The B2B E-commerce Revolution: Convergence, Chaos, and Holistic Computing[1]

Michael L. Brodie
GTE Laboratories Incorporated
Waltham, Massachusetts, USA

Abstract

The Internet has triggered the Fourth Information Revolution[2], which is leading to fundamental and irreversible changes in the way we do business and in the requirements for the supporting core technologies. Business-to-Business (B2B) e-commerce, the Information Revolution driver, is estimated to be between a $2.7 and a $7.3 trillion market in 2004. This pot of gold is resulting in massive competition in every business sector. Millions of Internet experiments (i.e., dot-coms) are testing hypotheses for more efficient business processes and technology solutions. No one knows which experiments will succeed or which technology requirements or solutions will emerge.

At the heart of the revolution are two diametrically opposed forces—convergence and chaos, in both the evolving business processes and the enabling technologies. Technology and business convergence is redefining the entire problem domain, while Internet experiments are appearing like the chaos in a gold rush. For technologists, chaos manifests in myriad noninteroperable existing and emerging technologies. B2B chaos will persist as long as the business processes are in flux. The technology chaos may persist longer.

How should technologists deal with the revolution and chart their map to the gold mine? What really matters in this revolution are the business processes that will come to dominate individual businesses. For technologists, what matters are the resulting technical requirements. These should be derived, from the top down, from the fundamental economic model, from the economic-chain, and then from specific business models and processes.

This chapter offers ideas from the now inseparable domains of economics, business, and technology. It examines the revolution and its challenges, and it proposes a holistic orientation for information technology (IT). The holistic view attempts to provide guidance through the chaos for requirements for core technologies that will underlie the future Internet-connected world.

---

1 In Information System Engineering: State of the Art and Research Themes, Eds.S. Brinkkemper, E. Lindencrona, and A. Sølvberg, Springer-Verlag Ltd., London. June 2000.

[2] The previous three Information Revolutions were based on writing 5,000 years ago in Mesopotamia; on the written book in 1,300 BC in China; and on Gutenberg's printing press in 1455 [1].

1 The Irreversible Information Revolution

1.1 The Fourth Information Revolution

Peter Drucker [1, 3] argues that we may be able to predict aspects of the Fourth Information Revolution based on previous technology-based revolutions. Just as the steam engine was the trigger for and symbol of the Industrial Revolution, the computer and the Web triggered the current revolution. As with the Industrial Revolution, the fundamental and irreversible changes of the current revolution will be in the ways business will be conducted. Whereas train transportation reduced the costs of manufacturing and distribution in 1820, B2B e-commerce reduces the costs (e.g., time) of most business processes. In the Industrial Revolution, it took over 40 years for new opportunities to be understood and incorporated into new business processes. It will take five to ten years to understand and incorporate the emerging opportunities into a new generation of business processes.

The revolutionary period will be marked by massive attempts to innovate and create better processes. A chief characteristic of this period of reinvention will be chaos in the affected businesses and in the supporting technologies. Existing processes will be improved directly by simple cost reduction. Drucker calls these improvements "routinization," to which he attributes the associated economic boom. Other processes will emerge, unanticipated, due to new possibilities. He observes that, so far, the train boom is very similar in size and impact to the Internet boom. The economic boom and the related chaos will continue until the experimental business processes stabilize and new business processes emerge. Hence, there may be waves of chaos and economic boom as models and processes in each business sector evolve and mature. According to the theory of growth economics [2], these waves will continue as long as innovation leads to value creation.

Some lessons are already clear. Connectivity and information access are leading to a shift in the balance of power from vendors to consumers. B2B leaders are using the Internet to increase customer value and build deeper relationships with partners and customers. This is a key characteristic of B2B business models.

Drucker argues that the most profound change will arise beyond routinization in unanticipated areas. His candidate for the Fourth Information Revolution is e-commerce "… the explosive emergence of the Internet as a major, perhaps eventually the major, worldwide distribution channel for goods, for services, and, surprisingly, for managerial and professional jobs. This is profoundly changing economies, markets, and industry structures; products and services and their flow; consumer segmentation, consumer values, and consumer behavior; jobs and labour markets. But the impact may be even greater on societies and politics and, above all, on the way we see the world and ourselves in it" [3]. E-commerce may be the basis of a class of new economic models.

In short, the economic boom and the associated chaos will continue for some time. More significantly, the chaos essential to innovation means that the ultimate business processes, business models, and perhaps even economic models are currently unpredictable. Entirely new industries may emerge. The long-term

beneficiaries of the technology boom will be ordinary companies that sell ordinary products and services to ordinary people—in short, real life.

1.2 B2B Is Fundamental and Irreversible

Technology is rife with predictions of world-shattering "paradigm" shifts. Yet none of the recent shifts (e.g., expert systems, client/server, 4GL, distributed object computing, business rules, ERP) has materialized as advertised. The Internet may look like a technology of the same ilk, but it is not. Predictions based on the Web cannot be overstated. Every business sector is on its way to the Web [4].

Like the Industrial Revolution, it is not about technology. It is about economics and business. Once you reduce the costs of a business process, there is no going back. It has already changed the way we do business in many domains, e.g., 50% of travel and 50% of car purchases are initiated on the Web. In 2004, the worldwide B2B e-commerce market in estimated to be $2.7 trillion by Forrester [5] and $7.29 trillion or 7% of the forecast total global economy by Gartner [25]. The world's largest corporations have committed to move to e-commerce models. General Electric (GE) has made a commitment to reinvent itself as an e-commerce company as has General Motors Corp. (GM) with its e-commerce supply-chain and Web-enabled design, manufacture, and distribution plan. Ford Motor Co. (Ford) is neck-and-neck with GM. Wal-Mart, Warner-Lambert, and Colgate-Palmolive have already moved substantial parts of their operations to the Web. These commitments have been confirmed by real profits. GM credits a significant part of its 1999 record sales and earnings to its e-commerce ventures. In 1998, Wal-Mart projected a $1 billion annual savings due to its e-commerce supply-chain.

A Forrester survey [5] estimates that 66% of all businesses will be on the Web to some degree in 2002. By 2005, e-commerce will include 25% of the auto supply-chain business; 17% of all energy trading; 20% of all shipping and warehousing; and 14% of all pharmaceutical and medical product trading. The related stock market boom that in January 2000 valued AOL at more than GM, Ford, and the entire American steel industry combined reflects investors' belief in the significance of e-commerce. In January 2000, the U.S. Department of Labor attributed the U.S. annual 5% productivity increase, in large part, to the Web.

1.3 Role and Significance of Information

Whereas the Information Revolution is about economics and business and not about computing, it is fueled by information. Everything on the Web is digitized information. Prior to the Web, 5%–10% of routine business was automated and represented in digital information. Current estimates suggest this will rise above 20% within four years, more than a doubling in four years of the digital information it has taken 50 years to accumulate. This takes into consideration neither the digitization required to use the Web nor the related increase in transactions. In the personal medical domain alone, a significant percentage of the annual 30 billion medical transactions is expected to move to the Web.

