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EMPLOYING A MULTILEVEL SECURE APPROACH IN CRM SYSTEMS

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ABSTRACT

This research shows how Multilevel Secure (MLS) data models can be used in a Customer Relationship Management (CRM) context. MLS models were originally developed as database models for the management of information in environments characterized by a strict hierarchy of security levels, such as military institutions and government security agencies. Improvements in evolving database technologies have made MLS data modeling practical as well as theoretically appealing. This paper illustrates how an MLS model can be used as a part of the technology for coordinating business-customer interactions with the objective of building long-term customer loyalty.

Several examples are used to show how organizing a database management system based on MLS principles can be used to help businesses provide consistent and appropriate content to various customers and partners. Improvements in flexibility and cost of applications, as well as opportunities for new CRM strategies, are discussed as potential benefits of integrating MLS and CRM technology.

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CONTRIBUTION

CRM systems should enable an organization to maximize the value of the relationship with their customers by providing appropriate content to each party. This paper shows how multilevel secure (MLS) data models can be employed in CRM systems to achieve this objective in a flexible and cost-effective way. MLS models were originally developed for environments that require strict hierarchical levels of security, such as military institutions and government security agencies. Although early implementations were technologically cumbersome and unwieldy, improvements in evolving database technologies have made MLS data modeling practical as well as theoretically appealing. While MLS data models have evolved considerably beyond their initial application to strictly hierarchical, high–security domains, new and practical applications for the technology have not appeared in the literature thus far. Demonstrating a broadly applicable and practical use for MLS modeling can serve not only to improve performance in the widely recognized area of CRM systems, but to generate research interest in the use of MLS in other application domains as well.

This paper demonstrates how these models can be incorporated into CRM strategies requiring the delivery of current, accurate, and consistent and appropriate information. By demonstrating and discussing the situations in which an MLS approach can mitigate CRM systems' problems with information delivery, costs of implementation, flexibility, and management of constant changes in terms of users and content, this paper provides useful knowledge to researchers in the areas of CRM strategies and applications, as well as to practitioners, especially vendors and adopters of CRM technology.

The literature relevant to MLS data modeling and CRM applications has evolved along non-intersecting paths. While MLS models can be incorporated into CRM applications with considerable performance benefits resulting from their inclusion, the integration of these two research domains is not intuitive and has not appeared in the literature to date. Demonstrating the practicality of applying MLS data modeling concepts to CRM application problems is the necessary first step in a mutually beneficial integration of the two research domains.

INTRODUCTION

The introduction of virtual supply chains and other e-commerce related technological advances have altered the character of business-to-business (Klose and Lechner 1999) and business-to-customer relationships (Alt and Fleish 2001). Cognizant of declines in customer loyalty[1] and increases in customer service expectations (Larson 2000), customer relationship management (CRM) has become a central business strategy for many companies (Newell 2000). Customer relationship management (CRM) is defined as an enterprise strategy that leverages technology to integrate all facets of a business in order to build customer retention and loyalty over time (Crosby and Johnson 2000b). CRM coordinates marketing, selling, and service activities across the organization and even between organizational partners (Swift 2000). In simple terms, CRM involves the intelligent deployment of database technology to the management of all customer interactions with the company (McKenzie 2001).

E-business strategies, in particular, emphasize personal integration and the building of customer relationships. It is estimated that approximately 40% of E-businesses have made investments in CRM communications technology. E-business categories that have been early and dominant

[1] Bain & Co. reports that on average, U.S. corporations can expect to lose half of their customers within five years (Crosby and Johnson 2000a).

adopters of CRM strategies include: electronic product catalog providers (Lincke 1998), product-search service providers (Liu, Lin, Chen, and Huang 2001), and retail service providers such as e-grocery services (Burn and Barnett 2000) and financial service providers (Körner and Zimmerman 2000). Regardless of the product or service category, CRM communications strategies must take into consideration all phases of the customer buying process, from pre-purchase to purchase to post-purchase and after-sales service, and the types of interactions required at each stage (Rust and Lemon 2001). The challenge is to communicate with customers at the right time, in the correct manner, and on the correct topic (Calaminus, Kloepfer, Kundisch and Wolfersberger 2001) in order to manage single-customer, multiple product relationships (Keefe 2001).

