

The Impact of E-Commerce on the Design and Construction Industry

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Abstract

Historically, the design and construction industry has been slow to innovate. As a result, productivity in the construction industry has declined substantially compared to other industries. Inefficiencies in this industry are well documented. However, the potential for cost savings and increased efficiency through the use of the Internet and e-commerce may not only increase the efficiency of the design and construction industry, but it may also significantly change the structure and composition of the industry. This is suggested because effective implementations of e-commerce technologies are not limited to one aspect of one industry. E-commerce may be most effective when it is thought of and applied to multi-industry enterprises and in a global context.

This paper continues the exploration of a concept that we have been working on for several years, namely that "...information technology is evolving from a tool that incrementally improves 'back-office' productivity to an essential component of strategic positioning that may alter the basic economics, organizational structure and operational practices of facility management organizations and their interactions with service providers (architects, engineers and constructors)." (Johnson and Clayton 1998) This paper will utilize the case study methodology to explore these issues as they are affecting the AEC/FM industry.

1 The Problem

As figure 1 shows, construction productivity seriously lags behind other industries. It is not hard to see why. According to one article, "inefficiencies, mistakes and delays account for \$200 billion of the \$650 billion spend on construction in America every year." (The Economist 2000). This article goes on to say that the typical \$100 million building project requires 150,000 separate documents such as working drawings, contracts, change orders, and requests for information.

Other industries have improved productivity through investing in information technology. The advent of the Internet and business-to-business e-commerce promises a continued increase in this trend. The definition of e-commerce has evolved as the use of the Internet has evolved. We use e-commerce in this proposal to mean all aspects of business and market processes enabled by the Internet and web technologies, including supporting issues such as data standards for interoperability. However, we also interpret e-commerce as something that is more than a collection of computer technologies. As in our previous study, we view e-commerce as the strategic deployment of technologies. The US Department of Commerce has estimated 1) that high technology has driven more

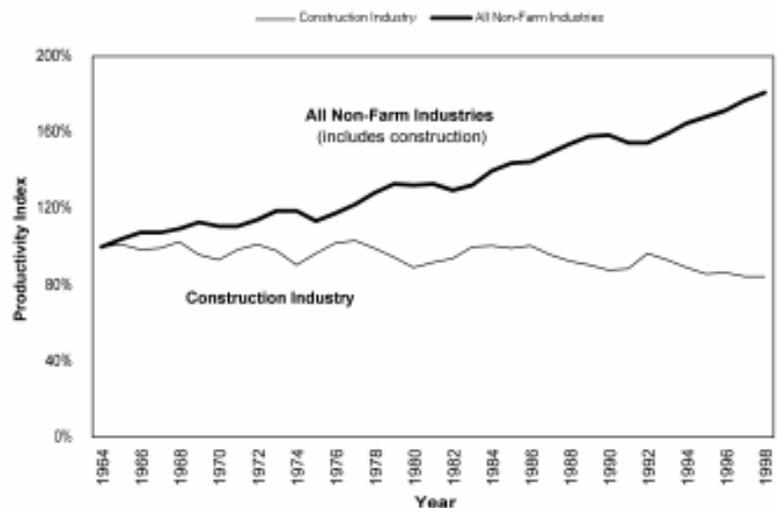


Figure 1. Construction Productivity Index, 1964-1998 (Constant \$ of contracts / workhours of hourly workers). This table was developed by Paul Teicholz, Professor Emeritus, Stanford, from data published by the US Bureau of Labor Statistics, Department of Commerce.