Current information technology is inadequate to meet the requirements of the Information Revolution, as discussed below. A significant challenge will be the development of new information technologies to capture, generate, store, search,

analyze, and disseminate information in volumes previously unimagined. Yet, information is more than part of the technology of the Web and an enabler of the Information Revolution. Information is its fuel or base currency (see 2.3), an integral part of the revolution. Information is required not only to conduct business but also to bring about and realize business change, the Information Revolution driver. As Claude Shannon, founder of information theory said, "Information causes change. If it doesn't, it's not information." The full role of data and information has yet to be appreciated [6]. This chapter examines the B2B-driven revolution with a focus on the role and significance of information technology.

2 B2B E-commerce: Business Convergence

Convergence is the synergistic coming together of people, ideas, or processes in novel ways. Traditional business processes, e.g., retail sales and manufacturing, developed over decades or centuries. The U.S. home-building supply-chain was established in the World War II era. Computing helped to reduce costs by automating internal functions and, with considerable cost and difficulty, some established relationships (e.g., EDI). Business homeostasis and technical challenges impeded change in business relationships, processes, and business models. The Internet changed all that. Its ability to connect everyone led to experimentation in new business processes that disintermediated existing partners and included new partners. Some experiments (e.g., GE, GM, Amazon) were dramatically synergistic (i.e., vast cost/benefit ratio). Clayton Christiansen [7] calls such businesses disruptive because they alter the conventional business entirely and irreversibly. Jack Welch, GE CEO (and reputedly the world's best CEO), coined the phrase "DestroyYourBusiness.com" to warn that if CEOs do not experiment with their businesses to increase efficiency, then others will and will put them out of business. This applies to all businesses, including large established ones like Toys "R" Us, GE, and GM. This is an enormous incentive to experiment with traditional business processes not only by the established companies but also by anyone with a novel, synergistic idea and a business plan.

The Internet has spawned the B2B revolution that is changing the way we do business in every business domain. The novelty, diversity, and richness of current B2B experiments (i.e., dot-coms) are astounding. The business processes details will determine future technology and information requirements; chief among them are integration and interoperability. This section examines B2B applications that require enterprise integration and B2B processes that require integration with partners.

2.1 Enterprise Integration Applications

The first phase of the current Information Revolution was based on the premise that enterprise success required understanding and managing a business in its entirety. Organizations with finance and employee information distributed in many business units or over a large number of heterogeneous disconnected systems were hard to manage effectively. Starting in the early 1990s, enterprise integration was enabled by a succession of enterprise applications, the most visible and successful of which are the 40 or more Enterprise Resource Planning (ERP) suites. ERP systems, like

SAP R/3 and PeopleSoft, provided a complete set of functional components that could run the back-office of the world's largest companies (e.g., Exxon Mobil Corp.). Back-office functions include the complete financial operations (e.g., general ledger, asset management, financial and business analysis and reporting), complete human resource operations (e.g., hiring, benefits, payroll, tax reporting), and other functions. By 1998, 60% of the Fortune 1000 firms had implemented ERP, which in less than 10 years became a $10 billion/year business, as large as the DBMS market.

ERP success had little to do with technology. Existing technologies were used to provide homogeneous solutions. ERP made significant technical contributions to making commercial off-the-shelf (COTS) applications a dominant means of software development and delivery and to making business processes the focus of enterprise operations; hence, process-orientation is now the focus of enterprise computing. ERP success was due to the competitive requirement, real or perceived, for enterprise integration, supported by massive cost reductions in back-office operations.

A key ERP requirement and benefit, business and technology integration, led to new enterprise integration applications such as Business Intelligence and Knowledge Management. Each requires integrated access to information already in ERP systems plus considerable additional information. Business Intelligence and the related Enterprise Performance Management (EPM) provide senior management with "what if" tools to plan, execute, and measure the effectiveness of their long-term business goals. For example, they help estimate how much it costs to make a potential product or service, the profitability, and the potential customers. Knowledge Management requires access to all enterprise "knowledge," whatever that means. Success requires access to all relevant information that is both precise and up to date. These requirements pose significant technology integration challenges.

B2B has overwhelmed enterprise integration since it addresses only part of the picture and inhibits enterprise interoperation beyond ERP [8]. B2B focuses outside the enterprise on customers and partners. This section concludes with the hottest B2B-driven application, Customer Relationship Management (CRM), which underlies all B2B processes, which are examined in the next section.

The shift of power from vendors to customers plus the ability to connect to all customers forces companies to increase customer value and provides the opportunity to build deeper connections with partners and customers. CRM involves the synchronization of all customer information systems, both data and functions. It started with the market-leading Siebel Systems, Inc., with sales force automation, which largely failed. It rocketed to acceptance when CRM was "sold" as addressing every customer-related activity, including customer profiles, sales and marketing, campaign management, order entry, and customer service. Like ERP, the first CRM wave was based on an integrated COTS application internal to the company. Siebel, Vantive, and Clarify offered the leading CRM applications. CRM was then touted as assisting in building a complete, real-time understanding of every customer, based on all employee-customer interactions, called eRelationship Management. This is leading to the rapid demise of internal CRM applications in the face of Web-based CRM, such as offered by BroadVision and

SilkNet [9]. The CRM story illustrates the rapid evolution of business processes and the rapid demise of even new, apparently successful, technology solutions.

2.2 B2B Business Processes

B2B is changing the fundamentals of every business process and model. Fifty percent of all U.S. car purchases and of all air travel initiates on the Web. Five percent of all news is obtained on the Web. Egreetings, one of many such vendors, send five million e-greeting cards per month. Sixty percent of U.S. farmers are now on the Internet along with their dealers, distributors, and manufacturers, who will spend an estimated $20 billion buying and selling chemicals, seed, and other agricultural products in 2002. One of the first agriculture successes was a manure portal created by a single woman farmer. The Internet and the music format MP3 are changing most music industry business processes. With financial instruments trivial to digitize, the financial and investment industry has seen the most dramatic changes, with 30% of its processes predominantly Web-based. U.S. trucking is becoming Web-based. Independent truckers are using the Internet to find loads and avoid making empty return trips. Few truckers travel without a laptop. U.S.-wide Yellow Freight Inc., which invested hundreds of millions of dollars to reinvent itself, manages every order, shipment, and activity through its Web-based central dispatch [10]. Yellow's real-time access to its entire network provided a gold mine of information that led to a 20% productivity gain. The core processes of U.S. presidential elections, campaigning, organizing, communicating, fund raising, polling, and platform development, have been reinvented through the Web. Every corner of the economy is affected [4]. To see the devil is in the details, we now look at several basic business processes.