Categories of CRM software and service providers include: 1) ECCRM-related – Internet-specific solutions focused on e-mail management tools (e.g., eGain and Kana Communications); 2) sales force-automation solutions – CRM features added to ERP software suites (e.g., Siebel and PeopleSoft); and 3) call center-related – Net capabilities added to existing call center systems (e.g., Clarify and Remedy). Industry sources report that the worldwide sales of CRM technology in 1999 have reached $2.3 billion, where sales of between $25-46 billion are anticipated by 2005.

Despite the steady growth in number of worldwide installations and sales, not all is perfect in the world of CRM applications. Industry studies suggest that approximately 60% of CRM software installations are failures (Crosby and Johnson 2000b). CRM applications are prone to problems associated with application flexibility and data management as a function of scale. As CRM related databases grow, problems related to their maintenance assume greater significance. Multi Level Secure (MLS) data models offer a technically elegant alternative to many of the procedures currently used to manage the types of problems associated with large-scale databases typical of CRM applications. Organizations have traditionally experienced limitations of pre-packaged software with respect to issues of flexibility, cost and competitiveness (e.g. Butler 1999; Lucas, Walton, and Ginzberg 1988) and pre-packaged CRM applications have heretofore necessarily assumed a relative homogeneity of organizational customer relationship management business processes and strategies. One of the most significant problems with current CRM software offerings is the lack of flexibility that allows for customized integration and updating (Crosby and Johnson 2000a).

CRM application providers frequently force businesses to adapt their business processes to fit applications rather than adapting the applications to fit their business processes (Greenberg 2001). Standardization of the technology makes it challenging for businesses to modify their systems when their needs change, either in terms of data management, including the updating of customer data and content-related information, or with any change to their business processes. Businesses with complex information systems or businesses with customers having complicated information needs may not be able to alter their business processes to fit the applications, or the adaptations may require a significant investment of corporate resources.

While CRM systems are typically delivered using standard DBMS technologies, the nature of data access in many CRM applications often demands process logic and data semantics that go beyond the inherent properties of relational databases. For example, customer loyalty, reward and incentive (a.k.a. frequent buyer) programs frequently require rather complex data structures to accommodate the multiple views of data relevant to various customer segments. In addition, successful CRM applications often exhibit relatively volatile data content. Although these requirements can be satisfied through the use of arbitrarily complex table definitions and extensive procedural scripting, the heterogeneity of sub-schema requirements and data volatility that are found in many CRM systems are much more readily manageable through the use of MLS data modeling.

An approach to providing increased flexibility in CRM applications in a cost-

effective and technologically efficient manner would be of great value to current and potential CRM users. After more than a decade of development in relative obscurity, MLS data modeling has matured and now emerges as a practical means to delivering desired enhancements to the capabilities of pre-packaged CRM systems.

The remainder of the paper is organized as follows: Section 2 describes various database access strategies, including an overview of the MLS approach. Section 3 illustrates how the MLS approach can be applied in the CRM context and Section 4 discusses the integration of MLS and CRM technology. Section 5 summarizes the findings and indicates the directions of the authors' future work in this domain.

DATABASE ACCESS APPROACHES

This section describes database access models typically utilized in contemporary CRM software tools, identifies aspects of those models that pose potential problems to CRM users, and proposes an alternative approach which can address those problems and enhance the performance of existing CRM solutions. The vast majority of contemporary CRM software applications are built around a relational database. The main goal of CRM applications is to present, in a timely and consistent manner, the right content from a database to its users. The right content is defined in terms of satisfying a customer's explicit and latent informational needs while matching the mental abilities, context, and environment of the customer (Calaminus, Kloepfer, Kundisch, and Wolfersberger 2001). In some cases, the content is distributed in a process that does not involve customers accessing a database (e.g. when companies send unsolicited customized e-mail messages with appropriate content to their current or potential customers). However, there are many cases when providing the right content requires providing some form of database access, either directly to customers (e.g. during on-line shopping) or to customer service representatives that are dealing with customers (e.g. when a customer service representative is dealing with a customer complaint via phone). In such cases, a database access control strategy must be chosen and implemented.

There are three distinct approaches to content access in databases. The first and simplest approach is to allow *open access* to all information by all users. However, this method does not offer any access control and contradicts the objective of providing appropriate content. Overwhelming a customer with a multitude of information, without regard to the customer's informational needs, mental abilities, or current situation, can be as counter-productive as giving the customer no information at all. In addition, open access is especially unsuited for the world of short-term relationships, where a current partner may become a competitor in the near future.