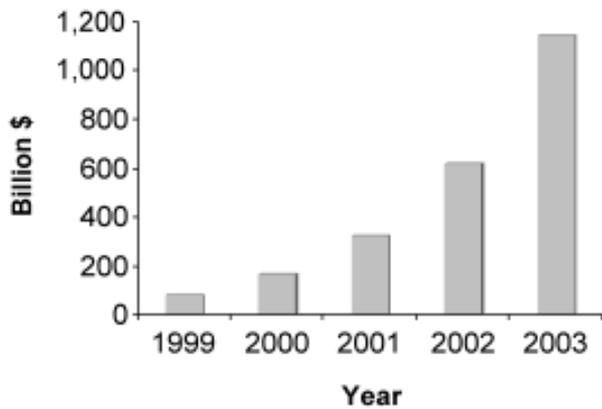


Figure 2. Business to Business E-commerce Revenue Estimates (www.idc.com 2000).

than a quarter of all economic growth since 1993 and 2) information technology sectors are growing at double the rate of the overall economy. The International Data Corporation (IDC) has reported (see Figure 2) that business-to-business e-commerce in the US is expected to grow from \$80 billion in 1999 to almost \$1,140 billion in 2003 (www.idc.com 2000).

The Internet and related applications associated with e-commerce have grown much more rapidly than anyone guessed even five years ago, spawning often radically new ways of communication, collaboration and coordination among consumers, businesses and trading partners. At the time of our 1996 survey, the web was being used primarily as a reporting mechanism. By late 1997 it had already become clear that the Internet would have an important impact on group decision processes and that

database connectivity would transform the web into a dynamic decision support system. Still, the advent of business-to-business e-commerce ventures such as business-to-business procurement and “cybermediaries” (who bring together previously unknown buyers and sellers) is an even more recent phenomenon with significant implications for design, construction and facility management. The purpose of this paper is to try to outline some of these implications.

Since innovations in the design and construction industry tend to lag behind others, an example from another industry might be instructive. Ford Motor Company recently announced their intention to become a New Economy, e-business company. By 2010, Ford expects to look more like Cisco, a company that manufactures very little (Akasie, 2000). The new Ford vision is to enable customers to purchase cars the way computers are bought at Dell. Business-to-Business e-commerce processes will facilitate the substitution of outside companies for manufacturing that is currently company-owned (outsourcing). The idea is to connect the car buyer directly with the “supply chain.” Substantial cost reduction is anticipated from improved efficiencies in transactions to lower inventories. In addition, Ford will have the ability to, for the first time, track consumer preferences after the sale through the life cycle of the automobile.

2 Conceptual Framework

In order to conduct this study we developed a conceptual framework (see Figure 3). The conceptual framework adopted by this research is an outgrowth of our earlier research that explored the role of information technology in facility management. This research began with a survey of how information technology is being used in Fortune 500 companies. We continued this research with studies on intranets, “best practice” site visits, and a series of studies with USAA that focused on as-built drawings and the use of information in a specific corporate environment. This research resulted in a number of findings that may be summarized in the conceptual model below (Figure 3).

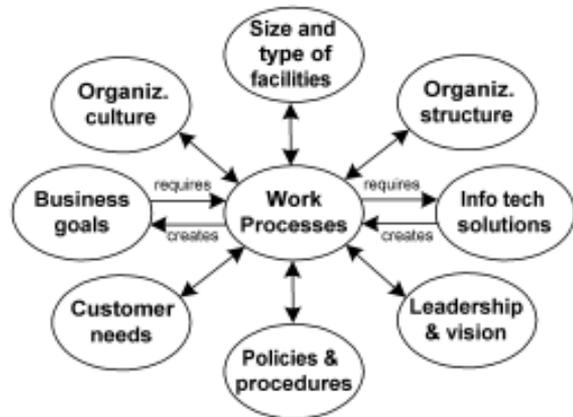


Figure 3. Summary of Recent Research on IT and Facility Management.

Through our research we found that the role of information technology was significantly influenced by a variety of factors that appeared to be unique to a given organization. The type of information technology solution adopted to improve work processes in a facility management organization was strongly influenced by the characteristics and goals of the parent corporation. For example, facility management departments that were managing multiple sites in different countries were likely to plan and implement information technology solutions in a manner that is entirely different from departments that manage space within a single building. Companies that had adopted charge-back policies used different information to drive decisions than companies that did not have such policies.

