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What strategic alignment, process redesign, enterprise resource planning, and e-commerce have in common: enterprise-wide computing

Atieno A. Ndede-Amadi
Department of Accounting and Management Information Systems, Bowling Green State University, Bowling Green, Ohio, USA

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Abstract *Unlike other purchases of information technology that have failed to deliver measurable improvements in corporate performance, enterprise-wide information systems in the manufacturing industry have immediate and positive impact on the bottom line. The transition from strategic alignment as the basis for IT investment, to redesigned business processes as the critical elements of organizational strategic planning to which IT investments must be targeted, to the integration of these processes into enterprise-wide systems, to e-commerce is examined. With supply chain collaboration, information systems have exited corporate boundaries.*

Process redesign and strategic alignment

Organizational strategies should drive technological strategies, not the other way around (Framel, 1993; Goodman, 1994; Pastore, 1994). According to Glazer (1993) successful firms have invested in IT like everyone else, but have differentiated themselves by viewing the management of information produced by these systems as being of paramount importance. As these organizations identify the relationship between corporate and IT strategies, they use information to integrate and manage this link. Such organizations succeed because of their ability to differentiate themselves from their competitors in this way. This viewpoint is supported by Parker *et al.* (1988) who maintain that justification for an IT application links to one of the two conditions: either it improves the performance of the current organization or it improves the outlook for new business opportunities and strategies of the enterprise. Framel (1993) also supports this viewpoint by maintaining that total business integration is a must for businesses that want to succeed in the information age. Total business integration, in his definition, is the full assimilation and integration of all information assets into the total organization using business need as the primary driver for the processes. Goodman (1994) agrees that a total management approach is needed which fully assimilates and integrates all information functions and technologies in the organization.

Tinnila (1995) identified three perspectives on process redesign: operational, organizational, and strategic. The operational perspective sees IT as an enabler of business processes by improving operative efficiency. The organizational perspective perceives the potential of business processes in the redesign of organizations. Organizational processes are those extending over different functions and having

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customers as well as suppliers. The focus is on the core and critical processes of the company. The objective is the development of these processes with predetermined customer segments, suppliers and products. The strategic perspective recognizes business processes as units of strategic planning and, therefore, acknowledges the need to connect them more closely to business strategies. The three perspectives all deal with the same phenomenon: radical rethinking of important and crucial processes to achieve dramatic improvements in several measurable operations. The perspective of this paper on process redesign aligns more closely with Tinnila's (1995) strategic perspective, but encompasses both organizational and operational perspectives. Business process redesign, defined as the deliberate and systematic adjustment of business processes to achieve alignment between business process and organizational objectives (Mandrish and Schaffer, 1995), can help achieve strategic alignment. Strategic alignment is said to exist when business process objectives (and the IT that enable them) are synchronized with organizational objectives.

The importance of process redesign in IT investment decision processes is supported by several earlier IS research findings which show that, traditionally, work and productivity have often not improved with the introduction of a new system and that only a small fraction of new systems generally alter business practices (Bashein *et al.*, 1994; Guha *et al.*, 1993; Moad, 1993). These research findings support the notion that it is strategic investment in IT, not increased IT investment dollars that is important for the success of a business. Strategic IT investment is defined as investment in IT that is aligned with the achievement of strategic objectives.

The concept of process redesign discussed here has been called different things by different IS researchers, such as: business process redesign (Ould, 1995); process improvement; and process innovation (Davenport, 1993). Other terms used for the same general concept include process change (Talwar, 1993), continuous innovation (Guha *et al.*, 1993), incremental change (Stoddard and Jarvenpaa, 1995), flexible milestones (Bruss and Roos, 1993), gradual change (Ditcher *et al.*, 1993), staged approach to change (Drew and Smith, 1995), evolutionary change (Stoddard and Jarvenpaa, 1995) and business process optimization (Petrozzo and Stepper, 1994). All mean basically the same thing with only minor variations: the deliberate and systematic adjustment of business processes in order to achieve alignment between business process and organizational objectives. For example, Davenport (1993) argues that process innovation involves stepping back from a process to inquire as to its overall business objective, and then effecting improvements in the way that objective is accomplished. It is a method for developing a new process or significantly altering a current one to better meet the needs of customers, cut costs, or improve efficiency (Petrozzo and Stepper, 1994). It is usually more comprehensive than process redesign as it involves understanding customer requirements and developing processes that best match customer needs. The newly created processes may be significantly different from existing ones (Donovan, 1994; Eason, 1988). For the purpose of this paper, process redesign is distinguished from business process re-engineering (BPR), which is considered to be more radical in its approach. In spite of this distinction, however, many research findings related to BPR apply equally to process redesign and are referenced here.