In early 2000, GM, one of the world's largest manufacturers, said that it would reinvent itself by moving its core design, manufacturing, selling, and shipping of cars substantially to the Web [11]. GM wants to do for cars what Dell Computer Corp. has done for computers—take orders online, custom produce products, and deliver them. This is a conversion of one of the world's largest companies from a "build to stock" business model to a "build to order" business model. The move includes reinventing the way cars are manufactured. Rather than producing a car from 3,000 parts, they want to produce a car from approximately 30 modules or major subassemblies. In comparison to the current eight-week period, GM wants to reduce the total elapsed time from order to delivery to between one and four days. Consumer satisfaction should rise when buyers get a car they design rather than one they choose from the lot by closest match.

Amazon.com is the best known retail revolutionary. With "One Click," customers purchase books 24 hours a day from anywhere with delivery to anywhere. Amazon's business processes are simple but profound. The corner bookstore is an endangered species. The Amazon story is a good example of rate of changes in retail and possibly all other domains. As Amazon says [www.Amazon.com], "Today, Amazon.com is the place to find and discover anything you want to buy online. We're very proud that 13 million people in more than 160 countries have made us the leading online shopping site. We have Earth's Biggest Selection™ of products, including free electronic greeting cards, online auctions, and millions of books, CDs, videos, DVDs, toys and games, and

electronics." Many details distinguish Amazon's e-business, including building and maintaining profiles on millions of customers, recommending purchases based on the behaviour of similar customers, services available over cellular phones, and partnering with myriad vendors (e.g., drugstore.com, Gear.com, HomeGrocer.com, and Pets.com). Could we have anticipated the bookseller to omni-seller transition, the books, pets, and grocery connections, or other details? E-retailers have threatened brick and mortar retailers to the point that U.S. malls and stores are being redesigned to better meet customer needs [12].

BuildNet.com intends to revolutionize the 55-year-old home-building supply-chain by providing electronic communications between builders and suppliers, enabling, for example, Internet searches that take seconds to locate items. The current chain, which includes tens of thousands of material providers and far more builders and subcontractors, is vastly inefficient. It often takes months to find materials dispersed over many warehouses, which must be physically searched. The Internet-based home-building supply-chain is in its infancy. It is impossible to predict the processes that will emerge from the current divergent experiments: top-down, bottom-up, and middle-out. USBuild.com hopes to completely replace subcontractors with electronic bidding and distribution and to offer discounts on aggregated volumes. Equalfooting.com is working from the bottom up, attempting to build the supply-chain from the small builders and suppliers to assist them with the communications and volume discounts obtained through cooperation. Finally, ImproveNet is working on the supply-chain on behalf of the consumer, providing connectivity between buyers, contractors, and suppliers. It will take time for it to shake out. In that time, each candidate process will require very fast means of creating and separating from potential networks of consumers, builders, and suppliers. The technical requirements are interoperability, flexibility, and speed.

With 273 million customers, 550,000 doctors, and 30 billion yearly health-care transactions, the enormous U.S. health-care industry has resisted many attempts at reformation. Healtheon/WebMD Corp., the largest E-health-care company, is about to change that with its network of 450,000 doctors. E-health-care is attempting to reformulate the currently paper-dependent health-care processes that include the major players—doctors, patients, hospitals, HMOs, pharmacies, insurance companies, and labs. Potential savings are estimated at $280 billion due to unnecessary administrative and clinical expenses. Business processes currently being changed to reduce cost and dramatically increase patient satisfaction include appointment scheduling, insurance claims, referrals, prescriptions, lab test data transmission, patient monitoring, and the exchange, integration, and transmission of medical records. Substantial benefits beyond cost reduction include time savings for all players; improved precision; automated checking; access to a wide range of providers; error reduction due to reductions in duplicated data or human errors; and accurate medical records that arrive at any medical appointment before the patient. The size of this change both technically and socially is mind boggling.

A final domain to consider is e-procurement and supply-chain, which are required by almost every e-commerce activity. E-procurement has a buy side, a sell side, and the connection of the two. On the buy side, a customer such as a company purchasing agent needs to access information on all relevant products, including product specifications, comparisons with all competitive products, pricing including discounts, delivery arrangements, and promises. The seller must have all

relevant information on the buyer, including company, finance, credit, contact, logistics, preferences, and legal. On the sell side, the vendor must provide all relevant, up-to-date catalogue information from hundreds or thousands of suppliers together with real-time inventories and pricing. For a sale, transaction details must be irrefutably committed on both sides, and reflected in the inventory and financial systems. But that is just the purchase. The purchased goods must traverse the supply-chain from the manufacturers through the stages of assembly into the final products to form the customer order to be delivered according to agreed-upon terms. Supply-chain management tools let companies configure products to order, confirm availability, and track orders and delivery schedules in real time. This is critical to e-businesses as well as to traditional businesses in increasingly competitive situations. Market leaders are Ariba, Commerce One, and Oracle [13]. Forrester claims that Oracle's lead is based on its understanding and support of interoperability.

Although supply-chain is a big story for all e-commerce, Ford and GM made the biggest supply-chain move in late 1999. Collectively, Ford and GM have 50,000 suppliers for their annual $300 billion in purchases. Originally, these plans required GM suppliers to use GM's TradeXchange open online marketplace and Ford suppliers to use Ford's Oracle-based AutoExchange. In February 2000, Ford, GM, and DaimlerChrysler AG announced a single automotive parts exchange that combines AutoExchange and TradeXchange and avoids a third from DaimlerChrysler. Most automakers worldwide are negotiating to join the exchange. As it is, the new exchange will form the world's largest Internet company and trade exchange. Similar exchanges are being established in other industries, including aerospace (MyAircraft.com), paper (PaperExchange.com), agriculture (ASAg.com), chemicals (ChemConnect), and steel (E-steel).

These exchanges are similar in concept to those already implemented, e.g., by Wal-Mart. Some include the ability to alter their supply-chains by altering a vendor's shop floor and delivery schedules and to analyze supply-chains for such things as supplier effectiveness. In addition to optimizing existing processes, Drucker's routinization, there are unanticipated results, such as GM's entry into the supply-chain business and Ford's entry into the Web design and hosting business.

2.3 B2B's Fundamental Characteristics

The B2B Information Revolution is all about business and not about technology. To understand it and to build the best technical support, we must understand the bigger picture. For example, we could focus first on the detailed business requirements in specific businesses and generalize where possible. The dominant characteristic of B2B business models is efficient interaction with all relevant partners, established on demand, sometimes at a very intimate level and in real time. Internal enterprise integration is necessary but far from sufficient, as illustrated by ERP. Every business model and process is being reinvented in a race where speed-to-market is king. The result is a chaotic range of diverse, rich business models that destroy both established and new models. Amazon, the world's leading online retailer, exemplifies both rapid evolution and unanticipated convergence. The current scope and scale of the B2B revolution is phenomenal, but the potential, illustrated by e-health-care, is vastly greater. Whereas some characteristics are common, the

current diversity, chaos, and unanticipated events make the ultimate characteristics unpredictable.

