Cover Feature

Making Business Sense of Electronic Commerce

Although its infrastructure is still very young, e-commerce continues to create new business models and innovative marketing and technology strategies. To avoid unraveling their core processes, organizations considering e-commerce applications must take time out to evaluate the many facets of adoption and integration.

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Electronic commerce is possibly the most promising information technology application that enterprises have seen in recent years. It has revolutionized supply-chain management and has enormous potential for retail merchandising and brokerages. PC Warehouse and Dell Computers report more than $1 million in daily Internet sales. According to OpenMarket (http://www.openmarket.com), relative to other methods, Internet technology offers five to ten times improvement in reaching new customers, increasing the speed at which business is conducted, and decreasing per-transaction cost.

These benefits do not come without careful planning, however. Most of the business community acknowledges that intensive use of any information technology means transforming current, often core, business models and processes. Firms that have successfully invested in e-commerce, such as Microsoft and IBM, have had to depart from some traditional practices. They often overlap business and technology skills, for example, so that they can search for and experiment with the most profitable combinations of technology and organization. This type of experimentation is key to gaining a competitive edge and requires being able to manipulate a range of business models, application frameworks, and strategies for adopting e-commerce.

The array of solutions can be daunting. E-commerce implementation alone offers a potpourri of special-purpose hardware servers, distributed computing software, Internet protocols, and transaction management technologies. Moreover, some technologies are in their infancy. Microsoft, for example, released one of the first distributed transaction servers for Web applications in December 1996. Distributed software component models such as Microsoft's DCOM (Distributed Common Object Model) and CORBA (Common Object Request Broker Architecture) continue to rapidly evolve.

In addition to selecting a business model and framework for evaluating applications, enterprises must select effective strategies for investing in e-commerce. These include outsourcing, whether to build the e-commerce application in-house or purchase one off the shelf, and what hardware and software technologies to consider in the decision-making process.

This article is meant to show the depth and scope of the decision-making process that accompanies e-commerce adoption. Although we talk about specific strategies and tools, the final selection inevitably falls on the individual organization and depends on too many factors to cover in one article.

BUSINESS MODELS

There are currently three main types of business model. However, although the business model largely dictates the application, new technologies (and hence applications) often motivate new business models. As e-commerce matures, we should see hybrids of these three models and possibly completely new ones.

E-broker

In the *e-broker* (also called the cybermediary) model, the enterprise is essentially a middleman between the supplier and buyer. Examples are 1-800-FLOWERS, amazon.com, and abe.com. This model has many advantages: It reduces the inventory management overhead from staffing and office space and frees capital that would otherwise be used up in inventory control. Most important, it provides specialization (marketing, product, delivery) across the supply chain from manufacturers to customers. E-broker companies are marketing specialists; their suppliers specialize in production planning, inventory management, and the specific product being offered. The more specialized the functions, the higher the quality of the service the company can provide for the cost. Because of these features, the e-broker model makes a com-

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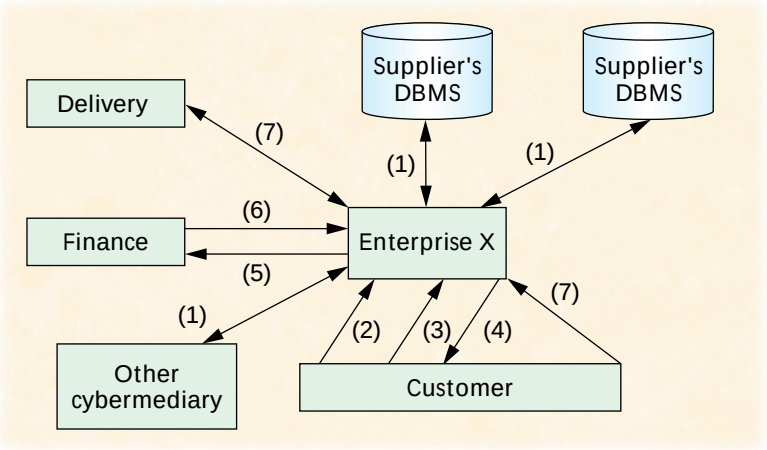

Figure 1. How the electronic broker model works. In (1), Enterprise X (the broker) electronically sources quantities of BuyAlot (the product or service) from multiple suppliers or other cybermediaries over the Internet to offer the best price and delivery terms. In (2), the customer has indicated the desire to purchase a BuyAlot by adding it to his shopping cart. In (3), the customer decides to purchase the BuyAlot and clicks on the buy button, which prompts a query for credit card information and user registration (4). The information is sent to a third party, in this case a bank (5), and the bank responds with an authorization number (6). Finally, Enterprise X sends the customer a notification that the order is confirmed, either on the spot or through e-mail. An order tracking service lets the customer check at what stage of delivery the product is at present time (7).

pelling argument for outsourcing, a strategy that works best for most small to mid-sized companies.

