular customer while interacting with that customer, and make appropriate decisions based on the importance of the customer. The Policies and Procedures repository contains information regarding standard procedures and policies that have to be followed in handling a particular situation. It also contains taxonomies of product codes and associated services. The Domain Knowledge repository contains information about the industry in general, and the latest developments and trends within that industry that decision makers have to be aware of, such as changes in governmental regulations, new standards and benchmarks, etc.

(d) **Knowledge utilization component:** The knowledge utilization component is responsible for supporting the later phases of the KM life cycle, in particular, activities related to searching and retrieving relevant knowledge, as well as sharing this knowledge with other stakeholders to

be utilized in different scenarios. It acts as the interface to knowledge repositories. It enables stakeholders to search the knowledge repositories for specific information related to the problem they are solving. This component is also responsible for content delivery (knowledge that may be of interest to certain groups) on a periodic basis. The knowledge utilization component consists of the following agents: (i) Repository Management Agent, (ii) Situation Analysis Agent, (iii) Predictive Modeling Agent, and (iv) Marketing Automation Agent.

(i) **Repository Management Agent:** This agent provides a number of functions for repository management such as organizing, maintaining and evolving the knowledge repositories. It also provides mechanisms for browsing these repositories as well as searching for specific knowledge elements relevant to a particular problem at hand. This agent is also responsible for knowledge dissemination, which includes various aspects such as presentation, personalization, collaboration, and publishing. This agent provides easy access to important and relevant data, in particular, makes more customer data available to call center operators so they can solve customer problems on the first call. This agent disseminates the information mined by analysts to the marketing, sales, and front-line customer service people who could actually use it. It also permits caller identification linked with customer histories and characteristics in order to identify most valuable customers and provide appropriate services.

(ii) **Situation Analysis Agent:** This agent provides mechanisms for the user to undertake problem solving and decision-making activities. For example, a customer service representative may be faced with an angry customer with a complaint. The representative can analyze the situation and reach a resolution quickly based on the customer profile and transaction history. Similarly, a manager has the ability to see which specific products in the store are selling well, badly or according to expected trends, and to take appropriate actions. The manager would have the capability to ask several key questions such as: is the product performing badly because of poor display standards, poor stock availability or incorrect location? Is the product right for the store, does it provide enough profit for the space allocated, could another product's space be enlarged or a new product brought in to provide better profit for the space? Without this capability, store managers may have no way of identifying the most profitable products and allocating more time to these profitable lines.

(iii) **Predictive Modeling Agent:** On the CRM analytics side, the biggest disappointment has been the failure to integrate business logic into the tools. The Predictive Modeling Agent enable managers to conduct meta-analysis and identify areas of strengths and weaknesses. For example, they can watch transactions in real time to spot patterns, such as decreasing transaction rates or balances for a high value customer that indicate that a customer might soon leave. It enables managers to get a grasp on customers' buying patterns, anticipate trends and more carefully align inventory to maximize profits in a chain of stores. Most timely information is of little use unless the corporate strategy aligns with what the customer data is revealing.

(iv) **Marketing Automation Agent:** One of the biggest pitfalls of customer databases is that the best customers are bothered endlessly—surveys, new offers, cross-selling etc. Lack of an integrated CRM system results in alienating customers by making inappropriate pitches and ignoring customers with low current returns but high potential. Another mistake that is often made is segmenting customers on the basis of demographics such as age, income, sex or education because this information is relatively easy to get. But the best CRM systems will segment customers based on fundamental values. The proposed KM-based CRM system will be able to match actual buying information to customer profiles and preferences, which can permit the marketing people to really see trends from individual customers and develop better marketing campaigns.