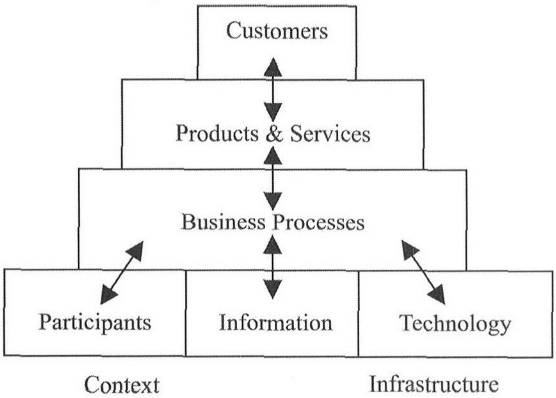
Many researchers (Davenport, 1993; Davenport and Short, 1990; Hammer, 1990; Rockart, 1982) recognize core processes as having strategic value. Stalk and Shulman (1992) proposed business process as an object of strategic planning, connecting processes to capability-based strategy, maintaining that the building blocks of corporate strategy are business processes that have to be transformed into strategic capabilities that provide superior value to the customer. One key to a successful process redesign effort is to examine what Moad (1993) calls end-to-end processes that are vital to the success of a company, then efficiently redesigning them in terms of who does what, and finally giving the people new tools with which to accomplish the work. An alternative approach is to persistently question why a certain existing task is done, what are alternative and better ways of doing it, who should be responsible for it, and which IT best supports the redesigned process (Barrett, 1994; Short and Venkatraman, 1992).

Some IS researchers have suggested that tools and techniques are the key to a successful process redesign effort (Drew and Smith, 1995). Some have maintained that the development of a process redesign strategy is the key to business success (Bruss and Roos, 1993; Ditcher *et al.*, 1993; Guha *et al.*, 1993; Talwar, 1993). Others have argued that the best rationale for acquiring IT is strategic alignment (Hammer, 1990; King, 1994; Leymann and Altenhuber, 1994; Moad, 1993; Schnitt, 1993). Still others have insisted that IT is worthless unless it is used in a business process (Alter, 2001).

The objective or ultimate goal of the organization is to compete effectively (Harrington, 1991a, b; Senn, 1992). Strategic process redesign focuses on redesigning the organization to compete. It realizes that every business process in an organization needs to be geared towards the strategy of the organization for this objective to be achieved. In this endeavor, it is important to determine and prioritize the organization's critical success factors (CSFs), key performance indicators, and performance targets. These vary from customer service, to speed of service and delivery, to product quality, depending on the industry (Harrington, 1991a, b). Business processes are then redesigned as appropriate to gear them towards the achievement of the strategic goals of the organization (Hammer, 1990; Schnitt, 1993; Short and Venkatraman, 1992). Such process redesign efforts are likely to culminate in the identification and acquisition of requisite IT components for the individual processes. It has been established that process redesign ought to be proactive and continuous (Guha *et al.*, 1993). IT investments ought to be made only on the basis of specific business process requirements (Alter, 2001; Leymann and Altenhuber, 1994; Moad, 1993). For the strategic alignment of IT with corporate goals, therefore, an enterprise selects IT as dictated by redesigned processes that actualize identified organizational strategies. The Mandrish and Schaffer (1995) approach supports this point of view and offers results-driven process redesign as an alternative to a radical all-or-nothing redesign characteristic of the re-engineering concept, which blends many of the techniques of re-engineering into a continuous improvement process.

Alter's (2001) work system framework also supports this viewpoint. It is a model that can be applied to any system in an organization, big or small, computerized or otherwise, but is one that aids in conceptualizing which, where, and how to apply IT in an organization. Each work system within an organization needs to be analyzed with the objective of identifying ways to improve its performance and to re-certify its scope with specific goals in mind such as increasing the efficiency of a business process or making a better product (Figure 1).

Leymann and Altenhuber (1994) discussed the concept of managing business processes as an information resource. Because the quality of the business processes eventually influences the quality and performance of an enterprise, successful firms start information management at the process level. Such firms treat process models as



Source: Adopted from Alter (2001)

Figure 1.
Defining elements of the work systems framework (adopted from Alter, 2001)

information resources. This information includes data about all resources needed to reach the objectives and goals of the enterprise. The collection of actions needed to achieve this goal is called "enterprise modeling". Enterprise models have two components: a data model, which describes what can be used by the enterprise to reach its goal; and the knowledge model, which describes how the enterprise uses its resources in order to reach its goal. Successful firms develop a detailed analysis of data flows and interrelationships that map their information needs into a fully integrated systems development plan (Framel, 1993; Leymann and Altenhuber, 1994). This data architecture helps the organization understand what is actually being done to accomplish corporate objectives through specific tasks and processes in the operations of the business (Framel, 1993). Without this ability, a firm does not tie its system acquisitions to its business needs, resulting in investments that only make bad processes faster, not more effective (Appleton, 1986; Blumenthal and Silverman, 1994; Framel, 1993; Goodman, 1994; Parker *et al.*, 1988).