Enterprise X, a relatively small company, has chosen the e-broker model for this very reason. It has targeted a product line called BuyAlot, which it thinks will sell well over the Internet. Enterprise X's core competencies are in its marketing ability and its good relationships with its suppliers. The business maintains a limited inventory. Enterprise X selects the supplier with the least cost, shortest delivery time, or most suitable stock. Its business model supports shipping the product from supplier to the consumer directly through another third-party delivery channel, such as Federal Express or UPS. It can communicate with other similarly organized e-brokers to find the best deal for the brokerage and client.

Figure 1 shows the process flow for Enterprise X. There is access to both the broker's internal databases and the suppliers' external databases. The suppliers are viewed as partner companies—companies with which the broker conducts business transactions and holds trusted relationships. The suppliers are not identified through an intelligent Web agent, but they are trusted and well known. Although the figure does not show it explicitly, the application incorporates security in the form of SSL (Secure Sockets Layer) and/or SET (Secure Electronic Transactions), and Enterprise X lets customers pay with credit cards.

Both the e-broker and auction models capitalize the most on the flexibility of e-commerce and its supporting technologies. Most cybermediaries, such as amazon.com, and auction markets such as ebay.com, have no brick-and-mortar complements and would possibly not have started if e-commerce had not made this model possible.

Manufacturer

In the cybermediary model, the enterprise adds no value to the product; it simply buys the finished good from suppliers and resells it. In the manufacturer model, shown in Figure 2, the enterprise adds value through its internal manufacturing processes—by either developing a product from scratch or enhancing an existing one. This model works best for organizations with configurable products, mature marketing staff, and sophisticated customer service processes. Established businesses such as car manufacturers and computer technology firms (Dell and Cisco, for example) would use this model.

A value-added service inherent in the manufacturer model is the convenience of being able to "build" a product by clicking on customizations of its parts. For example, suppose a customer wants a vehicle in an offbeat color, with a covered tray on the back, power steering, power windows, and a gearshift. He can click on those options at the e-commerce site and get immediate pricing and sometimes delivery statistics.

The manufacturer also has an advantage because it can gain valuable customer information it would not be privy to had it used a third party for marketing and distribution. This advantage echoes the much-touted "death of the middleman" idea in early e-commerce literature, which maintained that the manufacturer can gain by selling directly to customers at the higher list price normally used by the product's resellers or distributors.

Auction

In the *auction* model, also known as the Internet exchange model, potential buyers submit a bid, and the product is sold when the supplier accepts a bid. As Figure 3 shows, suppliers are considered clients. The auction site's job is to connect the client with someone interested in the services or products. Priceline.com, for example, helps airlines and hotels fill up tens of thousands of airline seats and hotel rooms that would otherwise remain empty.

This model is popular with organizations that want very little involvement with hosting physical inventory from suppliers or processing customer sales. Auction model strategies are customer focused and are suitable for high-volume, low-fee business transactions. Businesses that use this model derive their income from charging small fees to sellers when a sale is made through their site and to list goods for sale. Buyers are not charged any fees. Because it is customer focused, the auction model attracts price-sensitive customers and customers with a host of product requirements.

This large base provides another revenue source,

sometimes the primary one: the sale of advertisements at the site. Ebay.com is an outstanding example of a business that exploits all the possibilities of the auction model. It offers community building, easy-to-use site tutorials on bidding and selling processes, customized transaction statements for any customer, and acts of social responsibility (for example, donations of services to charity).

APPLICATION FRAMEWORKS

An e-commerce business model describes the business's operational and functional structure. As such, it focuses on high-level details such as goals, strategies, and the interaction of entities (customer, business, and so on). An e-commerce application framework defines what is needed in the e-commerce application itself. It has a low-level, technology-based perspective.

An application framework is imperative to any organization contemplating e-commerce applications because it shows how a potential e-commerce product will fit with the existing business model. Figure 4 shows a generic application framework for e-commerce business models.

The *functional component* describes common high-level features that most e-commerce businesses need. The *operational component* describes business-dependent operations. The *architectural component* addresses technological issues and is described in terms of data, connectivity, network infrastructure, and foundation software applications.