Two other approaches involve providing access control by the means of either *discretionary access control* or *mandatory access control* (Castano, Fugini, Martella, and Samarati 1996). Discretionary access control, currently the most widely used method, is based on granting and revoking privileges for the usage of system objects (portions of content). Access privileges are granted (or revoked) individually to every system user for every system object, and the information about these privileges is maintained in a user/object matrix. While this approach provides a great deal of flexibility in dealing with each individual customer or partner, it requires extensive maintenance, especially if the volatility of the database is high (e.g. the pace of forming and breaking relationships is very fast) or if a large amount of information is shared between various users.

Finally, the *mandatory access control* approach creates an environment in which the potential participants, as well as the data, are grouped into a finite number of access classes. With a mandatory access control policy, access to data is determined solely by the user's and data object's membership in access classes. Systems that implement mandatory access control are referred to in the literature as MLS systems, and their potential applicability has been mostly considered from the perspective of database systems containing extremely sensitive information with very strict access and security requirements. Environments such

as intelligence or military systems have commonly been viewed as the primary test-beds for these systems. Most of the original research in this area was sponsored by military institutions (e.g. - U.S. Navy) and published outside traditional business-related research channels. Consequently, CRM solution providers have shown little interest in mandatory access control, mostly due to a lack of awareness of the existence and applicability of MLS models.

MLS models; such as the Jajodia-Sandhu Model (Jajodia and Sandhu 1991), the LDV Model (Haigh, O'Brian, and Thomasen 1991), the Smith-Winslett Model (Smith and Winslett 1992), and the MLR Model (Sandhu and Chen 1995); are based on the classification of system elements, where access levels express classifications. Each subject (user) is assigned to one access level, while access levels of objects (individual pieces of data) are marked by access labels. Since objects can be accessible by either one or multiple access levels, object's label can contain one access level or a list of access levels. In MLS models, access levels and the relationship *dominates* can form a totally ordered set or a partially ordered lattice. An access level l_1 *dominates* another level l_2 (stated as $l_1 \geq l_2$), if l_1 is higher than, or on the same level as l_2 in the partial order of access levels. For example, consider the following environment with three-access-levels:

- T - Top
- M - Middle
- B - Bottom

where T is a higher classification than M and B, and M is a higher classification than B. In this example, the Top access level dominates the Middle access level, which in turn dominates the Bottom level: $T \geq M \geq B$. According to Bell-LaPadulla's so-called *simple property* (Bell and LaPadulla 1974) a subject (e.g. a user belonging to a particular customer group) can read a certain object (e.g. data revealing a particular detail of product description) only if the subject's access level dominates the object's access level. In other words, a subject cannot read an object at a higher or incomparable access level than the subject: a user with access level B cannot read objects labeled as M and T and a user with access level M cannot read objects labeled as T.

One of the most significant contributions made in the development of the MLS model is the addition of semantics based on the concept of belief (Smith and Winslett 1992), where users see and believe the contents of a database at their own level, and see the data objects at lower access levels. For example, in the previous environment, with three access levels, a member with access level T can see T, M and B objects, but believes only that T objects accurately represent the real world situation, and makes no such assumption about M and B objects. In belief-based models, the term "belief" is used (instead of knowledge) because the values for the same attributes of the same data object can be different at various levels.

As a result of progress in database technologies throughout the 1990's, MLS data models are now practical from a perspective of implementation feasibility[2]. However, while simplifying the management of access rights when compared to the discretionary access control methods, these models presented users with a difficult-to-interpret blend of information from the user's own access level and from the lower access levels (Jukic and Vrbsky 1997). This ambiguity was addressed and eliminated by the Belief-Consistent Multilevel Secure (BCMLS) Model (Jukic N., Vrbsky, Parrish, Dixon, and Jukic B. 1999) that provides a comprehensive method for asserting and interpreting beliefs about information at lower access levels. BCMLS recognizes that a higher-level user has several different possible interpretations of the lower-level information they see, depending on the existence of confirming or contradicting information on their level. A higher-level user can interpret lower-level information as

[2] For the list of major contributions related to access control models and the in-depth analysis of the advantages and shortcomings of various particular models we refer the reader to two comprehensive sources: a book (Castano, Fugini, Martella, and Samarati 1996) and a journal article (Jukic N., Vrbsky, Parrish, Dixon, and Jukic B. 1999).