Strategic alignment and enterprise-wide computing

The ability of a firm to tie its systems acquisitions to its business needs results in IT investments that support the strategic objectives of the firm. Streamlining processes and integrating systems to support both these processes and the strategic objectives of the firm defines "enterprise-wide computing". An enterprise-wide information system must, by necessity, start from an enterprise model that accurately captures the reality of a business and its operational tasks. The view for the model follows functional lines, starting with functional classifications within the business – like finance, manufacturing, and logistics – and proceeds through decomposition to activities and individual tasks (Leymann and Altenhuber, 1994). An enterprise model design is built from a detailed level of task decomposition for all functions and activities that a business must perform in order to function successfully. As more time and other variables are sliced out of a process, information must be readily available from which to plan and react (Bashein *et al.*, 1994). Having to react almost instantly means having to have a very lean but sophisticated process, which is a redesigned process (Hammer and Champy, 1993). It is one that is supported with information systems that allow every aspect either to operate in a computer-to-computer mode or, where human interface is needed, to ensure that users have the data they need when they need it (Moad, 1993). Working smarter is the key to increasing productivity. The first step in working smarter is to shorten the time it takes to accomplish a task (Tinnila, 1995). Advanced information technology plays the leading role here, not by merely automating tasks, but by allowing a business to redesign its processes, discovering new and better ways of doing business (Davenport, 1993). Whereas traditionally organizations have used information technology to automate the existing ways of doing things (Hammer, 1990), currently, they are using IT not just to speed up routine processes, but to redesign those processes in order to achieve dramatic improvements in productivity (Harrington, 1991a, b). Many IT managers concede that a large part of their success derives from using IT to re-engineer business processes (Rayner, 1993).

The failure of some enterprise-wide computing systems such as computer-integrated manufacturing (CIM) has generated learning opportunities for many organizations (Lopes, 1992). In the mid-1980s, many companies in the manufacturing industry implemented very large manufacturing systems, but were not able to realize the benefits that had been anticipated. What they missed in implementing these systems was the fact that, by itself, CIM is not enough. The concept of an enterprise strategy, which repositions a company to do that which it does best, was missing (King, 1994). They failed to realize that computer technology is only 20 percent of CIM and that the other 80 percent is the business process and people that make it work (Appleton, 1986). They failed to realize, too, that what CIM really is, is the orchestrating of people, information, and processes. One of the reasons for CIM failures was that employees shunned the new computerized systems (Lopes, 1992). Different firms have used computers differently: whereas some have replaced people with robots, others have empowered them with information, in some cases, with the help of computers (Turban *et al.*, 1999, 2001; Zwass, 1997). To such firms, the most important elements of CIM are the business processes that are developed and the people that man them, secondary to all of that is the computer hardware and software (Eason, 1988). CIM should be seen as the use of computer technology in ways that empower people to tackle the challenges of continuous improvement and competitiveness (Sprague and McNurlin, 1998), whose most essential component in the factory-automation business is creating the organizational changes required to take full advantage of the technology – such as focusing on the customer, key business processes, and project teams, as opposed to a functional departmental focus (Laudon and Laudon, 2002).

Business integration is the new framework for CIM (Greene *et al.*, 1991; Lopes, 1992). Organizations are now seeing CIM correctly as a tool to help them accomplish some of the objectives that they have to lay out in order to make business integration successful (Turban *et al.*, 1999). They now understand that in order to achieve enterprise wide integration (and customer satisfaction), they have to include people (Barrett, 1994). This means that not only do they have to change their management approach but they also have to design technology that is usable by people (Talwar, 1993).

The IBM Corporation understood that technology by itself is not very useful, unless people understand how to use it and that in order to understand how to use technology, a lot of employees need to be taken through change management (Bruss and Roos, 1993; Eason, 1988). IBM's Industrial Sector Division offers consulting services on just-in-time (JIT) methods or "continuous-flow manufacturing" to improve the manufacturing process prior to superimposing a computer system (Glazer, 1993; Sheridan, 1992), totally in the absence of any hardware or software. Adopting JIT methods is one step in the creation of a "lean enterprise" (Senn, 1992). The underlying notion is that enterprises cannot continue to do things the way they used to (Ryan, 1994). They have to figure out all the things that they can no longer afford to do and which things need to be automated and then proceed to automate those in a way that allows the company to be flexible and lean (Talwar, 1993). The concept of a lean enterprise encompasses all new business structures, including CIM, JIT systems, and concurrent engineering (Sheridan, 1992). CIM can fulfill its promise of enabling increased responsiveness to customers, better quality product, better profitability, and better time to market as long as there are trained people to employ the appropriate technology in an appropriate way (Sheridan, 1992). All other benefits such as lower manufacturing costs, flexibility, production control, and small lot manufacturing, then fall right in place (Baer, 1991a). Responsiveness to customers includes providing quick turnaround on product deliveries and the ability to respond to customer inquiries (Alter, 2001). Being able to respond to customers with information results in extra business, retention, and getting closer to the customer (Ould, 1995; Parker *et al.*, 1988).