PROTOTYPE IMPLEMENTATION

A proof-of-concept prototype is currently under development. This prototype uses the traditional client-server architecture, where the client is a simple web browser, using which the user can interact with the knowledge repositories. The user can also perform one or more CRM activities supported by the Knowledge Utilization component. The agents that are part of the Knowledge Acquisition

Component as well as the Knowledge Utilization Component have been implemented using JADE (Java Agent DEvelopment Framework) from CSELT, Turin, Italy (Bellifemine *et al.*, 1999). JADE is a middle-ware product that is used to develop agent-based applications, which are in compliance with the FIPA specifications for interoperable intelligent multi-agent systems. JADE is java-based and provides the infrastructure for agent communication in distributed environments, based on FIPA standards. The reasoning capability of the agents has been implemented through JESS, which is an expert system shell written in Java (Friedman-Hill, 2002). The transaction information, customer profiles and preferences, organizational processes and procedure information, as well as the application domain knowledge are captured and represented in XML documents with appropriate DTDs. These XML documents are stored in the corresponding knowledge repositories, which have been implemented as XML databases using the Tamino software (from Software AG—www.softwareag.com). Among other things, Tamino provides X-Studio, which is a complete suite of application development tools for creating XML-based applications. Tamino XML databases store data directly in native XML format and provide facilities for fast storage, exchange and retrieval of XML documents.

Sample session with prototype: The following paragraphs describe a brief sample session that provides a glimpse of some of the functionalities of the KM-based CRM System prototype. When the user accesses the CRM system, a login screen, shown in Figure 4, is presented where the user can type in the userid, password and the user type. Users are provided different levels of access to control the evolution of the knowledge repositories. For example, not all users can create new knowledge elements and store them in the repository or have access to sensitive information. Some of the typical users of the system are customer service representatives, department heads, division managers and senior executives. Once the user is authenticated, depending upon the type of the user, appropriate menus are presented. Users can also customize the interface to suite their tastes and preferences.

When the user logs into the system, he or she can perform various knowledge management and CRM activities. For example, if the user type is 'customer service representative,' he/she can,

