A Survey of the Current State-of-the-Art in Electronic Commerce and Research Issues in Enabling Technologies

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Abstract

Electronic commerce is a generic term that encompasses numerous information technologies and services used to improve business practices ranging from customer service to inter-corporation coordination. One of the most common instances of electronic commerce is the exchange of goods and services over the Internet but there are many other forms of electronic commerce such as controlled electronic purchase or virtual malls. Electronic commerce is not a futuristic dream; it is happening now with many well-established success stories. However, the electronic commerce services that are established so far are still far from being mature. There is no real integration of the underlying technologies, and the provided services lack many important but also more challenging features. Electronic commerce is not a single uniform technology, but rather characterized by a wide range of services and operations, including: establishment of initial contacts, suppliers search and negotiation; exchange of information; sales; pre- and post-sales support; electronic payment; distribution logistics; establishment and coordination of virtual enterprises; shared business processes; etc. In all of its forms, electronic commerce makes use of information technologies from very different areas: databases, transaction processing, interoperability of heterogeneous information resources, intelligent agents, multimedia systems, security and workflow systems. In this paper, the current-state-of the art as well as research issues related with enabling information technologies for electronic commerce are discussed.

1 Introduction

Electronic commerce, in its most general definition, refers to selling and buying on the net. In this context it is not an entirely new activity: Traditional electronic commerce through such means as electronic document interchange (EDI), bar code and interenterprise messaging has been an exciting and growing aspect of information and communication technology for several years. However since traditional electronic commerce relied for the most part on value-added networks (VANs) and private messaging networks which are relatively high cost and offer limited connectivity, the traditional electronic commerce never became a killer application. On the other hand, the Internet has worldwide connectivity, is growing phenomenally in every aspect of our society, can be interactive, and is relatively inexpensive and is thus making the most exciting development for commerce in this century possible. Electronic commerce is based on a variety of technologies, most notably,

- interoperability
- electronic catalogs, databases and multimedia systems
- intelligent agents
- workflow and process automation
- security protocols.

However, electronic commerce services that are established so far are still far from being mature. There is no real integration of the underlying technologies, and the provided services lack many important but also more challenging features such as properly structured support for:

- establishment of initial contacts
- suppliers search and negotiation
- exchange of information
- sales; pre- and post-sales support
- electronic payment
- distribution logistics

- establishment and coordination of virtual enterprises
- shared business processes.

Moreover, each of the underlying technological areas poses significant open research challenges by itself. Major progress in the above mentioned key technology areas is necessary to bring electronic commerce to a more advanced form that should be promoted as a ubiquitous service. In this paper the current state-of-the-art and future research directions in the enabling technology areas are discussed.

2 Interoperability

The progress and wider dissemination of electronic commerce will be hampered by self-contained, closed markets that can not use each others services and incompatible applications and frameworks that can not interoperate. As an example there is usually a need to access catalogs from different vendors. Furthermore, the catalog information need also be integrated with other computer applications like order entry, shipping, invoicing, inventory control, etc., to create a seamless electronic commerce system for the business. The differences and heterogeneities in such systems requires the handling of the interoperability problem. The interoperability architectures to be developed should be open and preferably be based on the mediator/wrapper paradigm where information sources are "wrapped" so that their interfaces to the outside world are uniform. Object-oriented technology can be used to realize mediator/wrapper paradigm. An object-oriented "communication bus" following Common Object Request Broker Architecture's (CORBA) Object Request Brokers (ORBs) can be used in conjunction with the Internet environment for this purpose (CORBA 2.0 and IIOP with HTTP, HTML and Java).

Indeed, these set of technologies constitute the basis of some of the major electronic commerce platforms like Netscape ONE (Open Network Environment), Oracle's NCA (Network Computing Architecture), IBM's CommercePoint and Sun and JavaSoft's Java Electronic Commerce Framework.