One of the most significant recent developments among leading-edge firms in the manufacturing industry is that CIM is no longer confined within the walls of a manufacturing plant, but rather is linking manufacturing to engineering, sales, finance, and other functions (Greene *et al.*, 1991; Tinnila, 1995). Moreover, the electronic linkages are extending beyond corporate boundaries to include customers and suppliers (Ditcher *et al.*, 1993). This trend has resulted in two distinct CIMs. "Small CIM" is the classical, restricted notion of what happens inside just the engineering and manufacturing organization – design, release, and manufacture (Donovan, 1994). "Big CIM" fully encompasses what is meant by the extended enterprise, all the way from the customers having access to information about things they might want, and dealing with the sales people or even design engineers, through the eventual release of design, production, shipping, and finally support of the product (Laudon and Laudon, 2002; Sheridan, 1992).

Enterprise resource planning

In the manufacturing industry, the importance of strategic alignment is no longer an issue for debate, but rather a foregone conclusion. Manufacturing has understood the importance of this concept and has reaped great benefits from its implementation in the form of what has become known largely as enterprise resource planning (ERP) systems. First, there was material requirements planning (MRP), then, there was a move to manufacturing resource planning (MRP II) by adding in financials, sales-order processing, etc. (Eason, 1988). The move to MRP II was more towards the process-oriented model and away from a bill-of-material-oriented model in manufacturing (Rayner, 1993). A process-oriented model permits understanding of the part that quality plays in the different processes, whereas the bill-of-material model is more product-oriented and so does not permit things like accounting for quality (Drew and Smith, 1995). In ERP are included things like quality systems, work-in-process (WIP) systems, and logistics systems (Ricciuti, 1992). ERP systems bend to suit the shape of the organization, integrating functions far more flexibly than otherwise (Guha *et al.*, 1993). This ability speaks to the paradox of the recognition that IT can be a catalyst which enables organizational change, on the one hand; and the reluctance to look beyond the parochial needs of individual functions, on the other (Eason, 1988). IT can add value by facilitating these discrete requirements, while still recognizing that departmental needs form part of a broader picture. ERP enhances the existing functions, introduces additional features and provides improved user interfaces (Krizner, 2001).

ERP can be better understood through three lenses: the underlying architecture, the technology, and the functionality (Parker, 2001). Of all the architectural issues, the most difficult one is open access to data, especially access that is unrestricted by application boundaries or data file types such as non-relational, relational or object (Ricciuti, 1992). Some manufacturers are using relational databases and creating a common data element template to be used by all the MRP systems they have in place. Those that need enterprise-wide system access to an array of data sources extract commonly needed information from a number of applications and enter it into a "data warehouse". But others even use electronic data interchange (EDI) transactions to transfer information between MRP II and other internal systems, information normally exchanged only with trading partners (Greene *et al.*, 1991; Robinson and Wilson, 2001).

Optimizing plant floor processes has a major incentive for firms searching for ways to increase productivity and efficiency (Baer, 1991b). Since an enterprise really does not have control over the cost of the raw materials, and it really does not have much control over the price of its products, optimizing the production environment by installing and making the links between the business system stronger is motivation enough for implementing an ERP system (Inglesby, 1992). Supply chain visibility and effective management of assets require that information and business systems be not only linked, but also linked in such a way that business systems key on data from integrated automation systems (Anonymous, 2001). Many practitioners agree that the bottom-line benefit of connecting the controls system to ERP is optimizing the supply chain (Hanseth *et al.*, 2001). The use of IT to integrate processes is not just confined to internal functions, however. High achievers in manufacturing are looking outside their own organizations and are using IT to change their positioning in the value chain (Harreld, 2001).