true and complete, i.e. consistent with a higher-level "view of the world". For example, if an inventory quantity of the Product X – Red Hammer is listed as 100 on level B, each user on level B will view this number as correct information and users on M and T level may also view this number as correct information. On the other hand, a higher-level user can interpret lower-level information as partially different, i.e. inconsistent with a higher-level view of the world - where some attribute value for the same entity may appear the same to both higher and lower level user while another attribute value appears different. For example, if an inventory quantity of the Product X – Red Hammer is listed as 100 on level B and the inventory level for that same product is listed as 120 on level M, each user on level M will view the B level information about the description of this product (Product X - Red Hammer) as correct. However the B level listed inventory quantity 100 for this product will be viewed by M level users as incorrect information, due to the fact that M level listed inventory quantity for this product is 120.

The BCMLS model enables the unambiguous interpretation of all visible information and gives the user access to the beliefs of lower level users. This feature is of great importance for the successful management of information in environments with dynamically changing content and constituent members, since it ensures that all users can present and interpret varying views of information, allowing them to relate with other users in a consistent fashion. The next section illustrates how providing belief support necessary for unambiguous interpretation of all visible information can be applied in the context of providing CRM system features used to promote customer satisfaction and loyalty.

APPLYING THE MLS APPROACH IN THE CRM CONTEXT

While recent research in the area of mandatory access control deals with processing (Atluri, Jajodia, and Bertino 1997) and limitations (Smith, Blaustein, Jajodia, and Notargiacomo 1997) of multilevel transactions, expanding the logic of MLS query languages (Jamil, 1999), and combining various access policies (Jajodia, S., Samarati, P., Sapino, M., and Subrahmanian, V. 2001), scant attention has been given to the practical applicability of MLS systems within business related information systems. In this section we provide a discussion of how and under which circumstances the MLS approach can be used to store and represent content in an information-related CRM context within an organization with multiple constituencies.

When MLS models are used in a highly secure environment (e.g. military) to provide access control to sensitive information; providing different information about the same fact on lower and higher level can be used to deliberately mislead non-screened lower level users in order to protect classified higher-level information. However, in customer related scenarios, MLS models are used only to ensure that each customer is given all the information that is pertinent to them.

To clearly illustrate the applicability of this data management approach we use examples involving a particular retailing scenario. This scenario is general enough to reflect common aspects of relationships between a large variety of product/service providers and their customers. The common theme is businesses' desire to communicate with different constituencies in a consistent manner without alienating or confusing any customer group.

Example 1:

A rare-books store Andes, classifies its customers either as Special (S), Valuable (V), or Regular (R). The bookstore wishes to depict differing information about availability of books to different groups of customers in view of the fact that certain books are available for sale at varying dates for different customers. In particular, the book "Wiggle Worm" becomes available for advance purchase by special customers on 1/1/2002, for valuable customers on 1/15/2002, and it becomes available to regular customers on 2/1/2002. The book "One More Trip" is available for purchase by special customers beginning from 1/2/2002 and for purchase by valuable and regular customers beginning from 1/10/2002. The book "Blind Faith" is

available to all customers at the same time and the starting availability date is 1/3/2002.

Figure 1 shows a BCMLS table that can be used to store and manage the information described in this scenario.

This table uses three totally ordered access levels: R-regular, V-valuable, S-special, where S dominates V, and V dominates R ($S \geq V \geq R$). All information is classified by an access label that lists the access levels that are allowed to view it. The open access level R represents the information accessible to all customers. The valuable access level V is available to valuable and special customers. Finally, the special access level S is available for valuable customers only.

As shown in Figure 1, the access labels for data can contain more than one access level, if a particular entry is accessible to more than one subject (customer) access level. However, the view of labels will be different, depending on the access level of the subject (customer) viewing the data. For example, a label RVS will be visible to the R level customer as R only, to the V level customer as RV, and to the S level customer as RVS. All three levels interpret RVS labeled information as "true and complete" R information.