The adoption of information technology was also influenced by the type of industry. Different industry groups tended to adopt technology in different rates and in different ways. We concluded that a number of organizational characteristics may be important factors that will influence how information technology was adopted within a given organization.

More recently, we have extended this model as indicated in Figure 4, below. This revised model hypothesizes that business goals are linked to investments in e-commerce because of the desire to improve efficiency and effectiveness. However, it also suggests that e-commerce is not only causing companies to rethink business processes, but is also creating the possibility for entirely new forms of business processes and organizations (see also Huang 1999 and Malone 1993). The purpose of this paper, therefore, is to explore the impact that e-commerce is having on the design, construction industry and facility management industry.

3 E-Commerce Definition

E-commerce is most commonly referred to as Internet-based buying and selling of goods and services. Another way to think of e-commerce is simply as conducting business on-line. This includes, for example, buying and selling products

with digital cash but it may also include trading products, goods and services. Using this definition, e-commerce has many similarities with catalog shopping and home shopping using cable TV. But e-commerce is not limited to this definition of on-line buying and selling. It also leads to fundamental changes in the way products and services are distributed and exchanged, involving all aspects of a business. The real revolutionary potential of e-commerce is in its effects on three different kinds of business processes: a) within-business processes, b) business-to-business processes (e.g., supply-chain management) and business-to-consumer processes. Improvements in all three of these areas will impact the AEC/FM industry.

4 Research Questions

The framework we presented above has suggested two fundamental questions that we sought to explore as part of this research:

1. What is the affect of e-commerce on the ability of AEC organizations to achieve their business goals? How might e-commerce significantly alter those business goals?

Business-to-business e-commerce is used for coordinating the purchasing operations of a company and its suppliers. It also is being used to improve customer service and maintenance operations. Companies of all sizes can communicate with each other without the need for traditional intermediaries. We will discuss developments in supply-side management in the AEC/FM industry and provide some examples of how this is changing the thinking of the role of real property design, construction and facility management.

2. What is the effect of e-commerce on business work processes? Does the effective design and implementation of e-commerce solutions vary among organizations?

E-commerce technologies are emerging in the AEC/FM industry and may significantly change the way business is done. Through our case studies we will explore several examples of within-business processes, business-to-business processes, and business-to-consumer processes in order to learn how different types of organizations in the design and construction industry are using e-commerce.

5 E-Commerce Case Studies

The following case studies help to illustrate how various organizations in the AEC/FM business are thinking about and using e-commerce today. As this is an exploratory study, these cases are not intended to be comprehensive.

5.1 E-Commerce Solutions for Project Management (3D/International)

The use of information technology and the Internet to manage projects was identified early on as a very good way to improve value. Sites such as BidCom, Cephren and BuildPoint are attempting to create globally recognized web portals for design and construction. Because of the extensive publicity surrounding these web sites, these sites will not be covered in this paper. These sites have proven to be effective for typical project management tasks such as document and RFI management and are vying for positions as major portals for business-to-business online purchasing in the construction industry. However, some of the largest architecture/engineering firms are pursuing a different strategy in attempting to improve their competitive position by providing customized e-commerce tools to clients. One of those firms is 3D/International.

3D/International (3D/I) was founded in 1953 as an architectural practice. Today it is a multidisciplinary architecture/engineering firm with its headquarters in Houston, Texas and multi-



Figure 4. E-Commerce Research Framework.

project offices in 12 locations. What makes 3D/I unusual in the industry is the fact that they invest about \$1 million per year on research and maintain a staff of about 15 people who are dedicated to developing program management information systems to support their design and construction management services (Thomsen 2001).