Not every business will need all the services in this framework. For example, many businesses following the manufacturer model would not need to cross-sell (list related products that a customer may want to buy to complement what he has already selected, such as leather protector for a new pair of shoes), but an e-broker would. Likewise, a business following the auction model would need a higher level of customer care, say, customizing client transaction statements every other week, than an e-broker, who may need to customize only twice a year.

The generic framework is based on the current state of e-commerce applications and the current popular business models. For now, most e-commerce applications are simple; their main purpose is to distribute and collect information such as orders. Browse, shopping cart, buy, and order status transactions are common. As the sidebar, "Will E-Commerce Ever Be Secure Enough?" describes, some form of security is essential. Security protocols such as SSL 3.0 and SET and general exchange protocols such as EDI (Electronic Data Interchange) have been integrated into the products of commerce server providers. Some commerce applications provide for alternative payment methods through credit cards and occasionally through payment systems such as Cybercash, Micropayment, or Millicent. Electronic cash payment systems attempt to emulate hard cash transactions. Micropayment systems, for example, allow transactions as small as $0.15.

As business models change, the services in the framework will also change, although the three components

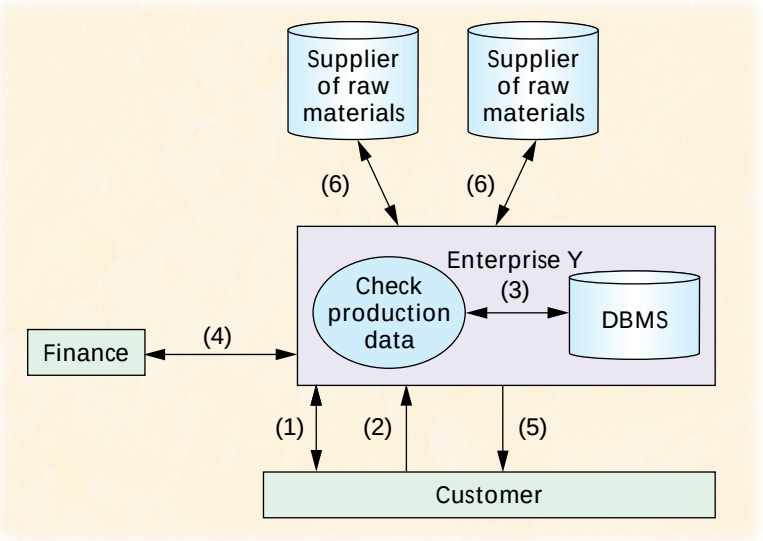

Figure 2. How the manufacturer model works. Unlike the e-broker model in Figure 1, the enterprise (Enterprise Y) adds value to the product through its internal manufacturing processes. It can manufacture an entire product or simply repackage supplied products. In (1) the customer selects product components and receives pricing. In (2) the customer issues a buy transaction. Enterprise Y checks its internal production database (3) to determine delivery timing and inventory requirements. It then queries a third party (most often a bank) to verify the customer's financial status (4). Finally, it issues an order confirmation to the customer and notifies him of the delivery date (5). In (6), Enterprise Y is buying products from suppliers, a transaction that may be in response to an individual order, but is most often the result of a collection of orders.

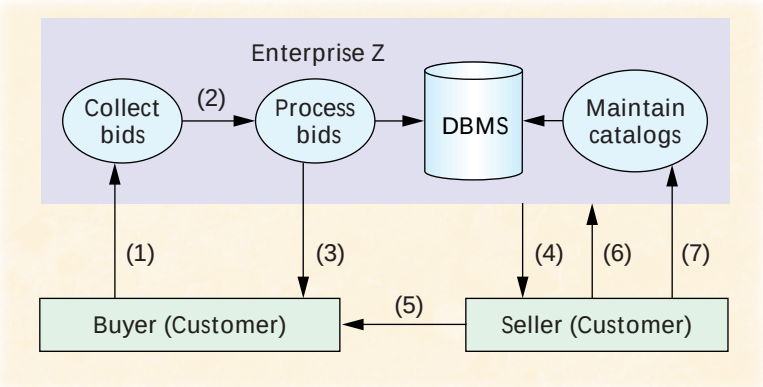

Figure 3. How the auction model works. Enterprise Z hosts the submission of bids, catalog lists of tangible goods or, if goods are intangible, facilities for collecting other information, such as geographic locations for flight or hotel reservations. Here, Enterprise Z also hosts a variety of customer services. In (1) the customer submits a bidding price, and Enterprise Z processes the bid (2). It then notifies the customer with that bid that he has bought the good (3) and notifies the seller of the winning customer's identity (4). The seller and buyer transact the final settlement details in (5), and the seller remits a transaction fee for the sale to Enterprise Z (6). In (7) sellers maintain listed items at the site.