The MLS based approach also allows for more than simple ordering of access through addition of labels. For instance, combinations of labels that warrant different interpretations on the different levels can also be used. For example a label R-VS would be visible to the R level customer as R only, to the V level customer as R-V, and to the S level customer as R-VS. R level customers would interpret such information as complete but V and S level customers would interpret that same information as incomplete or not truthful (i.e. partially or completely different), expecting an additional entry with more complete information. Similarly, the information labeled as V-S would be interpreted as true and complete by the V level customer, but the S level customer would interpret that same information as incomplete or not truthful (the R level customer would not even see the S-V labeled information).

The access level label is the key feature of this model, and its purpose is to ensure belief consistency. In addition to level labels for individual attributes, there is a separate access level descriptor (attribute) for entire rows, as shown as the last column in Figure 1. The label states at which level (or levels) a particular entire row is visible and accepted as either complete (labels not preceded by a dash) or incomplete (labels preceded by a dash). The simple property (mentioned in Section 2) ensures that users at access level S can see all six rows, while users at level V are allowed to see the four rows whose row label contains level V, and users at level R are allowed to see the three rows whose row label contains level R.

As shown in Figure 1, each attribute has its own label that refers to the truthfulness and completeness of the attribute value itself. Some information, such as the book titles, is labeled RVS, which indicates that it interpreted as complete by all three levels: R, V, and S. On the other hand, information such as January 10, 2002 availability date of the book "Blind Faith" labeled RV-S is interpreted as complete by R and V users and as incomplete by S users.

Book Name		**Available From**		**Level**
Wiggle Worm	RVS	January 1, 2002	S	S
Wiggle Worm	RVS	January 15, 2002	V-S	V-S
Wiggle Worm	RVS	February 1, 2002	R-VS	R-VS
One More Trip	RVS	January 2, 2002	S	S
One More Trip	RVS	January 10, 2002	RV-S	RV-S
Blind Faith	RVS	January 3, 2002	RVS	RVS

Figure 1: Andes Book-Availability Table

In the table shown in Figure 1, the three rows containing information about the book "Wiggle Worm" provide relevant data about that book as needed by three different levels of access. Regular customers (with access level R) see (e.g., on a web site) the "Wiggle Worm" availability date as the date when this book will be available to be purchased by them. The valuable customers with access level V see "Wiggle Worm" available date (January 15) as a date that is earlier than the availability date for regular customers (February 1). Finally, the customers with the access right S see the "Wiggle Worm" available date as January 1, which precedes the availability dates for valuable and regular customers. Customer representatives possessing S access rights and knowing the complete information about "Wiggle Worm" availability date, as well as what other access levels perceive and believe is the availability date, can therefore communicate with all three levels in a consistent fashion and provide the right content to every customer. For example, when the regular customer Joe R. logs on the Bookstore Andes web site in order to find out the availability date for "Wiggle Worm", he will see that the book will be available from February 1. In case Joe R. decides to acquire the information about "Wiggle Worm" availability by calling the Bookstore Andes call center instead, a call center representative will give Joe R. the same information, knowing that Joe R. is a regular customer inquirer. If a valuable customer Jane V. calls the same call center representative with the same question, the answer will be different (January 15), because the call-center representative knows that Jane V., as a valuable customer, is to be given different information about the date of availability for "Wiggle Worm."

The first example demonstrates how an MLS database may be used to enable the delivery of the right content, in cases when the right content must be chosen among different possibilities. In addition to illustrating the delivery of the right content, the second example demonstrates how an MLS database can be used to deliver multiple versions of the content in an unambiguous manner that can enhance the customer experience.

Example 2:

The bookstore Andes decides on the following award schema for the customers using their web site. Valuable customers will receive free shipping via USPS, while special customers will receive free shipping both via USPS and via FedEx. Regular customers pay $3.99 for USPS while both regular and valuable customers pay $10.99 for FedEx shipping. In order to contribute to the process of building and maintaining a long-term relationship with all of its customers, Andes would like to disseminate the information about the awards in a way that clearly indicates the benefit to the awarded customers, without alienating the non-awarded customers.

Figure 2 shows an MLS table "Andes Book Store – Shipping Table" that organizes shipping information in this example scenario.