Description of Software Solution

3D/I's software has been created to support what is now their core business: the management of large design and construction programs. The programs they have developed include three major software tools (COMET, IMPACT and COSMOS) as well as a number of project-specific web sites and web-based project manuals (see Figure 5). This software is typically customized to the needs of individual clients. 3D/I typically gives the software (code plus data) to clients for their use after the project is completed at no charge. Custom-developed modules are written in standard languages such as Visual Basic so that they may be maintained by the client.

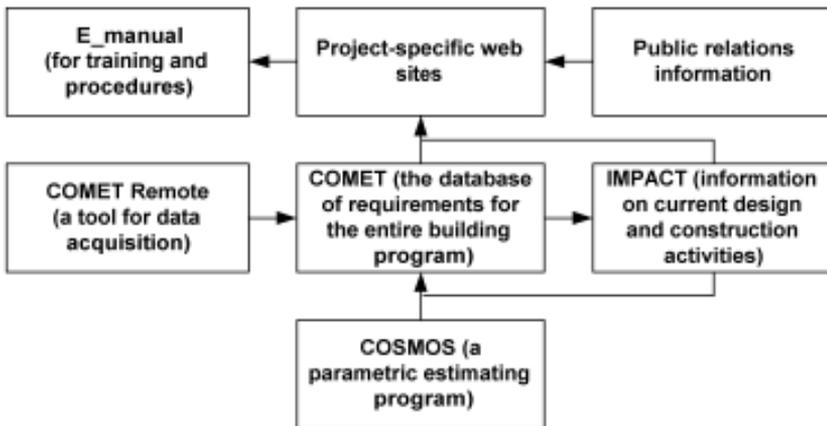


Figure 5. 3D/I Project Information Systems.

cost, schedule and quality information in one central database. It tracks details on each project, and can produce reports on total program management. Information, activities and agreements are organized by categories of cost, schedule and scope (quality). Report formats can be tailored to meet the unique needs of project managers or clients.

COSMOS (Cost Model System) is conceptual estimating software that is integrated with the RS Means cost database as well as 3D/I's historical construction estimate database. The system creates cost models from its historical data that are modified to fit different projects and conditions. The software allows the user to test the cost implications of changes in any building system or component.

3D/I also develops and maintains project and program websites to publish information about construction management projects and programs. This enables team members to communicate with each other, clients, contractors, and with the public. They are similar to other project management web site systems in that they are used to share cost and scope information, schedules, meeting minutes, web-based procedure manuals and drawings and other project information.

3D/I is an example of how one company has used e-commerce applications to differentiate itself from other service providers in an industry where design and construction management services are increasingly seen as commodities. Instead of using one of the increasingly popular web-based project management approaches it uses software to not only leverage its abilities and skills, but more importantly to customize its products in such a way that its services become unique and different from those sold by its competitors. It is an approach that is only available to the largest companies in the industry. The remaining question is whether or not even the large companies have the resources to keep up with the emerging "dot-coms" in the design and construction industry.

5.2 Operational Effectiveness (Conoco)

A major benefit for introducing concepts of e-commerce into an organization is to improve operational effectiveness. Common operational improvement objectives include improving productivity,

COMET (Condition Management Estimation Technology) was developed to help assess and evaluate facilities. COMET provides a method for inventorying, estimating and tracking facility deficiencies as well as projecting future facility renewal costs. It includes *COMET Remote*, which runs on a hand-held Pentium Windows-based PC, and *COMET PC*, which is used to facilitate uploading data from COMET Remote. This software system is used to record building deficiencies, project repair costs, and bundle deficiencies into projects.

IMPACT (Integrated Management, Project Accounting & Controls Technology) operates on a LAN, a WAN, and the Internet but keeps

decreasing costs or avoiding costs. One organization that exemplifies this approach is the facility management department at Conoco.

Conoco Inc., is a global energy company with 17,000 employees in 40 countries and is involved in various aspects of the oil and gas industry. Its revenues in 1998 were \$23.2 billion. Previously a subsidiary of DuPont, Conoco Inc. completed its separation in August 1999. The headquarters of Conoco is located in Houston, Texas and occupies 16 buildings of 1.25 million square foot on a site of 64 acres. The on-site population is about 2,570 employees and the churn rate is 60-70%.