Functional component
Application type
Business to business
Business to customer
Customer to customer

Service features
Security, electronic payment, catalogs
Scalability, interoperability, content, mobility, portability
Foreign-exchange facilities, customs restrictions, per-country government controls, cultural differentiation
Acceptable quality of service

Distribution type
Physical versus electronic

Operational component
Services
Service identification and requests
Agreement and postagreement
Cross-selling, upselling, sales, and promotions
Customer self-service
Customer transaction statement generation

System
System administration, maintenance, and update
Contract renegotiation
Definition of workflow processes

Architectural component
Data and connectivity
Databases
Third-party plug-ins to enterprise resource planning packages
Enterprise resource planning
Support for standards (OBI, EDI, XML)

Net-centric infrastructure
Distributed object models
Interoperability
Transactional middleware
Network infrastructure

Application software
Intelligent agents, search modules

Operating systems
Supported platforms (Unix, Windows NT)

Figure 4. Generic application framework for current e-commerce business models. Because e-commerce services and supporting technologies are in flux, the specifics of this framework will be short-lived, and not all business models (Figures 1 through 3) will need every service. However, frameworks will most likely continue to separate application functions, business operations, and technology issues.

(functional, operational, architectural) will probably stay the same. For example, suppose Enterprise X (see Figure 1) wants to simultaneously connect to three suppliers in one transaction. Its transaction manager model ("transaction middleware" in the architectural component) would have to be multithreaded and asynchronous. However, many transaction managers are based on simpler synchronous models and cannot correctly support such a task in a distributed Web environment. Thus, the application framework for the e-broker business model would have to include transactional middleware that supports nested and distributed transactions (such as IBM Encina).

In the near future, we can expect e-commerce software with sophisticated brokering and negotiation facilities and the potential to add value to a product through human intervention. Voice buttons are already appearing on e-commerce sites, which demonstrates a move toward unifying voice and data networks. Businesses that require a more human touch or negotiations too complex to be done solely through intelligent agents will benefit from this technology.

ADOPTION STRATEGIES

A business model and application framework are fairly useless without some strategy for adopting e-commerce applications. E-commerce is a complement of marketing, order collection, and procurement, and any adoption procedures must reflect this multifaceted nature. One approach is to modify the current system to integrate e-commerce. Another is to add distinct procedures for e-commerce without infringing on those that serve the established business channels. Either approach means a change in workflow that will affect inventory control, accounts payable, accounts receivable, purchase ordering, and material requirements planning, for example. Some of these changes need not be major. Enterprise Y, which uses the manufacturer business model (see Figure 2), has an established accountability flow. Introducing e-commerce should simply be a matter of distributing the electronic PO to other departments.

Historically, large companies have used electronic data interchange (EDI) channels as the medium for e-commerce. EDI typically involves expensive infrastructure: inflexible standards, costly software, and dedicated leased lines. In contrast, e-commerce over the Internet is over public networks and there are no standards as yet. Because of the relatively low entry costs of Internet e-commerce, small to medium enterprises (SMEs) have gained entry in markets heretofore considered too expensive to penetrate. At present, SMEs make up 99 percent of all companies across North America.

These new players have enriched the supply chain, which benefits large companies. The current strategy for large companies is to complement their existing EDI framework with Internet e-commerce infrastructure. For SMEs, the start-up costs for venturing into e-commerce vary, depending on how automated their data is. For example, a company with a database that properly reflects its products and operations would have considerably lower start-up costs than its paper-based counterpart, which may have to factor in expensive consultant fees to automate the data.

At this point, it seems natural to ask, "Doesn't the adoption strategy depend a great deal on the implementation platform and existing technology?" The short answer is, "Not really." Although these are certainly important adoption concerns, you can consider some

Will E-Commerce Ever Be Secure Enough?

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The Internet offers unprecedented opportunities for competition and introduction of new brand names. For example, in merely three years, without opening a single physical bookstore, amazon.com has become the third largest bookseller in the world. Apart from competitive market advantages, e-commerce also offers transaction cost savings. The processing of e-commerce payment transactions is very low cost, less than $0.02 as opposed to $0.80 to $0.90, when compared to that for traditional cash and check payment transactions.