The above B2B characteristics are details within something more fundamental, the economic model. Consider this in an analogy to database or programming language type systems. A data model defines a class of possible schemas that in turn define a class of instances. Similarly, an economic model defines a class of business models that in turn define a class of business processes, which have operational instances.

Twentieth century economics was based on wealth and value creation from assets such as land, labour, and capital[3]. Fifteenth century accounting practices for measuring value were augmented with twentieth century cost accounting that provided means for setting and measuring business objectives, namely profits. Twentieth century accounting focused on measuring assets and activities within an enterprise with the objective of maximizing profits and minimizing expenses by eliminating waste. To do this, it assigned values to assets and transactions or operations within a business. Traditional accounting was focused internally within the enterprise [1].

A new model of accounting, economic-chain, with origins in 1908, is now coming to the fore. Economic-chain focuses not on the internal operations of an organization but on external opportunities (and threats) and on the end-to-end processes (i.e., the chain of partners) required to realize them. A chain could start with raw materials and end with the consumer. The external context sets the parameters for efficient internal operations.

Economic-chain was developed in the United States by William C. Durant in the 1920s [1] and was applied in Britain in the 1950s and by Sam Walton as the basis of Wal-Mart's success in 1975. Economic-chain accounting addresses costs throughout the entire economic-chain, from the supplier to the ultimate customer. It is now being applied under concepts called value-chains in manufacturing, retail, services, and many other industries. It has influenced the focus on business processes and is leading to a more sophisticated notion of value webs. Economic-chain is the economic model of which B2B business models are instances. To understand what business models and processes are possible, one must understand economic-chain. The primary characteristics of economic-chain will also be those of B2B business models, which in turn define the requirements of next-generation technologies. Economic-chain has three main characteristics relevant to B2B. First, business is conducted as a process through a chain of partners. This requires the ability to do business with any potential partner, competitor, or customer. Second, business must address the entire end-to-end business process required to achieve the business objective, including planning, implementing, monitoring, and management. Third, flexibility is required to alter the business process and partners, to maximize opportunities and minimize threats.

[3] The objective of an economic model is wealth and value creation. In the information economy, twenty-first century economics has shifted from land, labour, and capital as base assets to hardware, software, and wet ware [19]. These assets permit value to be transferred at almost no cost. Twentieth century economics had major barriers to entry and exit (e.g., the factories, machines, and land) that are hard to change. Twenty-first century economics has a similar problem in software [23] and less so in hardware. This indicates the significance of technology, "knowledge" (e.g., wet ware), and information, which is far beyond its technical value. They are an integral part of the current chaos and economic growth.

To make the above arguments more concrete, consider SAP, AG's path to its recent mySAP.com product offering [www.mysap.com]. SAP's origins in the late 1980s were in ERP, with the objectives of cost reduction and business integration. The objective of their second-generation suite was "Inter-Enterprise Co-operation," with a focus on the supply-chain. SAP's current focus, mySAP.com, attempts to achieve for its customers "e-Community Collaboration" within their business communities, called e-marketplaces. This vision under construction is pure economic-chain.

3 B2B Technical Requirements

B2B has a vast number of detailed technical requirements, with far more to evolve as B2B matures. This section addresses four critical technical requirement areas.

3.1 Integration and Interoperation

The fundamental economic-chain requirement of B2B translates to technical requirements for interoperation and integration with both internal and external partners. Interoperation concerns processes, workflows, or systems interacting to achieve business objectives. Integration concerns the required combination of information resources to achieve business objectives. B2B's predecessor and prerequisite, enterprise integration, requires integrated access to information resources. B2B requires potentially intimate integration with partners' information resources.

Consider internal integration. Most organizations have many information repositories (e.g., GTE has more than 1,500), which have been developed over a long period of time, each designed to meet the requirements of a particular application. For example, there are often as many independent customer information repositories as applications that require customer data. CRM involves the synchronization of all customer information systems, both data and functions. Integrated customer information across the organization is currently considered to be mission critical for many enterprises. The objectives include providing a complete, real-time understanding of all customers, expanding customer contacts to all employee-customer interactions, and synchronizing customer relationships across all communication channels. Hence, significant effort has been invested in identifying and integrating all customer information in all information repositories. Similar arguments could be made for most information subjects (e.g., parts, inventory, finances, and products). Such arguments have been made for knowledge (knowledge management), finance and human resource data (ERP), and parts (MRO). The Global Data Management challenge is to be able to deal with all the information resources of an enterprise as a single information repository in which the same information subjects (e.g., customer profiles) can be accessed as if they were meaningfully integrated. The Global Data Management Challenge has been faced by every enterprise from the time it developed more than one database. The intensity of the need is reflected in the data warehouse craze, which provides read-only access to out-of-date, partly integrated data. Global Data Management is

mission critical in B2B for specific topics (e.g., customer and supply-chain data). Codd's goal of data independence is still elusive.

Consider external integration. The current most critical B2B and Business-to-Customer (B2C) (e.g., retail) applications are those that support purchasing, procurement, and delivery (e.g., supply-chain, e-procurement, fulfillment). Success in these domains depends on efficient, smooth partnering that requires integration between specific partner systems at a level similar to internal integration. The purchaser (e.g., Warner-Lambert, Colgate) may want direct access to suppliers' systems to plan, monitor, and alter production and delivery schedules. Each external integration requirement will depend on the details of the business processes being implemented.

The interoperation and integration requirements are augmented by other B2B requirements. Internet speed reduces the time to build interoperable solutions. The potential number of partners makes conventional point-to-point mappings economically infeasible. More significantly, B2B computing and data architectures may differ radically from those of today. Analysts [5] estimate that a significant portion of all business will be conducted on the Web. Speed to market forces most enterprises to connect their legacy data repositories, systems, processes, and workflows to the Web. The resulting architecture, with as many gateways as there are systems, will not support the transaction and data volumes. Nor will legacy systems support the anticipated number of trading partners. A significant portion of current and future computing resources will have to move from internal enterprise architectures to some new architecture on the network, as has long been predicted by Sun Microsystems and others [14]. The network is the computer.

3.2 Scalability, Reliability, Real-Time Access, and Accessibility

Four traditional database requirements, scalability, reliability real-time access, and accessibility are now mission-critical B2B requirements. All three stem from the nature of the Web. B2B business processes can be made available to anyone on the Web. Hence, they must be accessible 24 hours a day and scalable to the access requirements. Stories abound about the failure of a Web-based application to scale to the number of users. A recent survey [15] states that scalability is a serious problem for almost all B2B players and that 99% accessibility was seen by most players as inadequate for nonstop e-commerce. These factors not only limit business transactions, they significantly affect quality of experience, which is seen as the critical success factor in B2C [16].