As depicted in Figure 2, Andes bookstore is able to propagate the right content to the right customer by simply assigning the appropriate access level to each customer. Not only does each customer get the correct shipping price, but the customers on higher levels also can explicitly see the benefits of their status. For example, S level customers see that both USPS and FedEX shipping is free for them, while seeing at the same time that R level customers pay $3.99 for USPS shipping and that R and V level customers pay $10.99 for FedEX shipping. Meanwhile, customers on the lower levels should not become alienated, due to the fact that they are not shown the benefits provided to the customers on the

Service Name		Price		Level
Shipping USPS	RVS	$3.99	R-VS	R-VS
Shipping USPS	RVS	Free	VS	VS
Shipping FEDEX	RVS	$10.99	RV-S	RV-S
Shipping FEDEX	RVS	Free	S	S

Figure 2: Andes Book Store - Shipping Table

higher levels. For example, R level customers only see that the price for USPS shipping is $3.99 and the price for FedEx shipping is $10.99.

As these example scenarios illustrate, an MLS approach can easily be applied in a CRM information provision context. A possible criticism of the use of the MLS models (based on the mandatory access control approach) over existing solutions (using the discretionary access control principle) is that it requires the placement of users and information into a finite number of discrete categories. Consequently, it may be suggested that MLS models offer less customization potential than alternative relational database methods that underlie current CRM software applications. However, this theoretical limitation is unlikely to be problematic in most real-world cases. While the idea of ultimate personalization is conceptually appealing, it is in many cases unnecessary, as companies are discovering when struggling with the implementation of mass customization product delivery strategies. As segmentation theory has repeatedly demonstrated over the past twenty years, customers tend to cluster into a finite number of groups, sharing similar characteristics and having similar needs and requirements. It is more effective for businesses to group customers into segments (or classes) when designing CRM strategies than to treat each individual customer in a unique fashion. When developing and implementing CRM solutions, it is important for companies to enhance customers' value perceptions, build loyalty, and also be cost-justifiable. MLS models offer a practical approach to achieve all three of these objectives.

INTEGRATING MLS AND CRM TECHNOLOGIES

The previous section demonstrated how an MLS model can be used to support CRM processes. The current section considers the advantages of using MLS models instead of traditional RDBMS (Relational Database Management Software) in the context of CRM applications. A closer look at the example scenario is presented here in the context of evaluating the benefits of MLS with regard to implementation cost and integration flexibility of CRM software solutions, delivery of consistent and appropriate information, and management of dynamic changes among users and content.

Figure 3 shows how the database part of the Andes' CRM system would have to be configured in order to represent the shipping information described in the example scenario, using the discretionary access control approach. Discretionary access control requires the maintenance of a separate set of read privileges for each row.

Unlike the system of labels in an MLS model, there are no embedded semantics that explain the meaning of multiple records associated with the same entity in a discretionary access model. For example, the table shown in Figure 4 does not contain information about the meaning of two separate records for FedEx Shipping. It simply states the following: S customers can see two different prices for FedEx shipping – Free and $10.99. The fact that S customers have free S shipping and that they are also supposed to see that R and V customers pay $10.99 for the same service, is not captured by the database. In order to deliver consistent and appropriate

Service name		Price	*Readable by*
Shipping	USPS	Free	**V, S**
Shipping	USPS	$3.99	**R, V, S**
Shipping	FEDEX	Free	**S**
Shipping	FEDEX	$10.99	**R, V, S**

Figure 3: Andes Book Store - Shipping Table with Separate Row Privileges

information to the users, a CRM application based on this database would have to address this issue by an additional layer of business logic, i.e. coding-in the semantic that explains the meaning of multiple records. However, a CRM application based on the MLS table (shown in Figure 3), could utilize the already embedded semantics of access labels.Consequently, the development of the CRM application should be faster and less costly.

In the discretionary access approach, if several customers are to be given access to the same content in the database, they have to get the same access privileges as a group, which is typically done by the database administrator(s). If a customer is subsequently assigned to another group, his entry must be deleted from one group and written in another. Every time a group is to be given access to new database content, a new privilege has to be created, again by the database administrator(s). In short, many of the dynamic changes among users and/or content require maintenance effort by database administrators in the form of assigning, revoking, or re-assigning privileges. In contrast, in a database organized on MLS principles, many of the same changes are handled by simply changing the access label of a user or the access label of content. In other words, the management of dynamic changes among users and content is greatly simplified by the MLS approach.