The perceived and real lack of security —authentication, privacy, and nonrepudiation—over the Internet has been identified as a barrier to consumers' acceptance of online purchasing. The Secure Sockets Layer (SSL) security protocol provides for data security and is layered between the service protocols HTTP and TCP/IP. SSL provides data encryption, server authentication, and message integrity. SSL is widely used in the electronic commerce sites such as amazon. com and roswell.com. The SSL protocol employs public-key cryptography, which uses a pair of asymmetric keys, a public key and a private key, for encryption and decryption. The public key is made public by distributing it widely, and the private key is always kept secret by the owner. Data that is encrypted with the public key can be decrypted only with the private key, and vice versa.

Many issues must be settled before consumers willingly purchase over the Internet: There must be international agreement on a public-key infrastructure and key escrow, acceptance of digital signatures as legal instruments, and consensus on who has ultimate liability when a significant loss or fraud occurs.

A trade-off exists between the security of cryptographic systems and their speed and efficiency. Systems with very large key sizes are secure but are slow and difficult to implement. Cryptosystems are designed to be secure for a limited time, taking into account improvements in computing speed, memory, and algorithms. As an example, only a few years ago, 512-bit RSA systems were considered secure. Very recently, RSA140, one of a series of a challenge numbers from RSA Data Security Inc. was factored. This number of 140 digits or about 470 bits represents the current lower limit for security. Today, 1,024- and 2,048-bit RSA systems are considered secure for most applications.

Table A. How the RSA and elliptic curve cryptograpy (ECC) public-key algorithms compare in key size per bits.

RSA	Elliptic curve
768	132
1,024	163
2,048	210
21,000	600

Agreement on the public-key infrastructure is becoming more of an issue as elliptic curve cryptography (ECC) is becoming accepted as a viable alternative to the public-key cryptography algorithm developed by Rivest, Shamir, and Adleman. ECC is not new—the idea of using elliptic curves as the basis of a public-key cryptosystem was first published in 1985—but until recently it has been associated with systems that are far too complex to be practical. It is now part of systems that are being incorporated into many standards. An example is the elliptic curve version of the US government's Digital Signature Standard (DSS). (See http://csrc.nist.gov/encryption.)

ECC has a good chance of replacing RSA—at least in some performance-constrained systems—because it offers a higher level of security per bit of key length. The reason stems from the mathematical basis of ECC. RSA's mathematical problem is based on factoring; ECC's mathematical problem is based on elliptical logarithms. The difficulty of the elliptic logarithm problem is significantly greater than that of factoring. This is due to the fact that there is only one operation defined on the elliptic curve: point addition. Figure A shows an example of adding two points, *P* and Q. The problem an attacker has to overcome is this: Given a starting point *P* and an ending point *Q*, determine how many times *P* was added to itself (the integer *k*) to arrive at *Q*. This problem is difficult even for a relatively small key size, so much so that an elliptic curve system using 163 bits (key size) has the equivalent security of an RSA system using 1,024 bits, and the ratios get even more dramatic, as Table A shows. This high level of security per bit of key length means that applications can be faster, smaller, use less power, and require less information to transfer. These advantages fit nicely with applications like smart cards, pagers, and wireless networks.

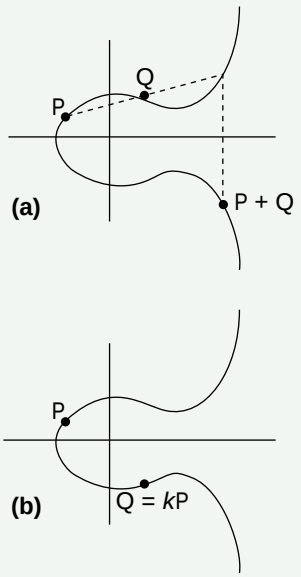

Figure A. The elliptical logarithm problem: (a) The attacker knows only starting point P and ending point Q, and must determine how many times P was added to itself to arrive at Q, represented by Q = kP in (b). The problem is extremely difficult to solve because point addition is the only operation allowed on an elliptical curve. This mathematical complexity translates into a higher level of security relative to the RSA algorithm, which is based on factoring.

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To take advantage of the emerging market for outsourcing e-commerce infrastructure, established and well-financed companies, such as telcos (telephone companies), are rapidly moving to position themselves as commerce service providers (CSPs).

strategies, such as outsourcing, regardless of platform. Reportedly the main barrier to creating an e-commerce site for the standard SME is a lack of skilled in-house personnel to create and maintain it. The operational monthly cost to outsource the e-commerce technology infrastructure for such enterprises is relatively low compared to acquiring and maintaining in-house systems and staff with enough technical expertise.