Real-time access to up-to-date data is critical for a large number of B2B processes. Internet speed and competition increases the need, possibly artificially. For example, retail sales, supply-chain transactions, and transactions involving changing prices (e.g., due to time, inventory, competition, airline reservation seat inventories) all require data at the instant of the transaction. Online retailers and wholesalers may sell products from thousands of suppliers. Pricing and delivery are based on inventory and fulfillment systems. The seller may require real-time read and write access to these systems to be able to make and complete the sale. Old data may cause the transaction or business to fail (e.g., selling goods or services too low or too high, selling already booked seats, selling products that cannot be delivered). Data warehouses that are updated periodically are inadequate. The data

must be obtained in real time. This leads to the requirement for real-time access to heterogeneous or federated databases.

3.3 Transactions and Cooperation

The initial Web driver, B2C, produced relatively low volumes of transactions (e.g., sales) directly into the sellers' databases. The technology was there to make them robust and reliable. Challenges will come as B2B generates the projected massive transaction volumes [5] for which there will be legal requirements for robustness, reliability, or at least nonrepudiation. Whereas trust and work will be required to make single operations transactionable between two partners, there is no technology to support transactionable multistep operations. The requirement for reliable, robust, and non-repudiable business processes is a direct result of the fundamental B2B requirement of supporting economic-chains, end-to-end.

Another basic technical requirement flows from fundamental B2B requirements. Economic-chain requires that enterprises continuously find partners, collaborate on a business opportunity, and cooperate to execute on the agreement. Forrester says that by 2003, live collaboration will become as much a part of business as e-mail is now. The characteristic that distinguishes Web-based collaboration and cooperation is time. These activities currently happen without computers but take considerably longer than with computers. Without the Web, enterprises automate partnering agreements using system interfaces that take months or years to build. The Web currently facilitates human-based collaboration and cooperation by dispersed people via Groupware, e-mail, messaging, calendaring, and bulletin boards, augmented by documents, database sharing, workflows, and project management. As these activities result in more process improvements (e.g., more efficient design and development cycles), there will be a requirement to automate collaboration and cooperation. You may want to find a partner over a very short time frame, possibly down to the single transaction level. In the near future, firms must form and disband partnerships at lightning speed: in days, hours, and minutes [17]. This will lead to the requirement to find partners without human intervention, maybe only for a single transaction especially in situations where systems do the work, e.g., trading, negotiation, and project and resource management. Fast partnering requires fast system-to-system integration. But more than that, it will require forms of discovery of services and capabilities, negotiating terms of a partnering agreement, and the planning, execution, monitoring, and termination of the partnership.

3.4 IT Provisioning

An enterprise's information systems have traditionally been the responsibility of a centralized IT organization. Centralized IT can be efficient when all IT resources are under one control that can set standards, leverage IT skills and solutions, and manage the entire IT environment. Central IT has attempted to reduce the problems of interoperation by establishing standards and reducing the number of technologies involved in an IT operation. The centralized IT model must be reinvented to meet the requirements of the B2B revolution. Relevant B2B requirements are business-driven, end-to-end solutions in an economic-chain.

B2B IT activities cannot be managed by a central control which is too slow to act [18] but, more significantly, very hard to create since there is no central control of processes on the Web. There may be 2 to 20 partners participating in implementing and offering a process. Although there may be a dominant player in one process, it is not likely that that player can act as the central IT for the process, since the required resources exist in the partner IT organizations. B2B's chaotic nature, which will persist for years, requires flexibility and speed. From moment to moment, different players, partners, and competitors may join or leave a process. Central IT is seldom known for flexibility or speed. Partner links, which used to be created over months and years, may now exist for seconds (e.g., for the duration of a transaction). Scalable and reliable end-to-end solutions must be constructed from the technology components of the current process partners.

A significant result of the success of ERP is the business-IT partnership for systems development, provisioning, and operation. This is entirely consistent with the fundamental requirements of B2B, and it is changing the face of IT. In the past, IT "owned" the entire information system life cycle. Information systems were considered complex technology that only IT could understand and manage. ERP systems embody complex business models and processes. Managing those business models and processes is the core responsibility of a functional organization. For example, in ERP human resource systems, many policy decisions, e.g., on employee reimbursement, are analyzed and implemented for the relevant employee populations not in paper memos but directly in the systems. Human resource organizations must be directly involved. As a result, massive ERP systems are now "owned," planned, designed, and operated by the functional owners with IT as a partner. The corresponding B2B situation is more complex. Business processes that cross organizational boundaries will involve multiple functional owners and IT organizations.

The context that core technologies must support and in which information systems must be developed and provisioned defines requirements for next-generation infrastructure technologies that are as significant as technical requirements, such as data access and transaction processing. Consider the fundamental B2B requirement for end-to-end solutions. Problem owners (i.e., now functional and not IT staff) face real-world problems with many facets for which they require end-to-end solutions. For example, emerging e-marketplaces require a complete solution, including the sell side, the buy side, and sales fulfillment, for every sales transaction. An end-to-end solution must meet the full set of requirements, including political, business, technical, and operational. Due to the complexity of real-world problems and the novelty of B2B, there are seldom off-the-shelf comprehensive technical solutions. Solutions must be created to meet the requirements from components solutions so that the business requirements are met and the component solutions fit together so as not to inappropriately raise the cost or complexity of the solution or place the overall solution at risk.

Traditionally, technology solution vendors offer solutions to very specific technical challenges, e.g., storage, search, data management, communications, applications. They tend to understand their technology area (and possibly closely allied technologies or products) in great depth. However, they tend to not understand the problem owner's problem. An example of this is data management. Data management solution vendors understand data management in remarkable

detail, including the most recent advances in databases, data management, and all the allied data management technologies and products. These are often wonderful solutions for well-understood data management applications. However, problem owners seldom have clear-cut, well-understood data management problems (e.g., the Global Data Management problem, for which data solution vendors have no solution). Functional ownership of information systems is leading to the development of end-to-end solutions. At the turn of the millennium, CRM is viewed as one of the highest priority IT solutions for competitiveness. As a result, a large number of data management solutions have been developed to address the Global Data Management problem restricted to CRM. These solutions do not come from the technology solution vendors, but from system integrators who create solutions from component technologies or products.

In summary, real problems require real solutions that inevitably involve many technical and business domains in conjunction. Historically, the IT community has not readily provided such solutions. Researchers, solution vendors, and IT organizations have focused on narrow technical and product areas. This has increased the technical chaos. Hopefully, next-generation technology will respond to the fundamental B2B requirements of economic-chains and end-to-end solutions.

3.5 Core B2B Technical Requirements

The core technical requirement of the B2B revolution is fast, efficient, and reliable interoperation of processes, workflows, and systems and meaningful integration of information resources, with internal and external partners. Access may be real-time but certainly always-on to support nonstop e-commerce. Multistep business processes will be in volumes and at speeds previously unimagined and must be transactional or at least non-refutable and traceable. Complete and flexible end-to-end solutions must be provided at Internet speeds by next-generation technology or by composing existing component solutions to meet complex and constantly changing business processes requirements. New technology solutions must include network-based architectures that provide reliable, efficient access directly on the network to the vast anticipated and changing set of business partners. Many of these requirements necessitate an ability to deal with the semantics of processes and information far beyond what is possible today. The step beyond these requirements is the automation of cooperation and collaboration.