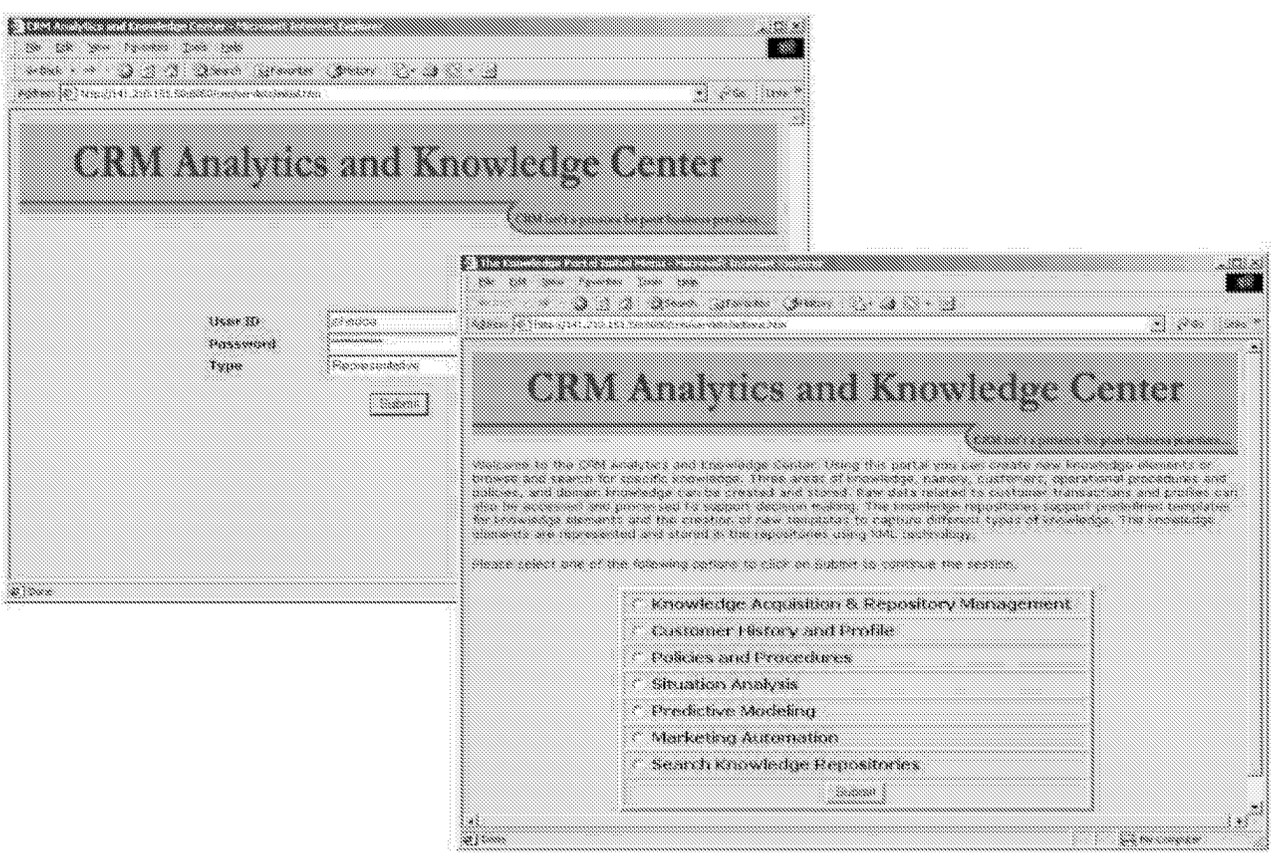

Figure 4. Initial screens from the KM-based CRM system

among other things, view customer profiles and histories as well as perform situation analysis. Figure 4 shows the initial menu that lists the options for carrying out various functions. The user can select any of the options and click on the Submit button to perform that particular operation. The 'Knowledge Acquisition and Repository Management' option enables the user to invoke the knowledge elicitation process from various sources or perform maintenance operation on one or more of the knowledge repositories. The user can explicitly specify tasks for the agents that are part of the knowledge acquisition component, or ask them to gather information on a continual basis. These agents can create new knowledge elements and add them to the appropriate knowledge repository using predefined 'repository management' procedures. The 'Customer History and Profile' option facilitates the user to probe available customer information and generate an up-to-date picture of a particular customer and determine the value of that customer. For example, a customer service representative can pull up the transaction history of a particular customer and get a sense of the value and loyalty of that customer. The customer transaction knowledge repository has been implemented as an XML database and can be searched using customer id or customer name. Figure 5 shows the interface for searching and viewing transaction histories. By default, the system displays the transaction history of a customer as an XML document (bottom portion of Figure 5), and by clicking on the Display button, the user can see the HTML rendering of the document using cascading style sheets.

The user can also browse the organizational processes and procedures knowledge repository or search for specific policies related to a particular situation by selecting the 'Policies and Procedures' option shown in Figure 4. The system provides another panel where the user can specify a few keywords, using which the repository is searched and matching policies and procedures are displayed to the user. The 'Situation Analysis' option enables the user to analyze a particular event or circumstance based on relevant information, and perform