Using CORBA 2.0 and IIOP with Web (HTTP, HTML) and Java rather than Web alone provides the following advantages:

- Updates and inserts are at the heart of electronic commerce. Originally updates and inserts were not possible on the Web: the only way to communicate with Web servers was by clicking on hyperlinks to surf between documents. In the middle of 1995, Web forms appeared which are HTML pages with one or more data entry fields and a mandatory submit button. When submitted, a Web browser collects all the inputs from the form, puts them in a HTTP message and sends it to a Web server. The server invokes the program or the resource named in the URL and passes the method request and the parameters to the back-end program using Common Gateway Interface (CGI) protocol. The back-end program executes the request and returns the result in HTML format to the Web server using the CGI protocol. When this HTTP/CGI layer is replaced by CORBA, since CORBA allows clients to directly invoke methods on a server, all this overhead is avoided. Furthermore any IDL defined method on the server can be invoked and typed parameters can be passed instead of just strings.

- With CGI a new instance of a program must be started every time an applet invokes a method on the server. With CORBA, the same server object receives successive calls from the client and preserves the state between these invocations.

- CGI is a stateless protocol, that is, CGI does not maintain information from one form to the next. Therefore hidden fields within a form are used to maintain state on the client side. Hidden fields store information a user enters and resubmit that information in subsequent forms without having the user reenter it. CORBA maintains the state between client invocations avoiding this overhead too.

- CGI creates a bottleneck because it has no way to distribute the incoming requests across multiple processes and processors. CORBA ORBs on the other hand can create as many server objects as necessary. These server objects can run on multiple servers to provide load balancing for incoming client requests.

- With CORBA, Java clients and applets can invoke a wide variety of IDL defined operations on the server. In contrast, HTTP clients are restricted to a limited set of operations.

- CORBA provides a rich set of distributed object services that augment Java, including metadata, transactions, security, naming, trader, and persistence.

It should be noted that, like HTTP, CORBA's IIOP uses Internet as the backbone. This means that both IIOP and HTTP can run on the same networks. HTTP can be used for downloading Web pages, applets, and images; CORBA can be used for Java client-to-server communications. Java, in return, complements CORBA. While CORBA provides a distributed object infrastructure that lets applications reach across networks, languages and operating systems, Java provides

a portable object infrastructure that works on every major operating system. Java is making CORBA ubiquitous on the Web. In fact Object Web may be the killer application for CORBA. For example, Netscape is bundling Visigenic's VisiBroker for Java (a CORBA compliant Java ORB) in all of its future browsers and servers. Another advantage brought by Java to CORBA is the following: Java code can be deployed and managed centrally from a server. The code is updated once on the server and clients can receive it when they need it. This brings the advantage that the client code need not be updated on each client when there is a change. This in turn simplifies code distribution in large CORBA systems.

As a summary, CORBA in congunction with Web and Java seems to be a very promising infrastructure for electronic commerce applications. Yet it should be noted that a major market shareholder, namely, Microsoft, is not using this technology but uses its proprietary Distributed Component Object Model (DCOM) as the infrastructure for its electronic commerce products.

3 Electronic catalogs, database systems, and multimedia systems

Electronic catalogs integrate graphical front ends with product databases to allow users to browse merchandise using their computers. Electronic catalogs have the following advantages over their hard copy equivalents:

- They provide a company access to global markets without requiring physical presence
- They save enormous amount of developing, printing, and distribution costs
- Electronic catalogs can be updated as frequently as necessary with information about product announcements, special sales and inventory status in contrast to hard copy ones which become out dated shortly after their distribution
- They are available to the customers 24 hours a day, 7 days a week
- Electronic catalogs can be integrated with other electronic commerce applications like order entry, shipping, invoicing, or inventory control
- They can contain full specifications of the products and can facilitate better customer service

In the following the features commonly found in electronic catalogs are summarized:

- *User Interface:* Most electronic catalogs use the Web for their user interface but some use or plain text.
- *Shopping Cart:* Electronic shopping carts are analogous to their real-world counterparts. A customer may add or remove items from the cart, which usually keeps a running price total of its contents. In some cases, the electronic catalog can store the contents of a customer's cart between sessions, or even provide the merchant with a profile of the customer's buying habits. Shopping carts are a useful way for customers to keep track of purchases throughout the many pages of a Web catalog.
- *Search Mechanism:* Although products are usually arranged in categories for convenient browsing, most electronic catalogs include search tools to help the customer to find a product. Searches by keyword or product number are common. More complex search tools allow logical expressions in queries.
- *Scalability:* Most catalogs allow the merchant to add and remove content to accommodate inventory expansion and reduction.
- *Order Processing:* Electronic catalogs vary greatly in how they handle order processing. Some catalogs merely provide customer and product information to the merchant, while others transfer funds between banking institutions over the Internet and automatically notify the shipping department of the order.
- *Database Layer:* Some electronic catalogs read or import product data directly from an existing database. Others require the merchant to translate their data to a different format or even re-enter product data by hand.

Most electronic catalogs can get product data from product databases, either through their ODBC interfaces or through a translation software. Catalog creation services typically handle data conversion as part of their contracts. Electronic catalogs range in complexity. Some of them contain only text data, however more complex ones include audio and three dimensional graphics as well as search tools.

Yet to provide further benefits to electronic commerce the catalogs should not only have the full multimedia capabilities with the inclusion of videos and audios but also provide database management system technology to manage multimedia catalogs. The use of database technology provides many advantages the most important of which may be the ability to query the data using a high level interface.

To provide a flavor of the existing technology, two of the Commercial Off the Shelf catalog builders are briefly summarized in the following:

- *Microsoft Site Server Enterprise Edition 2.0:* Site Server is a suite of programs for creating catalogs

under Windows NT and the Microsoft Internet Information Server (IIS). Merchants can create basic sites with the Web-based Store Builder Wizard and customize the results with the VBScript and JavaScript tools in Visual InterDev or HTML. Site Server connects to most major (ODBC-compliant) database formats and includes the Commerce Server 2.0 software to handle online purchases. It also includes a Usage Analysis module that can generate 25 different tracking reports and a Site Analyst tool for locating broken hyperlinks. Customers benefit from a persistent shopping cart that retains its contents and the Microsoft Wallet technology that can automatically provide payment method and shipping information when making purchases.

- *Netscape Merchant System 1.6:* Netscape provides this package for businesses expecting mid- to high-level purchase volumes. It includes three main components. The Merchant Server is the catalog front-end that contains all the layout and product information. It is also responsible for converting existing product databases into the Merchant System format. The Transaction Server processes customer orders on the back-end and gives merchants flexible pricing tools for sales and promotions. It also integrates with existing order systems. The Staging Server is an optional module for previewing a catalog site before releasing it to the public. Templates are included to hasten catalog layout. Customers are treated to a powerful search tool that accepts logical expressions, a shopping cart, and multiple security layers.

4 Intelligent agents

Intelligent agents are programs that perform specific tasks on behalf of their users. Agents are distinguished from other types of software because they are independent entities capable of completing complex assignments without intervention, rather than as tools that must be manipulated by a user. In other words an agent denotes the hardware or software based computing system that enjoys the following properties:

- *Autonomy:* agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state.

- *Negotiation ability:* agents interact with other agents (and possibly with humans) via some kind of agent communication language.

- *Reactivity:* agents perceive their environment, (which may be the physical world, a user via a graphical user interface, a collection of other agents, the Internet, or perhaps all of these combined), and respond in a timely fashion to changes that occur in it.

- *Pro-activeness:* agents do not simply act in response to their environment, they are able to exhibit goal-directed behavior by taking the initiative.

Research on intelligent agents has been there for sometime but has flourished since the advent of the Internet. The current state-of-art in agent technology is as follows:

- There are tour guide agents that recommend a user where to go next (e.g., WebWatcher). It learns user's intentions by observing reactions to previous recommendations.