The structure of the facility management (FM) group reflects the company's "small and smart" strategy. The FM group was downsized and reengineered and since 1992 the staff decreased from more than 100 to only 9. The majority of the maintenance and operation work orders are outsourced to about 40-50 contract workers who reside on site. Every effort is made to maintain a small in-house staff that is both competent and efficient. As a result of downsizing it became essential to adopt e-commerce approaches.

In their attempt to automate facilities management, many companies acquire comprehensive CAFM packages that end up sitting on their shelves gathering dust (Teicholz & Ikeda 1995). The best strategy to prevent the "shelfware" phenomenon is to "put first thing first" – clearly state your key objectives and aim at them. In Conoco's case, their highest priorities were project management, operations and maintenance, and customer services. After carefully evaluating their needs, Conoco decided on a two-part strategy for improving operational efficiency:

1. Use of a non-graphical system. Many computer-aided facility management systems utilize spatial management functions, such as CAD and space management. In Conoco's case, however, the configuration of the physical facilities did not change very much and therefore a graphic-based system was not necessary. Therefore, they selected a computerized maintenance management system (MAXIMO Advantage) that did not incorporate a graphical space management component.
2. Use of standard, off-the-shelf software. Instead of purchasing specialized FM software, Conoco facilities managers exploited the fact that the company had standardized on Microsoft Office throughout the corporation. Although other software may provide more functionality, the fact that virtually every employee in Conoco had the identical Microsoft Office configuration was identified as a significant advantage. Applications were developed using Microsoft Outlook, Access, and Microsoft Exchange Server to handle many scheduling, communication, and space allocation functions.

The standardized and extensive use of the off-the-shelf software enhanced productivity, allowed the facility management group to easily connect with all employees in Conoco, and substantially reduced the cost of both implementation and training. Using this approach, issues such as interoperability and CAFM integration with the larger enterprise were non-existent. It is an example of how the implementation of e-commerce technology can be used to significantly improve within-business processes with minimal expense.

5.3 *Web Portals (HomeWrite)*

Among the recent "dot-com" start-ups in the AEC/FM industry is HomeWrite (www.homewrite.com). HomeWrite has positioned itself as an interactive Web-Portal for homeowners, builders, remodelers, contractors and anyone else whose business or interest is homes. Its mission is to provide web-based services and tools that are tailored to the needs of various providers and customers in the homebuilding industry.

To achieve its goals, HomeWrite has forged alliances with other web sites such as www.repairnow.com (a web site designed to help home owners keep their homes in good repair and find qualified service providers), www.thehomevine.com (a web-community for experts and amateurs to exchange information about homes), www.homepreservation.com (a web site for home preventative maintenance and repair services), www.homeportfolio.com (a site that lets users choose favorite home products and organize them in an online scrapbook for communication spouse, builder, architect, or designer), and others. In addition, they have created a permanent, web-based online home record and owner's manual for homeowners. Think of it as the homeowner's equivalent of Quicken. All information about a home (floor plans, construction pictures, warranty information, etc) is accessible from the Internet. The idea is that contractors will input information as a value added for homebuyers. It is available when homeowners need it for repairs, remodeling, resale, etc.



Figure 6. Screen image of a HomeWrite home page.

The HomeWrite case study demonstrates the use of e-commerce for both business-to-business as well as business-to-consumer process improvement. It is an example of how one company is trying to position itself to be “the” electronic information broker for the home building industry.

5.4 Integrated E-Business Strategies (Luminant Worldwide)

A trend in the AEC/FM industry is the increased competition from non-traditional service providers such as Arthur Anderson Consulting. This trend was identified in last year’s AIA convention by presenter Mike Brandon, “S56-Business Management Trends Affecting the A/E Industry”, Friday, May 7, 1999. Consulting firms are getting involved in providing design services because their clients are demanding a single integrated strategy and solution for their business problems. Often, this strategy involves the design of buildings.