4 Integration Solutions: Overcoming Chaos

4.1 Significance and Difficulty of Integration

Integration and interoperation involve providing technology solutions to meet end-to-end business requirements from multiple, heterogeneous technical components. This section reviews the nature and significance of the challenge and briefly reviews the dominant solutions.

A core challenge for more than 50 years, integration solutions tend to be ad hoc, proprietary, and largely labour intensive. In the past decade, the need for much more effective and efficient solutions has increased. It is a core requirement of

dominant business trends, including corporate globalization, mergers, and acquisitions. It is a fundamental requirement of B2B. Mercer Consulting reports that Internet companies enter into mergers after 6 months of operations compared to 72 years for the top 50 Fortune 500 firms. The problem is compounded by the chaos of the diversity of emerging and disruptive [7] business processes and technical solutions, the number of trading partners, and the nodes in the network. Wintergreen Research estimates that 50% of the 1999 worldwide IT budget of $900 billion (U.S.) was devoted to the problem. Systems integration products and consulting services have become one of the largest sectors of IT.

Integration and interoperation solutions are mission critical. It is common that such problems dramatically slow the progress and increase the cost of the related business activities. Major mergers and acquisitions have failed or have nearly failed due to the integration challenges posed by their systems. System integration challenges in the Norfolk Southern Corp. merger with Consolidated Rail Corp. resulted in a $40 million loss of business in the first month [20]. Freight cars were misrouted, crews were misscheduled, and customers temporarily lost their products. It cost $29 million a month to repair the system over several months, followed by the cost of regaining the lost market share.

4.2 Integration Solutions

4.2.1 Middleware: Distribution, Databases, and DOC

Data independence, the ability of a database to provide data for many applications, was one of the greatest interoperation solutions in computing history. Unfortunately, the success and widespread use of databases led to noninteroperable solutions and the Global Data Management problem. Distributed and federated databases, conceived in the early 1980s to address these problems, were limited in their functionality and scalability, so were unsuccessful. Recent federated database solutions (e.g., IBM's DB2 Data Joiner and Garlic, Cohera's Data Federation System, and Metagon's Dqbroker and Dqview) resolve earlier limitations but have yet to be widely used. Whereas they facilitate interoperation solutions, they do not address the core semantic problems. Perhaps for similar reasons, distributed object computing (e.g., CORBA, COM+), which is more comprehensive yet more basic, has not been widely adopted [21]. As recent TPC benchmarks indicate (www.tpc.org), COM+ works wonderfully in a homogeneous environment. Workflow, an interoperation solution, has met with conceptual acceptance but limited application in heterogeneous environments. The Internet application need for interoperation is leading to a broad acceptance of XML and JavaBeans. These are more amenable to addressing semantic issues since they support a degree of metadata representation. However, semantic solutions still require the ability to understand (e.g., through standardization), which they do not support.

4.2.2 Enterprise Application Integration: Build It Yourself

Enterprise Application Integration (EAI) are suites of tools and technologies (e.g., messaging, transactions, workflows, and data translations) with which to build interoperation and integration solutions. Market leaders include IBM's MQSeries,

New Era Of Networks' E-business and EAI solutions, Tibco Software's TIB/Active Enterprise suite, and Mercator's Enterprise Broker and E-Business Broker. These products provide standard data and transaction integration layers that are placed on top of databases and systems. The solutions must be built with these relatively low-level tools (i.e., each data mapping and transaction must be defined) or tailored from their growing libraries of translators between common DBMSs and applications (e.g., ERP suites). Although EAI is one of the fastest growing markets, it still appears that organizations want to build their own solutions without these tools.

4.2.3 COTS: Integration in Isolation

COTS application suites, such as ERP, provided the greatest interoperation and integration solution in the 1990s. ERP application suites provided a single, homogeneous solution for a significant number of back-office functions. This biggest software trend of the 1990s typically provided integrated finance, human resources, and manufacturing/supply-chain business processes, systems, and infrastructures. ERP products and their partner products provided up to 30 functions covering the majority of back-office processing. An ERP integration and interoperation solution is based on common models for enterprise organization, security, business processes, functions, and data, as well as being based on a single language and architecture. ERP solutions are much deeper than mere technical interoperation. They provide common semantics at every level of the solution, from the enterprise, through the business processes, down to the data elements. Heterogeneity of legacy applications can be overcome by migrating to a homogeneous ERP solution. Migrations are typically massive challenges that are costly and that take considerable time, resources, and expertise. With some notable exceptions, the benefits vastly outweigh the costs. This attests to the significance of effective interoperation and integration solutions.

Yet ERP solutions are strongly limited, especially considering B2B requirements. First, ERP solutions exceed the complexity barrier. The functional and technical complexity of a single system that supports the entire back-office operations of the world's largest corporations is beyond human comprehension. This poses problems of understanding not only for ERP customers but also for ERP vendors. Limitations related to this complexity include the inability to specialize the system to the requirements of entire industry sectors, e.g., telecommunications, let alone an individual company. ERP suites provide powerful interoperation and integration solutions within the scope of the suite. Integration and interoperation outside the suite is as difficult as for non-ERP system, except that ERP systems must interact with hundreds of systems. For some ERP products, integration with external systems is made more difficult by the fact that the technical and functional aspects of the ERP product are designed assuming the required resources will be built within the ERP system. This assumption is seldom true because organizations cannot always eliminate non-ERP systems since ERP systems support only a small portion of the functionality required by an enterprise. ERP homogeneity and inflexibility is counter to core B2B requirements.

4.2.4 B2B Integration Solutions: Portals and E-marketplaces

At the turn of the millennium, an emerging B2B integration and interoperation solution is arising in the form of portals and e-marketplaces. The primary motivation for portals and e-marketplaces is economic. Those who control an e-marketplace attempt to monopolize the Web for a specific service, product, or industry. For example, search engines, such as Yahoo!, attempt to maximize their market share for Web searches. They maintain and build the customer base for their core and related businesses. Control of a portal permits the imposition of solutions that address Web heterogeneity. An e-marketplace is a recent and potentially very sophisticated form of portal. An e-marketplace is an online market for all stakeholders in a given market. For example, it would include all the buyers, sellers, and others (such as banking and fulfillment) required to support the worldwide pharmaceutical industry. Twenty-five percent of those surveyed by Forrester [5] anticipate that most of their online trade will flow through e-marketplaces in 2002. The most dramatic e-marketplaces in terms of their projected size are already in place (e.g., the Ford-GM-DaimlerChrysler auto parts exchange; SAP's e-marketplaces in chemical, pharmaceutical, oil and gas, and health-care equipment; and others named in Section 2.2). Although e-marketplaces are economic entities, they provide the opportunity for those in control to overcome the heterogeneity chaos. The November 1999 plans called for the 30,000 Ford suppliers to use Ford's Oracle-based AutoExchange and a similar number of GM suppliers to use GM's Commerce One-based TradeXchange. The merger of these exchanges was forced not only by economic reasons (e.g., control of the supply chains by auto companies and not the technology companies) but also to overcome heterogeneity. The exchange will establish one standard for auto part exchange. Ford and GM have forced Commerce One and Oracle to work together. It is likely that e-marketplaces will arise for almost all domains in 2000, and standards will be set in 2001. As the GM and Ford examples illustrate, there may be multiple standards per industry.