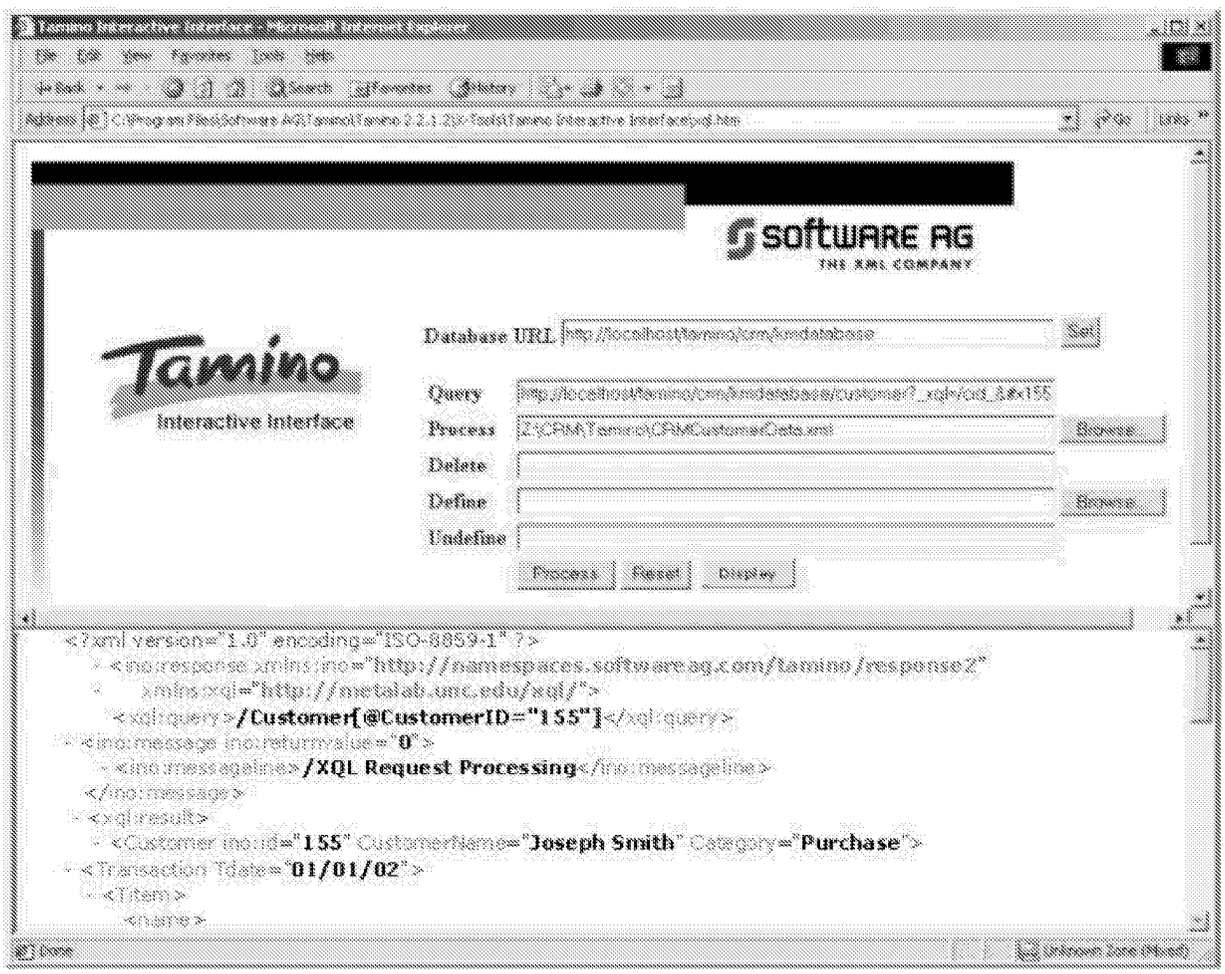

Figure 5. Viewing transaction information for a specific customer

Figure 6. Situation analysis interface

what-if analysis before reaching a meaningful conclusion. For example, a customer service representative may be faced with a situation where a customer is not satisfied with a product or service and is calling up and demanding recourse. In this situation, having quick access to that customer's history and rating, as well as the policies and procedures that dictate how such a case should be handled, can help that representative quickly resolve this situation to the satisfaction of the customer and still stay within the parameters that the representative has to operate under. A simple situation analysis interface is shown in Figure 6. The representative can enter customer information in the 'Customer Info' box and some keywords describing the situation in the 'Situation Info' box and get relevant customer information as well as applicable policies and procedures displayed by clicking on the appropriate buttons. When the user clicks on the 'Recommendation' button, the system provides some recommendations based on pre-established rules. When the user clicks on the customer profile button after entering the customer identifier, an appropriate query is generated to search the transaction and customer profile repositories. The retrieved information is displayed in the window shown in the lower part of Figure 6. Similarly, when the user enters situation descriptors, those keywords are used in searching the policies and procedures repository and relevant policy and procedure information is displayed in the lower window.