A related trend in the industry is the outsourcing of AEC/FM services to contract workers. Companies often do this to decrease costs, but another incentive is the ability to identify and organize “best in class” service providers so that they can focus on their “core business” and create more value for the corporation. This has resulted in the definition of a new term, “Infrastructure Management”, which is defined as “the integrated management of non-core functions.” (Wales 2000).

Luminant Worldwide (www.luminant.com) is a relatively new company whose mission is to provide a single integrated business strategy to those companies who have a special focus on e-business. Part of their service portfolio is developing strategies for the management of a company’s infrastructure and facilities. They provide strategic planning services to Global 1000 and Internet-centric companies that specialize in creating Internet value. Of particular interest to this paper is the dual focus on corporate infrastructure management and e-commerce.

As described by Luminant (Wales 2000), “point” solutions that address specific operational needs have led to the proliferation of incompatible solutions and are no longer acceptable. The new goal of many clients requires managing all assets as a strategic component of overall business strategy. This can only be accomplished by creating truly corporate-wide infrastructure solutions using e-commerce principles and technologies.

One example of the impact of this strategy on the AEC industry is provided by Nortel. Material in this section is taken largely from a presentation by Mr. Juan Cano of Nortel at an IDRC Chapter Meeting, Houston, Texas, June 6, 2000. Not very long ago, Nortel was a manufacturer of telephone switch equipment; they have since reinvented themselves to be an eBusiness “virtual” enterprise providing support through both hardware and services. Nortel has embarked on a program code-named the Mercury Principle. Prior to this program, Nortel had a large, internal facilities department similar to that shown in Figure 7. In this traditional organization, Nortel had a large facilities staff with 10 separate departments and hundreds of employees. Each department had a manager and their own staff. Their role was to control all the service providers to achieve what Nortel wanted — high quality at a low price. Each department had separate contracts with service providers (e.g., architects and contractors as well as others) that had to be run through their legal department. Nortel decided that the cost of this way of doing business was prohibitive.

Their goal became to evolve to a new environment where, instead of stressing control of service providers, they stressed collaboration and interdependence among service providers. This included sharing knowledge, talent and resources among service providers who frequently compete with each other for clients. (Hence, the title “Mercury Principle”, that derives its name from the propensity of mercury drops to attract each other and become one.)

In this new environment Nortel has a small number of facility employees called “client primes.”

These people facilitate communication between Nortel and their service providers. Instead of separate contracts with each service provider for each project, Nortel has a limited number of “Tier 1” providers (Strategic Associates) with which they have sole-source contracts.

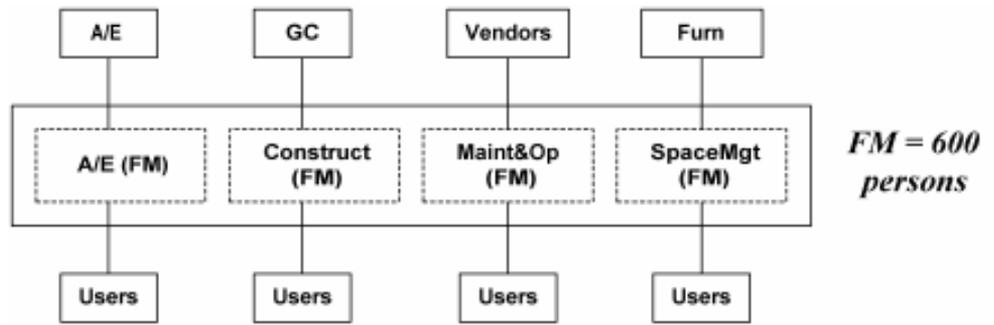


Figure 7. Traditional, in-house facilities organization.