4.2.5 IT as a Service: Let the Experts Do It

The technical challenges posed by the current incomplete interoperation and integration solutions lead an increasing number of enterprises to outsource the problems. Many forms of outsourcing are emerging, each providing a portion of the interoperation solution. A dominant ERP model is to outsource their development to systems integrators. Since ERP systems are not comprehensive and organizations can have more than one, portfolio assemblers have arisen. They are systems integrators that work with you to select and develop the optimal portfolio of ERP and other systems to support an enterprise. Once developed, ERP systems operations can be outsourced to an Application Service Provider (ASP) that is a world-class expert at ERP operations. An ASP variant is a Business Service Provider (BSP), to whom individual business process are outsourced. There are also ASPs that permit organizations to outsource their entire IT function. Hence, organizations can outsource any part of their information systems, from selection, design, and development to operations, all on the basis of individual business processes, business domains (e.g., human resources), or any subset.

A typical premise of outsourcing is that the outsourced activity is not the core business over which you require complete control and the necessary skill sets. Another premise is that the outsourcing organization is world class in its domain, allegedly far better than central IT in an enterprise. For example, Oracle is reinventing itself as a full-service ASP. Oracle's depth of knowledge in data management, back-office (e.g., ERP), and some front-office (e.g., CRM) business domains may explain their leadership in procurement applications [13]. An Oracle solution is likely to be a homogeneous, thin-client Oracle solution but with market-leading [13] interoperation capabilities.

Just as there are business-process-specific ASPs, there is an emerging ASP for B2B online data provisioning. Online data brokers [22] support the critical B2B requirement for data and are world-class experts at data integration as well as information analysis, usually restricted to specific domains (e.g., credit information). As a domain-specific B2B data portal, the online data broker must move their data resources to the network. They attempt to be masters at making data available online tailored to fit the requirement—the right data designed to optimize business performance (e.g., transactions, real-time, dynamic pricing, and accessibility).

4.3 Integration Solution Status

The current solutions do not address the core B2B technical requirements dominated by the need for end-to-end solutions. Some solutions avoid the problem by outsourcing. Other solutions attempt to reduce heterogeneity with homogeneous solutions (e.g., ERP); still others provide intermediate interoperability layers or gateways (e.g., CORBA, standards) between heterogeneous technologies and augment them with functions needed to complete the particular distributed computing model [23]. Interoperation layers will be necessary as long as there are legacy systems. The trillions of dollars of legacy systems must be included in solutions for some time since there is often neither a target solution to which to migrate nor the resources and tools with which to migrate [23]. Current solutions are labour intensive. There may not be enough labour to build the solutions required by the anticipated growth in interconnection.

5 Holistic Computing

The current generation of infrastructure technologies does not meet the requirements of B2B e-commerce. Although it will continue to satisfy the requirements of conventional applications, it is coming to the end of its useful life for next-generation applications. Just as business is being reinvented, so might technology be reinvented to meet current B2B requirements as well as future requirements that will emerge from the unanticipated opportunities that will arise and come to have a greater impact on the world than the initial results of the revolution [3]. This final section proposes ideas toward the process of technology reinvention.

5.1 The Challenge

Next-generation technologies must directly support future economic models. Current computational models and information technology are based on twentieth century economic models designed to manage the internal resources of an enterprise [1]. Twenty-first century computing, starting with B2B e-commerce, should support advanced economic models such as economic-chain. Hence, a fundamental requirement of twenty-first century computing is cooperation or collaboration with resources inside and outside the enterprise [24].

Seen from today, a future generation of infrastructure technology might be inherently distributed and support interoperation and integration as primitive operations independent of any programming or computational languages, models, or architectures. But it is far too early in the revolution to tell what will emerge. The revolution has just begun, driven by emerging economic and business models and processes. The chaos due to changes introduced by routinzation will continue for five to ten years. Consider automobile manufacturing. GM projects that it will take until 2003 for them to reinvent their manufacturing processes and supply-chain. Will B2B e-commerce-based automobile manufacturing processes be stabilized industry-wide by then? The e-commerce revolution is going through each industry at a different pace. The revolutionary five to ten years will be marked by continuous and dramatic changes in business models and process. These changes may disrupt companies [7], processes, or even entire industries (e.g., retail book sales, the music industry). The changes will lead to new, possibly unanticipated technical requirements.

What is a technologist to do, especially under the pressure of Internet speed and myriad emerging and converging technology opportunities (e.g., network and mobile appliances)? The results of adopting apparent solutions too early and the waves of alleged paradigm-shifting technologies has littered the IT landscape with heterogeneous legacy systems and technologies. This is just the problem we want to avoid. Due to the vast investment in and value of legacy systems and the migration challenges, legacy resources must be part of almost all near-term solutions. Even Amazon must obtain information resources from thousands of partners whose businesses operate on legacy systems.

5.2 A Holistic View

The Information Revolution is driven by economic and business models and is enabled by technology. Technical solutions to B2B e-commerce challenges and opportunities require an understanding of how economics, business, and technology relate. An economic model defines a class of business models that are, in turn, defined in terms of their core business processes. The business requirements of a process determine the requirements of the technology solution that will support it. This big picture provides a holistic framework for the role of technology in the Information Revolution. This framework is the next-generation virtuous cycle beyond that of Intel and Microsoft for processing capacity and need. A depth of understanding of economic models, such as economic-chain, and B2B business models and processes will help immensely in developing technology solutions for B2B e-commerce.

Technology triggered the current Information Revolution by enabling connectivity. But this technical solution would not have succeeded had it not met a critical business requirement. The coincidence was fortuitous and, as they say, the rest is history. With the hope that such a rare coincidence will rise again, some technologists may continue to invent technology *que* technology. With the significance of B2B e-commerce and the urgent need for technical solutions, we should turn our attention to a deeper understanding of economic and business requirements and their relationship to the requirements for the next generation of infrastructure technology. For example, there is some volatility in the evolution of economic models, leading to entire new classes of business models. There is enormous volatility in the evolution of B2B business models. It is almost impossible to develop a full technical solution until the full business requirement is understood. It may be possible to develop long-lasting, general-purpose technical solutions in specific areas that will meet the requirements of many business processes based on an understanding of current requirements.

One might imagine an e-commerce computational model composed of basic operators or services called e-services. Current B2B business processes may lead to a set of e-services such as "order procurement, online trading, customer relationship management, product promotion, or real-time car navigation and traffic information services (www.hpl.hp.com/hosted/tes2000)." Experimentation with potential e-services is exactly the right research direction. However, it will take a much deeper understanding of B2B e-commerce as well as time for its evolution before the full requirements and technical opportunities are known. How might this necessary technical experimentation be conducted?