The 'Predictive Modeling' and 'Marketing Automation' options (shown in Figure 4) are utilized by managers interested in analyzing the performance of specific products or services and also understanding the customer base for developing specific marketing campaigns and promotions. The 'Search Knowledge Repositories' option (shown in Figure 4) provides ad hoc querying capabilities using which the user can search one or more knowledge repositories for related information.

DISCUSSION

This section highlights some of the major implications of this research. Our approach to integrating

knowledge management techniques into customer relationship management activities provides several advantages. Individuals, various business units, and the organization as a whole can all benefit from the proposed integrated KM-based CRM environment. At the individual level, customer service representatives can browse the knowledge repositories, perform plain-text searches for specific customer information, customer profile and history, and rating. This real time access to relevant information enables the representatives to better serve customers. Different business units can benefit from such a system by being able to gain access to customer and sales information that are gathered through various touch points, as well as the standard policies and procedures that are otherwise not easily accessible. At the organizational level, our system could be utilized in providing a common infrastructure for carrying out customer relationship management activities and institutionalizing a comprehensive set of CRM policies.

The proof-of-concept prototype we implemented, demonstrates the operational feasibility of the proposed KM-CRM integration framework. Current technologies such as intelligent agents and XML technologies were selected and used for implementation because (1) to reduce the cognitive burden on the user in problem solving and decision making activities, and (2) these technologies facilitate the easy integration of knowledge management activities and CRM activities. For example, intelligent agents can be tasked to monitor certain types of transactions or search and retrieve specific customer related information in real time. XML technology permits easy codification and dissemination of knowledge elements to interested parties through push or pull technologies. In addition, it improves the interoperability of knowledge elements between different applications. Traditionally, KM tools use proprietary knowledge structures and internal representations that prohibit the exchange of knowledge between various applications. In contrast, our system uses XML representation, which alleviates this problem to a great extent. Storing customer information in an XML database also facilitates various stakeholders to view information at different levels of aggregation through specific transformations. For example, customer service representatives can query the XML database for individual customer histories and profiles, whereas, marketing people can view customer information based on certain 'value propositions'.

While the implemented prototype incorporates the necessary functionalities and capabilities to adequately prove the operational feasibility of the proposed integration framework, it is by no means a full-blown system. Therefore, the current version of the prototype has the following limitations. First, while we have developed the DTDs for some of the common knowledge elements, much work remains to be done in order to capture all types of knowledge that would be useful in carrying out comprehensive CRM activities. Second, knowledge repositories as well as operating procedures evolve over time in an organizational setting. Hence, the prototype needs additional capability to ensure that the knowledge repositories are consistent with business processes on a continual basis. Third, the prototype currently does not provide application interface to several potential third party software that could be easily utilized in predictive modeling and automating many of the marketing related activities.

Further work is required to bring the prototype to a full-blown system as well as to address some of the issues that arise in integrating knowledge management techniques into customer relationship management. Our future work on the prototype includes incorporating additional components for knowledge acquisition and utilization, and providing APIs for various decision analytic tools for facilitating the creation of an integrated KM–CRM portal with customizable functionalities. The resulting full-blown system will be able to support better query facilities for searching knowledge repositories, particularly, natural language based interfaces that provide flexible query mechanisms. Subsequently, field testing and empirical validation of the full-blown system is necessary to evaluate its effectiveness from the perspective of target users. While the present prototype uses current technologies such as intelligent agents and XML, potential use of other enabling technologies like Ontologies, UDDI (Universal Description, Discovery, and Integration), and Web Services need to be investigated. Future research should also address additional issues related to the integration of KM and CRM activities such as configuring KM activities to align with the overall objectives of CRM initiatives, identifying the types of knowledge needed for specific CRM activities, and managing the evolution of a consistent set of knowledge repositories.