Tier 1 providers are Grubb and Ellis (FM), CB Richard Ellis (FM), HOK (Architecture) and Herman Miller (furniture systems and services). Tier 1 providers are expected to work cooperatively (“co-opetition”) to solve Nortel’s facility problems. In turn, Tier 1 providers will have sole-source contracts with Tier 2 providers (Service Associates) and Tier 2 with Tier 3 providers (Supply Associates). Nortel, however, only has sole-source contracts with Tier 1 providers. In effect, the idea is that Tier 1 providers are a virtual facility management group for Nortel. For example, senior vice presidents from the Tier 1 providers participate in Nortel cabinet meetings.

Traditional roles in this arrangement tend to change in direct response to client needs. For example, Herman Miller is a manufacturer of Herman Miller workplace furniture. In this model, Nortel is less interested in workplace furniture than they are in servicing the needs of users. This means that Herman Miller becomes more of a service provider to meet user needs and, if necessary, will specify and deliver furniture from other manufacturers.

Last year Nortel saved \$15 million while at the same time growing about 25% through this new arrangement. Their goal is to eventually have only 1 person in the whole of Nortel who is responsible for facilities (Figure 8). All other employees will be focused on their core business. As Nortel evolves to this organization, the way providers do business dramatically changes. E-commerce will be necessary to facilitate communication within this organization.

5.5 Web Auctions (FreeMarkets)

Web auctions are an intriguing example of how the Internet has approximated the essence of a “pure” free market economy where a typical assumption is that consumers and buyers have perfect information. FreeMarkets (www.FreeMarkets.com) is an Internet company that conducts online auctions for industrial parts, raw materials, commodities and services. In these “downward price” auctions, suppliers compete in real time for the purchase orders of large buying organizations by lowering their prices until the auction is closed. In one examples, a company that paid \$745,000 for its last batch of plastic auto parts before using auctions was rewarded by paying only \$518,000 for the same parts using a FreeMarkets.com “reverse” auction (Colvin 2000). Closer to home, the construction industry’s “first” reverse auction was reported in an article by Paul Doherty (Doherty 2000), who gave a graphic description of how this auction worked even though the identities of the buyer and sellers were withheld. Although both of these examples deal with products, FreeMarkets is also auctioning “tax preparation services, relocation services, temporary help, and other services.” (Colvin, May 1, 2000, p. 74). It is entirely conceivable that design and construction services might also find themselves in bidding for someone to buy their services on the Internet.

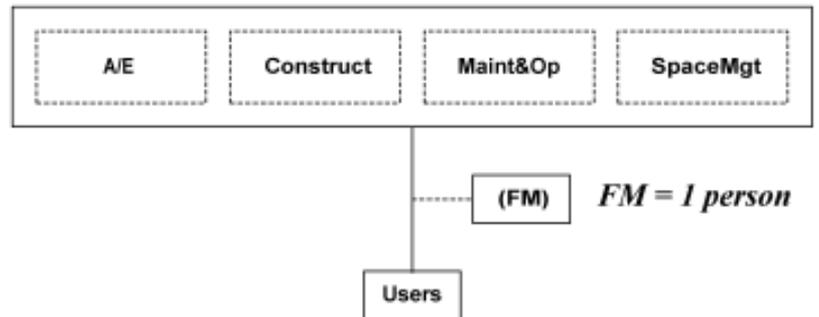


Figure 8. Nortel's facility organizational goal.

6 Conclusions

The case studies in this paper illustrate how the Internet and e-commerce are causing many companies to redefine how value is provided to the end user.