On the surface, using an MLS model in dealing with non-technical customers and clients might appear somewhat complex due to the access label system. However, it is a relatively straightforward task to incorporate the access label management function(s) into the front-end applications that utilize a database. In fact, many technical complexities are ultimately irrelevant. For example, the widespread use of relational databases is prevalent in business settings despite the fact that most of the general user population is not fully aware of what a relational data base model is. Benefits of an MLS approach can be realized transparently, in much the same way. For example, Figure 4 shows a web-based interface to the Andes Book Store database used by various users.

The application interface shown in Figure 4 could be based either on the table in Figure 2 (MLS) or on the table in Figure 3 (regular relational database with discretionary access control approach). However, as stated earlier, the source code for application based on the table in Figure 4 would be substantially larger and more complex, due to the fact that it would have to incorporate interpretation semantics, which would involve steps such as: search and comparison of the values stored in the table, examination of the read privileges of the table, and determining the meaning of each record meaning based on assigned and non-assigned privileges. On the other hand, the source code for the application of the table in Figure 2, would only have to incorporate the simple logic for interpreting access labels.

While the examples presented have considered issues related to database volatility and dynamic content, MLS models also offer advantages in terms of data volume and scaling. By dramatically reducing the required level of explicit data administration, MLS modeling enhances an organization's ability to respond rapidly to changes in its environment. On the other hand, developing an MLS based CRM application certainly introduces its own complexities, especially in the initial design stage. For many years, one of the more significant obstacles to utilizing an MLS approach was a general lack of availability of commercial MLS software implementations. However, an MLS system can be implemented as an embedded application within an existing relational database management system, using regular RDBMS products (such as Oracle 8i, MS SQL Server, or IBM DB) by utilizing triggers and stored procedures. In addition, some vendors now offer, integrated with their RDBMS tools, features specifically designed to enable development of MLS applications[3].

[3] For example Oracle has recently developed a customizable row-level access control feature based on security labels (Oracle Label Security), accompanied by a GUI administration tool (Oracle Policy Manager).