- There are indexing agents that perform an autonomous search on the Internet and store an index of words in document title and texts. The user may ask to find documents containing a keyword.

- There are Frequently Asked Questions (FAQ) agents (FAQ-Finder) that connect a large number of FAQ sites and provide a better user interface.

Intelligent agents can provide the much needed abstraction on the Internet in the future in such a way that, a user will not need to know or use any browser or Internet at all, the intelligent software agents will handle lower level operations on their behalf. Yet there is a need for further research and development in this area.

One of the promising use of intelligent agents in electronic commerce will be as a shopping assistant to reduce the required time and achieve best price performance. One such example is the agent ShopBot which is a domain-independent comparison-shopping agent. Given the home pages of several online stores, ShopBot automatically learns how to shop at these vendors. Learning process involves extracting product descriptions from home pages. This is not an easy problem because home pages vary in format and also contain other information like advertisements and links to other sites. After learning, ShopBot is able to visit over a dozen software vendors, extract product information, and summarize the results for the user. Preliminary results show that ShopBot enables users to both find superior prices and substantially reduce Web shopping time. ShopBot relies on a combination of heuristic search, pattern matching, and inductive learning techniques.

Yet ShopBot has several limitations. It works only on home pages that have a searchable index. It expects product descriptions to start on a fresh line. More importantly, ShopBot heavily relies on HTML. If a vendor provides information exclusively by embedding

graphics or using Java, ShopBot will be unable to handle that vendor. Furthermore ShopBot shopper's performance is linear in the number of vendors it accesses which is not acceptable commercially given the number of resources on the Web. There is definitely need for research and development in this area.

5 Security in electronic commerce

Security is a very important part of an electronic commerce protocol since communication can be easily intercepted, messages can be inserted, and the absolute identity of involved parties may be uncertain. While there are many individual proposals concerning the security of various aspects of electronic commerce, there is a lack of a consistent and coherent set of protocols to cover the needs of merchants and consumers. Secure Electronic Transaction protocol (SET) has been put forward by VISA/Mastercard as a method for performing secure electronic credit card transactions over an insecure network. Several other proposals involve stored value cards, debit cards, electronic purses, etc. All these proposals deal with only certain aspects of the overall security problems of electronic commerce. Furthermore, many electronic commerce systems depend on some ultimate, trusted authority. However, even in the case where one uses a trusted server, one should minimize the effects of security failures of that server. All of these aspects of security need to be investigated in order to build reliable electronic commerce systems.

6 Workflow technology in support of electronic commerce

Electronic commerce involves the management of business processes that support critical business functions, such as issuing purchase orders, inventory control, and payment transactions. A business process in electronic commerce applications can be modelled as a set of steps that are ordered according to the control and data flow dependencies among them. This corresponds to a workflow process, which is an automated business process in that the coordination, control and communication of activities are automated, although the activities themselves can either be automated or performed by humans.

Existing workflow products have proven their ability to achieve considerable improvements in critical, contemporary measures of performance, such as cost, quality, service, and flexibility by coordinating and streamlining complex business processes within organizations. In order to bring these advantages to electronic commerce, existing commercial products need to be enhanced and extended: current workflow systems are complex to install, use and maintain, have only limited resilience to failures since they do not support a truly distributed architecture, have poor scalability, and are too inflexible to cope with the characteristics of electronic commerce processes. Furthermore, existing Workflow Management Systems (WFMS) fail to satisfy the user expectations in areas such as handling heterogeneity and interoperability, providing data consistency, flexible worklist management and history tracking, supporting mobile users, handling exceptions, providing advanced security mechanisms, and improved interoperability between different workflow servers. More importantly, workflow systems in support of electronic commerce should be adaptable to the situations such as: changes in process execution flow, context sensitive information updates, change in a network configuration and to other external and internal events. These issues need to be investigated for the development of workflow technology in support of electronic commerce.

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