ERP is a major positive force in manufacturing because it is a fully designed solution from the ground up and not an evolved solution like MRP II (Greene *et al.*, 1991). Some practitioners have argued that ERP is no more than what can already be achieved with open systems by selecting strongly featured departmental application systems and then integrating them (Lopes, 1992). Neither enterprise-wide computing nor strategic alignment concepts support this notion. On the contrary, although there was migration from MRP to MRP II, the move from MRP II to ERP did not evolve. ERP is a completely different computing paradigm that relates to client/server, meaning that there is a set of technology factors that are part of ERP that did not permit an evolution. It required a revolution (Greene *et al.*, 1991; Sheridan, 1992). Enterprise-wide systems must be designed and built differently. One of the technology factors that really differentiates the enterprise-wide system from other clustered application packages like MRP II is object-oriented programming (OOP). Lopes (1992) observed that OOP and enterprise model design are the two core building blocks upon which next generation information systems are built. As object-oriented concepts evolve in the area of ERP, it becomes easier to encapsulate the different types of processing that go on in manufacturing (Inglesby, 1992). As other types of inventory-management systems emerge, it is easy to attach them to this type of model. The effort is towards the achievement of a single, logical database that is distributed on multiple, physical servers throughout the enterprise. The benefits of ERP range from price/performance improvements of the technology to the enterprise solution that finally ties controls and engineering directly and strategically to business systems (Leymann and Altenhuber, 1994; Sheridan, 1992). The emphasis is on promoting closer communication and alliance with all internal functions, suppliers, and customers. True enterprise-wide solutions must be re-conceived, redesigned, and engineered from the ground up (Greene *et al.*, 1991; Manetti, 2001).

Extended ERP

There is much interest in the process manufacturing arena in what is called extended ERP (ERP II), which is the capability of getting outside the ERP system, collaborating with customers and suppliers and extending the workflow out of the enterprise (Lopes, 1992). Internal integration allows the ERP system to receive information from the production facility as well as and as easily as from engineering systems. Integration with the core business systems, such as mail, significantly reduces the need for paper and its associated costs (Baer, 1991b). External integration includes EDI as originally defined, but affords even more unique integration opportunities. ERP II has expanded on the traditional role of ERP to encompass such functions as quality management, regulatory reporting management, laboratory information management, and the integration of control systems and engineering systems (Greene *et al.*, 1991). Through ERP II, the view that using IT successfully means using it to change internal business processes and to create external business networks has finally gained acceptance (Davenport and Short, 1990; King, 1994).

Although information systems should help management consistently meet and exceed performance objectives, most systems tell managers what happened after the fact. If management is able to see the impact of operational decisions and activities in real time, then there are significantly fewer fiscal and operational surprises. Such systems constantly monitor unit and company performance and variance from plan. Variances outside pre-defined upper and lower limits trigger an alert and automatically generate an impact assessment and a recommended course of action. At any time, the system alerts management to current operational performance problems, which, if not corrected, would negatively impact on management's ability to meet revenue and profit projections. The executive information system (EIS) then suggests the best course of action, based on orders on hand, available resources, and customer schedules (Baer, 1991b; Hanseth *et al.*, 2001; Krizner, 2001). For these reasons, process manufacturers are growing increasingly interested in linking plant-floor process control equipment with enterprise systems that can manage what customers need, what suppliers can produce, and what planners require for decision making (Greene *et al.*, 1991; Hannon, 2001). For those who do a lot of computer-linked quality checking in some of their production processes, decisions on whether or not parts meet acceptable quality standards are made automatically. If a part is out of specification, it is automatically rejected at a kick-out station. No human judgment is necessary because the computer is preprogrammed to determine whether the part is good or bad. In some cases, the computer system will shut down the line if it finds a certain number of defective parts in a row, and then the system will tell the manager where the fault lies (Inglesby, 1992).

The biggest driver behind ERP II has been the need to transform to e-business, getting more efficient inside the company by extending processes out. Whereas an enterprise needs a solid ERP platform to support new functions, ERP II is "an application and deployment strategy that expands out from ERP functions and achieves integration of an enterprise's key domain-specific, internal and external collaborative, operational, and financial processes" (Mausey, 2001; Robinson and Wilson, 2001). Many firms are putting emphasis on ERP II because a front-end is only as good as the order fulfillment system, a philosophy that everyone is embracing as they move their business to the Internet (Harreld, 2001).