To take advantage of the emerging market for outsourcing e-commerce infrastructure, established well-financed companies, such as telcos, (telephone companies), are rapidly moving to position themselves as commerce service providers (CSPs). Traditional revenue services such as long distance services have taken a back seat to new product lines based on e-commerce. Long-distance service may become free in the not-too-distant future; the dramatic decreases in long-distance charges in the past few years have altered the revenue model for telcos. According to James Craig, senior manager of business-to-business e-commerce solutions at Maritime Tel & Tel (a major telephone company in Halifax, Nova Scotia), the intention is to provide low- to high-end e-commerce services. At the low end, the company hosts intranets on a per-seat basis for local companies. In the medium range, the company hosts total/partial e-commerce sites for companies, and at the high end are plans for hosting enterprise resource planning services. Thus, small to large businesses will have a means to outsource all or part of their e-commerce infrastructure to the telco or other CSP.

Implementation platform

The implementation platform consists of the hardware and software needed to make e-commerce real. As a minimum hardware requirement, you must have one Web server and one database server. To enhance performance and ensure security, you could also have a proxy server in front of the Web servers and a firewall system with filtering. You could have both a Web server and database server software on the same machine, but we do not recommend this for Internet sites because it degrades performance. On the Internet, distributed functions and hence concurrent servers work best because the workload can be distributed.

E-commerce systems with dozens of Web servers are common because the bottleneck tends to be in the front end at the HTTP and script engine servers. According to Jim Gray of Microsoft Research, few database servers are required, since the back-end load is relatively light on the CPU, compared to the front-end load. Redundant arrays of independent disks (RAID) and machines with high I/O bandwidth architectures are sufficient for the database server to perform well with the typical e-commerce site load.

Companies such as Microsoft, IBM, Netscape, and Digital offer commerce servers—from application toolkits to packaged e-commerce solutions. Commerce server software often resides on the Web server machine, so the choice of commerce server often dictates what system components (operating system, Web server software, and so on) the business will need to invest in.

Application toolkits work best for e-commerce sites that require lots of flexible customization, but they require sophisticated programming skills. Two of the most popular are

- *Microsoft's Site Server Commerce Edition*, a low-cost option that packages five storefront models, a set of Web tools, and (recently) a free auction module. Runs only on Windows NT and with the IIS Web server.
- *IBM's Net.Commerce*, which supports a cybermall, although it can be used for a single storefront. Runs under a host of operating systems, including Solaris, AS/400, and Windows NT. Works with Netscape's Enterprise Server 3 or Domino Web server software.

Packaged high-end commerce server products reduce development time and are suitable for CSPs and big businesses, but they are considerably more expensive than toolkits. Two of the most popular are

- *Netscape's ECXPert/SellerXPert/BuyerXpert*. Runs mainly on Solaris. List price starts at $250,000; http://home.netscape.com/newsref/pr/newsrelease593.html.
- *Open Market's LiveCommerce/Transact*. Runs only on Windows NT and only with the IIS Web server. List price is $45,000 for LiveCommerce and $125,000 for Transact.

IBM DB/2 and Oracle are major contenders as database servers. Past DB/2 installations have successfully supported more than 100,000 users, Oracle has scaled to tens of thousands of users, and SQL Server to thousands of users. Because database technology is mature, connectivity to other platforms and ports to many operating systems are available.

Underlying technology

If an organization considering e-commerce has already invested in a complete or partial IT infrastructure—which is typically the case—it is important to pick an e-commerce application that is compatible with its current investments. It is never a good idea to host a proliferation of technologies and systems, since you also need workers with equally diverse skill sets to maintain them. SMEs that choose not to outsource

their technology requirements should consider ease of use a high priority because it will speed up the product's time to market.

At present, the three main underlying technologies for e-commerce and other distributed Web applications are CORBA, DCOM, and Java Virtual Machine (JVM) and its APIs. E-commerce applications also require transaction manager software.

CORBA specifies interfaces and protocols for a distributed infrastructure, working through software engines called ORBs (Object Request Brokers). It is an extremely powerful and extensible framework that companies such as IBM and Sun have adopted in deploying their e-commerce solutions. Netscape's ECXpert/BuyerXpert/SellerXpert solution is built on Visigenic's ORB.