CONCLUSION

Analytical CRM systems achieve a single, unified view of the customer and facilitate a seamless exchange between customers and corporations. However, a single view of customers requires tightly integrated applications both within the

realm of CRM applications and back-end technologies, such as knowledge management. Organizational knowledge creates value in use. A key challenge in the application of knowledge is transferring it from where it was created or captured to where it is needed and should be used.

We tried to address the issue in this research by developing a simple and overall framework to integrate the traditional CRM functionalities with the management and application of knowledge in the context of marketing decisions. The operational feasibility of the framework was tested through a proof-of-concept prototype, which was built using intelligent agent and XML technologies. We contend that the framework can be the basis for enhancing CRM system functionalities and development.

REFERENCES

Aguirre JL, Brena R, Cantu FJ. 2001. Multiagent-based knowledge networks. *Expert systems With Applications* **20**(1): 65–75.

Alavi M, Leidner DE. 1999. Knowledge management systems: issues, challenges, and benefits. *Communications of the AIS* **1**(7).

Alavi M, Leidner DE. 2001. Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *MIS Quarterly* **25**(1): 107–136.

Applehans W, Globe A, Laugero G. 1999. *Managing Knowledge: A Practical Web-Based Approach.* Addison-Wesley: New York.

Balasubramanian V, Bashian A. 1998. Document management and web technologies: Alice marries the Mad Hatter. *Communications of the ACM* **41**(7): 107–114.

Bellifemine F, Poggi A, Rimassa G. 1999. JADE—A FIPA-compliant agent framework. *Proceedings of PAAM'99*, London, 97–108.

Berry MJA, Linhoff G. 1997. *Data Mining Techniques: For Marketing, Sales, and Customer Support.* John Wiley: New York.

Bose R, Sugumaran V. 1999. Application of intelligent agent technology for managerial data analysis and mining. *Database for Advances in Information Systems* **30**(1): 77–94.

Brown SA. 2000. *Customer Relationship Management: A Strategic Imperative in the World of E-Business.* John Wiley: New York.

Caldwell N, Clarkson PJ, Rodgers P, Huxor A. 2000. Web-based knowledge management for distributed design. *IEEE Intelligent Systems* **15**(3): 40–47.

Davenport TH, Grover V. 2001. General perspectives on knowledge management: fostering a research agenda. *Journal of Management Information Systems* **18**(1): 5–21.

Davenport TH, Prusak L. 1998. *Working Knowledge: How Organizations Manage What They Know.* Harvard Business School Press: Cambridge, MA.

David M. 1999. SQL-based XML structure data access. *Web Techniques* **June**: 67–72.

Day GS. 2000. Managing marketing relationships. *Journal of the Academy of Marketing Science* **28**(1): 24–31.

Decker S, Melnik S, Harmelen FV, Fensel D, Klein M, Broekstra J, Erdmann, M, Horrocks I. 2000. The semantic web: the roles of XML and RDF. *IEEE Internet Computing* **4**(5): 63–74.

Devedzic V. 1999. A survey of modern knowledge modeling techniques. *Expert Systems With Applications* **17**(4): 275–294.

Fahey L. 2001 Linking E-business and operating processes: the role of knowledge management. *IBM Systems Journal* **40**(4): 889–907.

Fowler A. 2000. The role of AI-based technology in support of the knowledge management value activity cycle. *Journal of Strategic Information Systems* **9**(2/3): 107–128.

Fraternali P. 1999. Tools and approaches for developing data-intensive web applications. *ACM Computing Surveys* **31**(3): 227–263.

Friedman-Hill E. 2002. Jess, the expert system shell. Sandia National Laboratories, Albuquerque, NM, URL: http://herzberg.ca.sandia.gov/jess

Gold A, Malhotra A, Segars A. 2001. Knowledge management: an organizational capabilities perspective. *Journal of Management Information Systems* **18**(1): 185–214.

Goldfarb CF, Prescod P. 1998. *The XML Handbook.* Prentice Hall: Upper Saddle River, NJ.