ERP II is able to handle many variables within the supply chain, including more types of shipments; more shipments to multiple sources; shipping directly to consumers; bypassing distribution centers; and increasing deliveries of JIT inventory (Krizner, 2000). It provides the ability to see a problem more quickly. This is important because if a problem can be seen in real time, it can be solved in real time. The manufacturing execution system (MES) of the MRP II tracks inventory and WIP and enables a business to have a firmer grip on its supply chain, which in turn enables it to plan and execute its organizational objectives better. To detect problems anywhere along the supply chain in real time, the manufacturing facility of an enterprise must collaborate with suppliers and customers, a concept that has become known as supply chain collaboration (SCC). Without adequate interconnections with the plant floor, the supply chain is just guessing about where orders are, what inventory is needed, and what the most profitable use of resources should be (Parker, 2001). As has been observed by some practitioners, competitive advantage is no longer company versus company, but rather supply chain versus supply chain. ERP and related systems must interconnect with manufacturing processes to maximize the use of resources. Automation and control software, MES, plant portal and information systems, and other software aim to provide the interconnectivity and two-way information flow needed. The exchange of data is crucial for control and to head off potential revenue-draining problems (Manetti, 2001). Some of the reported benefits of supply chain collaboration include improved product quality, faster cycle times, reduced inventory, and better delivery performance (Robinson and Wilson, 2001). Software solutions within ERP II enable integration and transaction configuration platform to automate the supply chain. This is important because, for manufacturing, the biggest issue is inventory management in terms of how much to have in stock and how much to send to customers and when to perform each function (Hanseth *et al.*, 2001). Historically, inventory was distributed in decentralized fashion due to lack of real-time information. This made it necessary to have inventory sitting as close to the customer as possible, which meant artificially high inventory levels throughout the network (Harreld, 2001). With software solutions integrated into ERP systems and MES expanding visibility beyond the four walls of an enterprise, efficiencies include improved inventory turnovers, better contract compliance, and faster product launches (Mausey, 2001). The objective is to keep an enterprise viable by squeezing inefficiencies out of the supply and demand chains (Manetti, 2001). Supply chain allows visibility: transaction-by-transaction, event-by-event (Parker, 2001). Being able to simultaneously look at each link of an entire supply chain from raw materials through shipping to the customer allows the enterprise to direct inventory to where it is needed the most (Greene *et al.*, 1991). It is important for an enterprise to connect its decisions to the supply chain because the supply chain is the operational device that leads to where the company wants to go (Barrett, 1994). If a company does not have its supply chain linked, it will never reduce costs and improve the bottom line (Blumenthal and Silverman, 1994). ERP II has enabled a transition from a "push model" to a "pull model" (or from a make-to-forecast to a make-to-demand) strategy where customers can purchase products at their leisure, not at a time and place of the manufacturer's choosing (Hannon, 2001). The pull model is beyond the capacity of traditional ERP and other legacy systems. Because ERP II applications are often multi-enterprise, businesses must overcome process and cultural changes associated with spanning the corporate firewall (Siriginidi, 2000).

The two technologies that have fundamentally transformed how organizations do business are data warehousing and the Internet (Yurong and Houcun, 2000). For instance, the Internet has completely reshaped EDI as we know it (Robinson and Wilson, 2001). In the past, EDI involved closed networks between buyers and vendors with a third party often engaged to coordinate the flow of information (Greene *et al.*, 1991; Sprague and McNurlin, 1998). Now, many businesses have shifted their EDI transactions to the Web, making the whole process easier and cheaper (Manetti, 2001). In the supply chain arena many ERP vendors have added electronic commerce packages to their software suites that enable discounters to integrate order management and distribution operations with those of their suppliers over the Web (Alter, 2001; Mausey, 2001). Internet-based electronic commerce has become necessary for most since the real speed in IT is on the Web now (Rayner, 1993). The technology is available, and none of it is as expensive as ERP systems. What an enterprise needs is a method of disciplined decision making aimed at selecting and installing no more than is necessary for the IT network to facilitate the business (Anonymous, 2001).

Enterprise asset management systems

Those who have implemented complex ERP applications are discovering that ERP is not enough. They are finding out that they need a broad range of software applications such as enterprise asset management (EAM) systems, generally billed as a decision support tool for predictive maintenance, forecasting, and other reporting and analytical functions. It captures, archives, and time-stamps historical and real-time data from plant equipment then integrates the data with other enterprise systems and trading-floor programs (Mausey, 2001). With an EAM system, inventory is removed from stock and marked for reorder as it is used; the work request may show the quantities that remain; trends can be spotted more easily; accounting personnel can track spending more accurately; expenses can be integrated into a report to track equipment reliability based on individual vendors and equipment models, which, in turn, can be used when deciding future purchases for both repair parts and for capital equipment (Siriginidi, 2000). Some EAM system implementations may allow work requests to be generated that automatically include a complete list of parts required for a particular job function (Greene *et al.*, 1991).

Collaborative product management (CPM) systems are used in tracking and managing production in the manufacturing environment, with capabilities that include production planning, finite scheduling, material management, data collection, lot and work-order tracking, plant-floor and enterprise system interfacing, and messaging and alarming to the plant, upper management, and the supply chain (Harreld, 2001). Some software solutions, such as SeeCommerce, extract data from the various legacy systems and apply the appropriate components of data to affect real-time supply chain to empower its everyday users to understand the data in the context of their business, which allows these users to make critical decisions (Mausey, 2001).