5.3 Holistic Experimentation

Technical experimentation could be done within a holistic framework such as proposed above. Economic-chain suggests holistic guidelines. First, technical solutions should be for comprehensive end-to-end business processes. Like many vendors [16], SAP, AG is using a scenario-driven approach to develop e-services in areas such as procurement, collaborative bidding, auctioning, collaborative forecasting, CRM, distributor/reseller management, available to promise, online training, online consulting, and Web marketing. Second, as current architectures will be reinvented as resources move to the network, architectural views of systems may not be as helpful as process-oriented views. Technical optimization will involve the execution of operators and the flow of information and control. Processes provide those requirements for next-generation architectures. Technology components have specific dependencies (e.g., interfaces) in current IT architectures (e.g., the levels of the ISO stack). These dependencies may change radically as network-based architectures evolve. Processes may indicate potential next-generation technology components and their dependencies. Finally, it is essential for technologists to partner with the relevant business and economics subject matter experts to ensure the relevance of experiments.

Experimentation can follow the conventional scientific method but should be as close to reality as possible (e.g., in real dot-coms or in real e-marketplaces). Let a real context provide the ultimate evaluation. There is a wonderful, possibly apocryphal story about an Amazon marketing experiment. Allegedly, senior

executives were discussing two potential marketing strategies. Should they give airline miles or frequent-book-buyer credit? Jeff Bezos, Amazon's CEO, said that they didn't need to speculate as to which would be the more effective. All they needed to do was to run live with one and then with the other option and evaluate both. The experiment was both decisive and took less time than the anticipated discussion. The world has changed, and new opportunities abound!

6 Summary

Business-to-Business e-commerce is driving the Fourth Information Revolution that was triggered by the computer and the Web. The revolution is leading to fundamental and irreversible changes in the way we do business in every domain. As a result, all business processes are in flux and there appears to be chaos, as in a gold rush, in diverse and creative Internet experiments.

B2B's Web-centric requirements are beyond the capabilities of current infrastructure technologies and legacy systems. Intelligence (i.e., applications, workflows, data) must move from individual resources in internal IT architectures to integrated resources on the network. This re-frames current integration challenges and provides new opportunities. A new generation of infrastructure technologies is required.

The requirements of the new generation will be those of the B2B business models and processes that will emerge from the current apparent experimentation. Following previous technology-based revolutions, the chaotic period will last for some time and have unanticipated results. With incomplete requirements for five to ten years, how do we design the next generation of infrastructure technologies?

While it is premature to determine the next generation, challenges of the current generation remain and are further exacerbated by B2B. Specifically, heterogeneity and interoperability, far from resolved today, are mission critical in the connected world of B2B e-commerce. The flood of new technologies and the Internet speed at which solutions are required further complicate these problems.

This chapter examined the current chaos of B2B e-commerce and the nature of significant business processes. It considered B2B technology requirements and reviewed some current solutions. It concluded by proposing a holistic view for the period of intense experimentation that will lead to a new generation of infrastructure technologies to support an interconnected world.

7 Homily

The most profound changes resulting from technology-based revolutions are the unanticipated ones [1, 3]. The Gutenberg press led to secularization and the Reformation. The steam engine and the Industrial Revolution led to factories, the rise of cities, and the middle class. The current Information Revolution has the potential to change our world as much as have electricity and the telephone. Technologists may not be able to anticipate or understand the coming changes, nor control them. However, we can work with those who might to more fully understand what we are doing. More fundamentally, we can appeal to basic morality and ethics. We should be aware of the potential for the B2B e-commerce revolution to change

the way we conduct business and to impact everyone on the planet. These are powerful forces. Let's develop them for the common good.

References

1. Drucker PF. The Next Information Revolution, Forbes ASAP, Aug. 24, 1998.
2. Romer P. with Evans, G and Honkapojha, Growth Cycles, S. American Economic Review, Vol. 88, No. 3, June 1998, 495-515.
3. Drucker PF. Beyond the Information Revolution, The Atlantic Monthly, Oct. 1999.
4. e-volve: Dot-Com and Beyond, A Comprehensive Study of the Second Stage of the Internet Revolution, Bear Sterns, New York, Feb. 2000.
5. EMarketplaces Boost B2B Trade, Forrester Research Inc., Cambridge, USA, Feb. 2000.
6. Brodie ML. Broadening the Database Field, www2.aucegypt.edu/vldb2000, Dec. 1999.
7. Christensen CM. The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail, Harvard Business School Press, Boston, 1997.
8. Brodie ML. Rethinking ERP: The Second Generation, 1st Int'l Conference on Enterprise Management and Resource Planning, Venice, Nov. 1999 e-proceedings (http://mosaico.iasi.rm.cnr.it/emrps99).
9. The Demise of CRM, Forrester Research Inc., Cambridge, USA, July 1999.
10. High Tech Truckers, National Public Radio (www.npr.org), Feb. 8, 2000.
11. GM Retools to Sell Custom Cars Online, Wall Street Journal, Feb. 22, 2000.
12. Faced With the Online Threat, Developers Race to Improve Their Layouts and Maps, Wall Street Journal, Feb. 8, 2000.
13. Oracle Leads SAP to Procurements Apps, Forrester Research Inc., Cambridge, USA, Aug. 23, 1999.
14. Intelligence Is Moving to the Web, The Economist, November 13, 1999.
15. Is Nonstop Enough? Forrester Research Inc., Cambridge, USA, Feb. 2000.
16. Why Most B2B Sites Fail, Forrester Research Inc., Cambridge, USA, Dec. 1999.
17. Brokered Partner Integration, Forrester Research Inc., Cambridge, USA, Jan. 2000.
18. The Death of IT, Forrester Research Inc., Cambridge, USA, Jan. 2000.
19. Karlgaard R. "Digital Rules" Technology and the New Economy, Forbes, Aug. 10, 1998.
20. Merged Railroads Still Plagued by IT Snafus, Computerworld, Jan. 17, 2000.
21. Brodie ML. *The Emperor's Clothes Are Object Oriented and Distributed,* in Cooperative Information Systems: Trends and Directions. M.P. Papazoglou, G. Schlageter (eds.), Academic Press, 1998.
22. Online Data Brokers, Forrester Research Inc., Cambridge, USA, Feb. 2000.
23. Brodie M.L. and M. Stonebraker. *Legacy Information Systems Migration: The Incremental Strategy*, Morgan Kaufmann Publishers, San Francisco, 1995.
24. Brodie ML. The Cooperative Computing Initiative*:* A Contribution to the Middleware and Software Technologies Sub-Subcommittee of the Presidential Information Technology Advisory Committee, Jan. 22, 1998.
25. Triggering the B2B Electronic Commerce Explosion, Forecast Analysis, Gartner Group, Stamford, Jan 31, 2000.