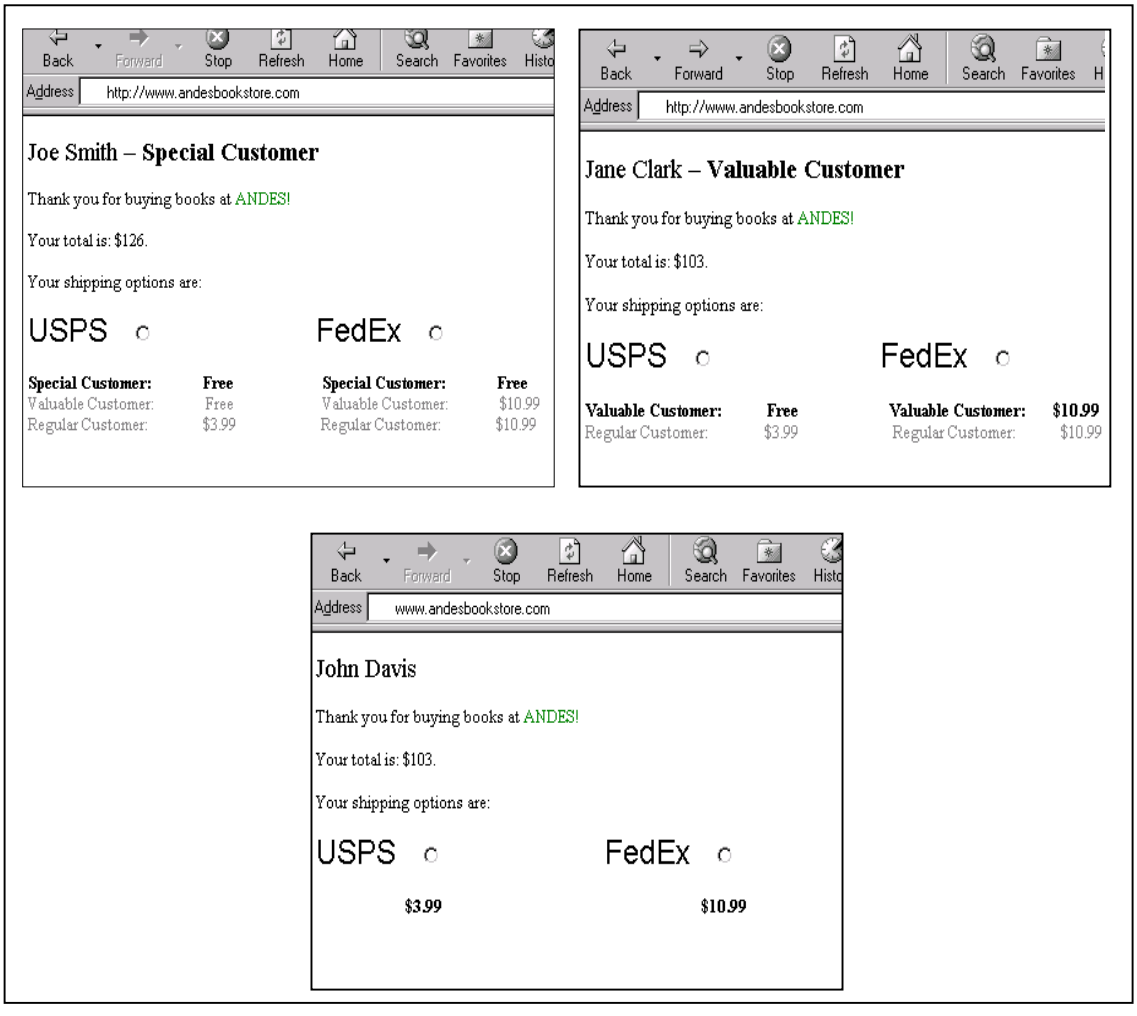

Figure 4: A sample of Andes Bookstore interaction with users from different groups (S, V, and R)

MLS models can provide a platform for implementation of CRM solutions to software vendors and in-house development teams alike. Investing time and effort within an organization in implementing the MLS approach on the database side of systems can result in meaningful improvements in deployment and management of underlying CRM applications, especially in cases when such applications support large number of users that have varying views of the shared information. CRM application developers should carefully consider the potential advantages offered by the MLS approach and determine if the initial effort of embedding the MLS logic into their RDBMS databases will be rewarded by the availability of added semantics and the reduced need for future maintenance and administration.

CONCLUSIONS AND FUTURE WORK

Organizations increasingly use information in a proactive rather than reactive manner. The recent and dramatic proliferation of virtual organizations, inter-organizational systems, and other E-business applications has greatly increased the need for flexible, multi-purpose data management techniques (Scharl 1998). One of the most rapidly expanding application categories in this area is CRM. An examination of the underlying database technologies utilized in these applications

suggests that functional improvements may be realized through the incorporation of multi-level secure (MLS) data models.

Although widely known and proven in non-commercial environments with strict security requirements, MLS models have yet to be commercially exploited. As we have shown in this paper, CRM applications are a natural domain for MLS data modeling. While it is possible to develop CRM applications to provide different views of the same information to various groups (of customers, clients, and/or partners) based on regular discretionary access schemes, this paper demonstrates that utilizing MLS principles can result in simplification and improved efficiency of the application development process. The ease with which MLS systems handle poly-instantiation[4] could inspire practitioners to consider new customer relationship strategies, which previously would be deemed either non-implementable or prohibitively expensive (when using a traditional discretionary access approach).

Consumer-centric orientation is being adopted by contemporary businesses (especially E-businesses) as a necessary condition for competing effectively in today's marketplace. CRM links people, processes, and information via technology to provide maximum customer satisfaction at all stages of the purchase process (including post-purchase). Utilizing MLS models for CRM applications addresses the shortcomings of current systems - including the delivery of appropriate information in a consistent and interpretable format, the reduction of implementation costs by allowing for flexible integration within the organization, and allowing for dynamic updates of users and content in a feasible manner. With the introduction of MLS models for CRM functions, many businesses should be able to meet (or exceed) consumer expectations more effectively than at present, thereby fostering the development of business-customer relationships and engendering customer loyalty.

We are currently conducting a comprehensive experimental study, to further examine the benefits of utilizing MLS technology in the CRM processes. The current phase of the research employs a web-based application (an expanded version of the example shown in Figure 4), which incorporates two versions of a virtual storefront. Both storefronts offer products and services to several totally-ordered groups of users. One of the storefronts presents users with the information that pertains only to their level. The other storefront implements MLS concepts and presents users with the information that pertains to their level and the levels below. The main focus of this study is to measure the difference in perceived customer satisfaction when customers are made aware of poly-instantiation. We plan to publish the results of the study in subsequent publications.

[4] Poly-instantiation: the term that describes the situation when different records in the same table in the same database refer to the same real-world entity.

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