Gordon I. 1998. *Relationship Marketing: New Strategies, Techniques to Win the Customers You Want and Keep Them Forever.* John Wiley: New York.

Helmke S, Dangelmaier W, Uebel MF. 2001. CRM-systems as technology enabler for a customer-oriented knowledge management. *PICMET '01—Portland International Conference on Management of Engineering and Technology* **1**.

Hess TJ, Rees LP, Rakes T R. 2000. Using autonomous software agents to create the next generation of decision support systems. *Decision Sciences* **31**(1): 1–31.

Kalakota R, Robinson M. 2001. *E-Business 2.0: Roadmap for Success.* Addison-Wesley: Boston, MA.

Kohli R. 2001. Managing customer relationships through E-business decision support applications: a case of hospital–physician collaboration. *Decision Support Systems* **32**(2).

Kotler P. 2000. *Marketing Management.* Prentice-Hall. Upper Saddle River, NJ.

Leebaert D. 1998. *The Future of the Electronic Marketplace.* MIT Press: Boston, MA,

Liebowitz J. 1999. *Information Technology Management—A Knowledge Repository.* CRC Press: Boca Raton, FL.

Liebowitz J. 2000. *Building Organizational Intelligence—A Knowledge Management Primer.* CRC Press: Boca Raton, FL.

Maes P, Guttman RH, Moukas AG. 1999. Agents that buy and sell. *Communications of ACM* **42**(3): 81–87.

Massey AP, Montoya-Weiss MM, Holcom K. 2001. Reengineering the customer relationship: leveraging knowledge assets at IBM. *Decision Support Systems* **32**: 155–170.

Murch R, Johnson T. 1999. *Intelligent Software Agents.* Prentice Hall: Upper Saddle River, NJ.

Nissen M, Kamel M, Sengupta K. 2000. Integrated analysis and design of knowledge systems and processes. *Information Resources Management Journal* **13**(1): 24–43.

Offsey S. 1997. Knowledge management: linking people to knowledge for bottom line results. *Journal of Knowledge Management* **1**(2): 113–122.

O'Leary DE. 1998. Enterprise knowledge management. *IEEE Computer* **March**.

Orzec D. 1998. Call centers take to the web. *Datamation* **June**.

Parasuram A, Grewal D. 2000. The impact of technology on the quality–value–loyalty chain: a research agenda. *Journal of the Academy of Marketing Science* **28**(1): 168–175.

Probst G, Raub S, Romhardt K. 2000. *Managing Knowledge: Building Blocks for Success.* John Wiley: Chichester.

Rabarijaona A, Dieng R, Corby O, Ouaddari R. 2000. Building and searching an XML-based corporate memory. *IEEE Intelligent Systems* **15**(3): 56–63.

Reichheld F, Schefter P. 2000. E-loyalty—your secret weapon on the web. *Harvard Business Review* **July–August**.

Shoemaker ME. 2001. A framework for examining IT-enabled market relationships. *The Journal of Personal Selling & Sales Management* **21**(2): 177–185.

Swift RS. 2001. *Accelerating Customer Relationships: Using CRM and Relationship Technologies.* Prentice Hall: Upper Saddle River, NJ.

Sycara K, Pannu A, Williamson M, Zeng D, Decker K. 1996. Distributed intelligent agents. *IEEE Expert* **11**(6): 36–45.

Tiwana A. 2001. *The Essential Guide to Knowledge Management: E-Business and CRM Applications.* Prentice Hall: Upper Saddle River, NJ.

Wiig KM. 1999. What future knowledge management users may expect. *Journal of Knowledge Management* **3**(2): 155–166.

Winer RS. 2001. A framework for customer relationship management. *California Management Review* **43**(4): 89–107.

Wu DJ. 2001. Software agents for knowledge management: coordination in multi-agent supply chains and auctions. *Expert Systems With Applications* **20**(1): 51–64.

Zeithaml VA. 2001. The customer pyramid: creating and serving profitable customers. *California Management Review* **43**(4): 118–145.