A typical value chain (indicated in Figure 9) is the traditional way of thinking about how firms and their activities are organized. In this model, “value” refers to customer value, which is the ultimate source of profitability and survivability for firms. The construction industry is famous for the

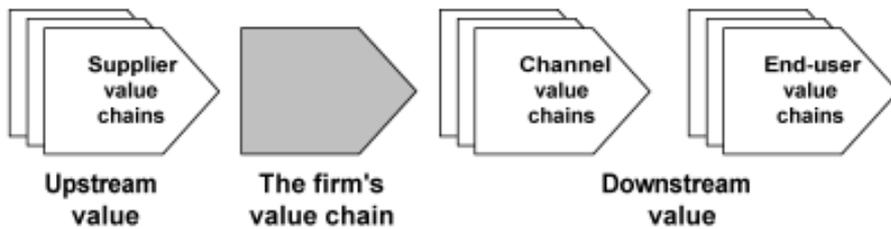


Figure 9. Value chain (after Porter, 1985).

approach working relationships may be difficult to maintain and it may be difficult to optimize customer value across the entire value chain. Nevertheless, it has been argued that this condition persists because of the inherent benefits of “small and flexible” production systems. For an interesting discussion of these two perspectives, see Tombesi, Paolo, “Travels from Flatland: The Walt Disney Concert Hall and the Specialization of Design Knowledge in the Building Sector,” unpublished Ph.D. dissertation, UCLA, 1997.

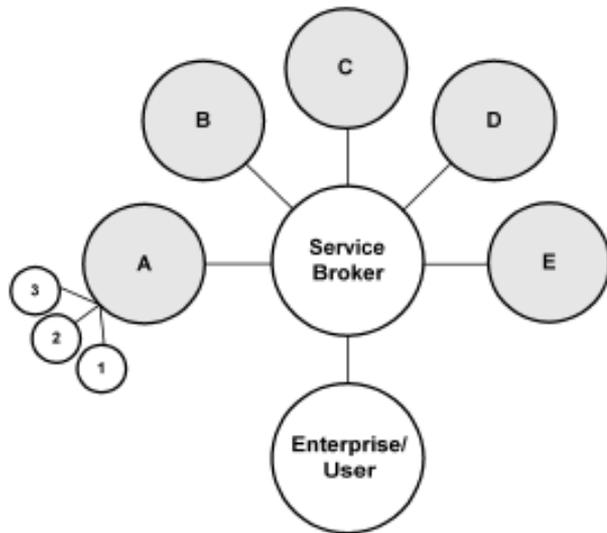


Figure 10. Networks and Service/Information Brokers.

Although the advantages of flexible production systems are significant, there is a tendency to sub-optimize on localized value chain production issues and to be relatively insensitive to upstream or downstream information needs. As one example of this problem, we have found that although facility management organizations have a great need for design intent, this upstream information is lost because it is not required for the construction of a building. Sharing information across value chain activities has been difficult to achieve in the AEC/FM industry. However, the trend towards outsourcing and the increased use of e-commerce technology to coordinate among various service providers may be changing the AEC/FM model from one of a linear value chain to more of a network model (see Figure 10). HomeWrite and Nortel both provide examples of this network model, where a “cyberintermediary” or service/information broker is responsible for organizing and supplying the needs of the end user.

E-commerce seems to have a dual effect on intermediaries. On the one hand, owners and owner’s agents may be able to eliminate intermediaries in value chain transactions ranging from bidding to procurement. With the Internet, transactions will be able to occur on line directly among those individuals or firms that desire the transaction. Exchanges will be direct, instantaneous and efficient. Internet companies such as Cephren.com believe that the elimination of intermediaries will allow them to revolutionize inefficiencies in the \$250 billion market for building materials. These web sites, not only share documents, but also provide a mechanism for construction materials to be purchased online. With the growth of web auctions it will not be long before these web sites organize online bidding for construction business.

On the other hand, examples such as Nortel suggest that, because every industry has specialized needs, intermediaries will become more necessary as more information becomes available and more connections are possible. Successful solutions will require comprehensive consulting, service and support. Intermediaries may become the electronic brokers in the chaotic information space. In any case, the cases reviewed in this paper suggest that e-commerce technologies may result in a significant restructuring of the AEC/FM industry.

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