The underlying architecture

Years of piecemeal technology purchases have resulted in information silos whereby sharing data across applications is often difficult and usually accompanied by either complex internal programming or by intense human interaction (Hannon, 2001). The only way to engineer an enterprise-wide solution capable of integrating all the islands of information and automation in the factory is to base it on open systems. Currently, many enterprises continue to struggle with ERP implementations that impose rigid business rules on top of existing business processes (Manetti, 2001). Internally, they can benefit by creating information architectures that allow systems to easily exchange data. To support divisional decision making and to automate front-office functions, organizations have found ways to offload processing and data manipulation to cheaper microcomputers and workstations and have provided users access to host data. The client-server architecture has been the most effective means of achieving such objectives (Hannon, 2001).

Client/server architecture; relational database with SQL; object-oriented databases, graphical user interface; 4GL; multiple database support; front-end systems for decision support; automated EDI; interoperability with multiple platforms; and standard application programming interfaces are some advanced technologies being incorporated in most next-generation systems. Roughly 80 percent of MRP II packages feature either an integrated EDI module or an EDI interface. The best approach depends on the current and planned enterprise structure (Inglesby, 1992; Krizner, 2001).

Forward-looking computer industry players offer software solutions that go well beyond the rigid constrains of the early MRP II systems. IT systems today must reflect the changing style of contemporary business management. The watch words are innovation, responsiveness to market demands, service, and quality (Robinson and Wilson, 2001). These players understand the need to dismantle time-honored corporate management structures (Davenport, 1993; Davenport and Short, 1990; Hammer, 1990; Hammer and Champy, 1993). This means flatter organizations in which good communication is essential (Leymann and Altenhuber, 1994). Right sizing means putting the interactive computing power of today's technology into the hands of users (Inglesby, 1992). In the process, a new model has to be crafted, client/server or distributed systems that fundamentally move away from the monolithic system of the past to one that is more responsive to the needs of the user, in the financial organization, on the floor of the manufacturing operation, in the engineering department, and everywhere where business systems are used (Harreld, 2001; Krizner, 2001).

Open-systems, defined as software environments consisting of products and technologies that are designed and implemented in accordance with standards, established and *de facto*; that are vendor independent; and that are commonly available (Lopes, 1992), enable "open-systems" computing, the increased use of standards in hardware platforms, networking products, and software to simplify computer connectivity and interoperability, commonly involving client/server architectures. Open-systems computing is a major facilitator of integration of computer systems in a multi-vendor environment (Baer, 1991a). Open standards for information exchange are important in selecting an EAM system as they make integration much easier because links do not have to continue to be created one at a time. An effective EAM system should revolve around open standards, using industry-accepted methods of data exchange. It is imperative to be able to access data using open protocols so that engineers and managers can compare or evaluate information that originates from different systems (Harreld, 2001). This notwithstanding, inclusion of proprietary systems is important because manufacturing firms generally buy systems and keep them for a long time (Harrington, 1991a, b). The use of proprietary systems will cause the flow of information within the enterprise-wide deployment to be severely limited, so it is important to determine if an industry-accepted means of information exchange is being applied, without special modification. This will allow the purchase of additional services and platforms from competing vendors to communicate with the EAM system seamlessly. Whereas traditionally businesses have been leery of standards because the time it took to get a standard in place was long (seven to ten years), that attitude has changed because the pace has picked up. In many cases, standards are now being put in place much faster because it is in the interest of everybody involved to get over it and to get something in place that can be used (Appleton, 1986).

To many, the enterprise-wide computing architecture of choice is the "client/server" configuration, in which a large or mid-size computer (the server) is networked to numerous smaller computers (PCs or workstations) in a distributed computing environment. The current trend is that top managers are becoming increasingly aware of the savings involved in micro-technology-based computers and in networking. In distributed systems, they can place the power in the function where they need it the most. Moreover, the client/server architecture opens up the information system to the user so that end-users can create their own application programs and more sophisticated users can create their own customized software (Ditcher *et al.*, 1993). For some businesses, shifting to distributed computing with the aid of open-systems technologies has provided the opportunity to re-examine their processes. They are looking at open systems as the key to allowing them to re-engineer in a control mode (Ryan, 1994).

Web services change the underlying principles on which most information technology systems are constructed as they depend on an open architecture to accomplish true data integration. There are three layers to a typical Web services architecture:

(1) Software and communication protocols.

(2) The service grid.

(3) The application grid.