Another middleware component model is Microsoft's DCOM. DCOM is very easy to use, and you can write its components in many languages, including Visual Basic, C++, Java, and Cobol. Plans are under way to interface DCOM and CORBA components, thus preserving any existing investment in each technology. DCOM's strength is in managing presentation and user interaction, while CORBA's strengths are in providing a distributed infrastructure and integration medium.[1] How COM (or DCOM), CORBA, and Java-based technologies will perform by themselves or integrated with each other remains an open question. Robert Orfali[2] offers some comparative figures for COM and CORBA performance in the context of a simple counter application. Although a COM-CORBA mix would constitute a powerful toolkit,[1] the distributed application infrastructure landscape is evolving, and its individual relative strengths (as well as any inadequacies) may disappear overnight.

Java began as a platform-independent language for creating client-side applets that run inside the Web browser. In addition, JavaSoft also has a component model, JavaBeans. Enterprise JavaBeans extends the lightweight JavaBean model with multi-user security and resource management.[3] Java provides a mechanism for components to discover each other's interfaces at runtime and may run on different platforms because of the JVM. Java and CORBA are commonly used together to combine strengths of the Java client and CORBA distribution medium. However, many businesses use Java on their client-side applications and languages like C++ for the server side. C++ is faster than Java; Java, on the other hand, offers portability and better presentation services.

Businesses with the e-broker model must be particularly careful in choosing a middleware product if they have a high buy rate. They will need full-featured distributed transaction managers to exploit the parallelism within their distributed transactions. Chief among the transaction manager selections is Microsoft's MTS (Microsoft Transaction Server), which provides an environment for executing distributed applications built from COM components and frees the application programmer from writing two-phase commit procedures and semaphores. MTS is suitable for enterprises that have already invested in Windows NT or that place ease of use and productivity above other concerns.

IBM has a long history in transaction management. Most recently, it has made its CICS (Customer Information Control System) into a suite of middleware products that manage sites being hit by thousands of HTML form requests. It has also announced a component broker for release next year.

OTS (Object Transaction Service) is the service CORBA 2.0 specifies to assist the application designer in dealing with error handling and recovery in a transaction. OTS-based products include DAIS OTS from ICL, Orbix OTS from IONA, and Encina OTS from IBM.

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Measurement tools

Two categories of measurement tools are useful in evaluating an e-commerce investment. One category contains high-level business analysis models that try to measure business performance in terms of dollars. The other represents technical tools, or benchmarks, that use metrics such as response times, transaction throughputs, availability, reliability, and quality of service. Unfortunately, there are still disconnects between the two categories; for example, there is still no way to translate response times into dollars.

Feasibility models such as Total Cost of Ownership (TCO) fall into the first category. The Gartner Group TCO model lists four cost factors: technical support (21 percent), capital cost (21 percent), administrative costs (13 percent), and end-user operations (45 percent). The lion's share of the costs of ownership is attributed to the workers' use of the platform (end-user operations), which we find subjective, to say the least. The Total Benefit of Ownership (TBO) model (http://www.microsoft.com/technet/tco/value/value.htm) is a complementary model that measures benefits as dollars. Benefits can take the form of additional revenue expected from the Internet or the lower costs of sales and customer service. They can also be a gain in market share, reduction in time-to-market, a decrease in delivery time, and an increase in customer loyalty.

Web application benchmarks can help in estimating such parameters as system response times under various loads, throughput, and scalability. Some useful benchmarks are

- *Webperf* from Standard Performance Evaluation Corp. (SPEC), a benchmark for Web servers that

Table 1. E-commerce positions and their core requirements. The growth in positions that require primarily business skills indicates the move to cultivate hybrid competencies.

Positions requiring primarily technical skills	Positions requiring primarily business management skills
MIS director, MIS manager	Electronic Commerce (EC) segment analyst
Y2000 project manager	EC manager
EC/EDI coordinator	EC project manager
EC project manager	Director, associate director
EC technology specialist	Researcher
EC site manager	Registrar, associate registrar, financial aid officer
Online business coordinator or manager	Senior officer
Online operations manager	EC coordinator
	Traditional marketing/distribution titles
	Webmaster
	Operations manager
	"Ringmaster" or relationship manager
	Chief information officer (CIO)
	Senior manager or senior executive: CEO, president, vice president, dean, associate dean, and so on

calculates throughput in HTTP operations per second and client response times per HTTP operation.