At the foundation, Web services depend on Internet protocols or standards to mark up the data and to make movement of data from system to system possible. Web services description language (WSDL), hypertext markup language (HTML), extensible markup language (XML), and universal description, discovery, and integration (UDDI) are tools that facilitate the description of the portability of underlying data. Communications protocols such as transmission control protocol/Internet protocol (TCP/IP) (for moving data from Internet server to server), hypertext transfer protocol (HTTP) (for coding and displaying Web pages), and simple object access protocol (SOAP) (for data and object access) are required for easy exchange of information from system to system over the Internet. XML combined with SOAP allow information to connect freely to other applications and then to read messages. Converting XML-tagged data to business intelligence depends on good underlying definitions that both people and computers understand. In the middle is a collection of utilities that take care of performance issues, including a business intelligence management layer where all the definitions and logic supporting the XML tags reside. Other middle layer functions include system security, auditing, and transport management. Information about the data (metadata) is housed either on a company server or on any server accessible over the Internet (Hannon, 2001; Harreld, 2001).

Return on investment

Unlike most purchases of computer systems that fail to deliver measurable improvement in corporate performance, enterprise-wide information systems have immediate and positive impact on the bottom line (Greene *et al.*, 1991). The return-on-investment (ROI) analysis on client/server networks is compelling. It is possible to buy the new open systems hardware for a few months' worth of maintenance on the mainframe (Rayner, 1993). Even without counting the operational benefits and savings, an organization can often obtain extremely high ROIs through the savings it gets by moving to an open system, thereby taking advantage of the good price/performance ratio. When such an investment is made, an organization gets all the advantages of next-generation systems, their functionality, and the high-level tools that come with it (Parker, 2001). According to Inglesby (1992), it is pretty hard not to get a good ROI: "... you start saving money as soon as you start running your business directed by the plan the software develops". Businesses are able to reduce their time to achieve a measurable ROI because they are able to deploy solutions much faster now. ERP vendors say that they can provide modular applications with measurable ROI almost as soon as they go live (Mausey, 2001). Many firms see this consistent global ERP platform as an opportunity and foundation to "Webify" the company and to enable a virtual, consumer-driven supply chain (Harreld, 2001; Ricciuti, 1992).

Discussion

Control is a central issue in ERP and other enterprise-wide computing system implementations. The main objective behind the development and implementation of any information system, like ERP, is to enhance control over processes within the organization. Technology of any kind are tools that help their implementers improve control over resources and processes (in nature, in society, and in business) (Hanseth *et al.*, 2001). ERP systems, with their emphasis on standardization, streamlining, and integrating business processes, are an ideal control technology. The user organization gains higher control over its IS application portfolio because a large number of disparate systems (in some cases in the hundreds) and applications are replaced by an integrated one. Better control, coordination, and governance are achieved through integration of the data created and used in different parts of the organization. Even more effective and comprehensive control is obtained when an ERP system is implemented in parallel with a BPR project that integrates the different units and processes within an organization (Hanseth *et al.*, 2001). The role of IT in organizations as a key factor of change is because it is perceived as an opportunity to enhance control and coordination while at the same time opening access to new global markets and businesses (Jarvenpaa and Ives, 1991).

As devices of control that enable built-in efficiencies and effectiveness within processes, and hence within the organization, information systems, it seems, have completed a full cycle. They have come from haphazard system by system implementations of the 1960s and 1970s, to the emphasis on strategic alignment of systems with organizational objectives of the 1970s and 1980s, to the identification of redesigned business processes as the critical elements of organizational strategic planning to which IT investments must be targeted of the 1980s and early 1990s, to enterprise-wide computing – first with MRP, then with MRP II in the early to mid-1990s, to ERP in the early 1990s to ERP II which use an amalgamation of software solutions to enable and empower supply chain collaboration, control extending beyond the boundaries of the firm, but yielding efficiencies and measurable performance improvements never seen before in business.

Conclusion

The manufacturing industry has experienced a quantum leap in strategic alignment; redesign business processes; and systems integration as evidenced by ERP systems, and more recently, ERP II systems that have also facilitated the move to the Internet. The best rationale for acquiring IT is still the development of detailed analyses of data flows and inter-relationships that map information needs into fully integrated systems development plans, a data architecture that helps the organization understand what is actually being done to accomplish corporate objectives. This enables firms to tie their system acquisitions to their business needs, resulting in investments that make processes more effective. As a result, information systems in this industry have delivered measurable improvements in corporate performance, while the productivity paradox continues to be a true dilemma in other industries. The best rationale for acquiring IT is still strategic alignment and the support of redesigned processes. The best rationale for system integration and enterprise-wide computing is the control of resources within processes, procedures, and tasks. This control allows built-in efficiencies that leave little room for waste, enabling measurable performance improvements. Whether strategic alignment, process redesign, system integration, enterprise-wide computing, and e-commerce can come together to resolve the productivity paradox in industries outside manufacturing remains to be seen.

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