- *WebStone*, which measures the performance of an HTTP server, making it easy to evaluate different implementations of an HTTP specification. There are several workloads, including modem use, download time, and content.
- *Benchmark Factory 97*, a suite of benchmarks that can stress test the performance of database servers, Web servers, file servers, and mail servers. Benchmark Factory's suite, which is based on industry standards for benchmarking, includes TPC-B, TPC-C, TPC-D, and Wisconsin benchmarks. The TPC-prefixed benchmarks are sanctioned by the Transaction Processing Council, a standards body that defines benchmarks and validates benchmark results. In January 1998, the Council announced its intent to create a Web e-commerce benchmark, TPC-W, which will be released later this year (http://www.tpc.org).
- *WebEC*, the first benchmark released specifically for e-commerce. Developed by Bodorik and Jutla, WebEC demonstrates the performance of an e-commerce system under the workload typical of the e-broker business model.

A business should use at least one Web server and database server tool to measure the performance of the associated individual e-commerce system components.

Human resources

Along with the infamous shortage of technical expertise has come the many-hats syndrome: Managers are increasingly called on to be organizational designers, coaches, teachers, and leaders of business-value creation. Many enhance their business's value by managing their investment in human resources and knowledge assets. A logical consequence of this is the demand for managers who have only a surface technical expertise but a richness of cultural knowledge, organizational, and social skills, and the specific skills to use IT for business.

The ability to successfully assimilate and exploit advanced information and communication technologies ahead of the industry curve requires two distinct skill sets. One is the technical skill set generally supplied by competent IT specialists. Around this group are the firm's management and administrative functions, which provide internal coordination and link the firm to its business network. These functions represent the firm's business knowledge, not its technology-related operational skills.

The legendary problem of aligning the firm's technical capability with its business strategy arises in part because technical workers and management fail to understand each other's objectives and processes. This IT-business strategy disconnect has been serious for the past two decades, and CIOs consider it the number one IT management problem.[4]

One remedy has been to cultivate hybrid competencies. Indeed, when a core competency is the ability to exploit new technology—as is true of e-commerce—technical skills and management skills must overlap and hybridize. Table 1 shows examples of e-commerce-related positions that are technical and business-centric, taken from interviews and conversations with observers from industry and academia. E-commerce job listings at HeadHunter.NET (http://

www.HeadHunter.NET) also classify jobs according to either technical or business management skills.

The table shows several interesting patterns. For example, the EC manager generally creates business plans to develop, implement, coordinate, and support customer and business-to-business online services. Qualifications for these positions may or may not require any specific technical expertise, such as Java programming. The focus is often on a business education and *experience* with online technologies.

An EC/EDI coordinator, on the other hand, requires a hybrid set of skills, though the primary need is technical. Individuals holding these positions in organizations coordinate the implementation of EDI and e-commerce. They are likely to work with trading partners to specify requirements and set up processing, which require mainframe and/or Unix skills.

Perhaps most interesting are the positions not traditionally thought of as technical. The registrar at a university is a good example. The registrar is responsible for managing, among other things, student records, the course calendar, exam scheduling, special student needs provisions, and admission assessments. A strong technical competency is not implied. Yet as universities look to the Web as a means of delivering these services to students, the registrar is fast becoming someone who must have some experience with e-commerce applications in a higher education setting.

Finally, a defining characteristic of skill in the current knowledge economy is lifelong learning, which itself will naturally emphasize a hybrid of business and technological skills.

Arguments for not investing in e-commerce are rapidly dissolving. It is now widely accepted that a business cannot ignore e-commerce investment without incurring heavy penalties over the long run. We believe organizations that want to invest in e-commerce must have a significantly higher degree of technological fluency and a bolder approach to experimentation with unfamiliar business models than they would for investments in other areas. Successfully exploiting e-commerce requires creatively linking an organization's strategy and its supporting technology as well as managing pervasive IT applications that change very quickly and are becoming increasingly integrated and convergent. Only then can enterprises achieve the flexible and adaptive behavior that is central to effective e-commerce. ❖

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References

1. R. Rosen and D. Curtis, *Integrating CORBA and COM Applications*, John Wiley & Sons, New York, 1998.
2. R. Orfali and D. Harkey, *Client/Server Programming with Java and CORBA*, John Wiley & Sons, Toronto, 1998.
3. D. Pountain and J. Montgomery, "Web Components," *Byte*, Aug. 1997, pp. 56-68.
4. "An Organizational Look at the Information Executive 1997," *CIO/Ernst & Young*, 1998; www.cio.com/archive/ 040197_role.html. (Current 11 Feb. 1998.)

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