Title: Emerging Technologies for the Third Mellennium

Course: EMGT 520/620
Term: Fall
Year: 1998
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Report No: P98064

Abstract: Emerging technology by definition is technology on the cutting edge of innovation. This technology admittedly is filled with potential for failure. It also has the potential to accelerate revenue growth for an organization through increased markets, knowledge and efficiencies. Two areas of emerging technologies are examined in this paper: decision making technologies and new internet applications.

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EMP-P98064

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EMGT 520/620

Strategic & Policy Issues

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Introduction

Emerging technology by definition is technology on the cutting edge of innovation. This technology admittedly is filled with potential for failure. It also has the potential to accelerate revenue growth for an organization through increased markets, knowledge and efficiencies. Yet, engineering managers must be careful to find the correct emerging technology to fit an organization's business needs and structure. Once found, the new technology must be integrated in a systematic manner and have corporate-wide support. Two areas of emerging technologies will be examined in this paper: decision making technologies and new Internet applications.

Computers have been an integral component of businesses for over forty years. Historically, especially for offices, their main function has been to store and retrieve data and to automate some repetitive data entry tasks. In the last ten years, computer speed has increased dramatically and at the same time hardware costs have plummeted. This has made powerful computing affordable for every organization. Since decision making software intensely taxes computing resources, these solutions were not commercially viable until recently. A forward-thinking engineering manager should take notice. Decision making technologies can help uncover new markets, design new products, cut waste, and reduce training costs. Now that the hardware is ready, new software products are emerging to address the need for automated decision making. These products are taking the form of genetic algorithm solutions, data mining, and software expert systems.

Another important area where technology is emerging is new Internet applications. The power of the Internet lies in the ability for companies to communicate effectively with partners, customers and internally. Engineering managers must move quickly to adopt new Internet technologies before their competitors do. However, it is especially important to incorporate the correct technology for a firm's business model. This is a difficult challenge in light of the rapid growth and changing of standards in this area. Three emerging Internet applications that will be examined are: electronic commerce, distance education and distributed virtual teams.

Genetic algorithms can be employed to a wide variety of optimization problems and perform particularly well for large-scale problems which are often very challenging for traditional optimization techniques. As the mutations allow random changes to the solution population, and the crossover suggests a different lineup of variables each time 'reproduction' takes place, genetic algorithms tend not to get trapped in a local optimum [2] [4]. However, genetic algorithms do have difficulty finding the exact global optimum, therefore researchers prefer switching to traditional techniques once the global optimum is approached. Studies are being made to develop genetic algorithms towards a universal optimization method [5]. Being such a good tool for solving nonlinear and complex problems, GAs have been applied to water-distribution networks for least-cost design [6], construction problems to minimize time and cost [7], and such different areas from machine learning [8] to market analysis for businesses [9].

Strategic Implications

Genetic algorithms are already earning respect in a wide area of applications. The adaptive nature of the method offers striking advances in fuzzy logic applications and machine learning. Fuzzy logic control models incorporate the uncertainty and abstract nature of human decision making into expert systems. Historically, there has been a lack of design tools for these systems and GAs offer systematic and intelligently automatic approach to design such systems [10].

Classic problems of optimization such as time-tabling, job-shop scheduling, and other scheduling problems are vigorously attacked by GAs. The modular nature of the fitness function allows incorporating relatively arbitrary constraints and the objective function easily in a single function. From then on, the flexibility of GAs insure quick, high-quality solutions instead of the best, but expensive solution traditional methods fin [11].

Software programs are being developed to adapt GAs into decision-making tools. Real life problems require highly nonlinear relations which are very challenging for traditional optimization tools. One company, who is developing and marketing software for making financial decisions, advertises their software helps unemotional and unbiased decision making, insuring soundness of the decisions when compared with human beings. Such businesses develop software that make use of GAs to help businesses in making market analysis, developing strategies, planning, budgeting [9] [12]. These companies make special use of the 'natural

selectivity' of GAs in that conditions no longer existing are automatically dropped and the dynamics if GAs promise continuous improvement.

The lead researcher in the area, David Goldberg, however, states that GAs will have their biggest impact on emergence of innovations. This is a promising argument in an age where knowledge determines power. The rate of mutations occurring in the reproduction cycle can be determined in evolutionary programming. Mutations enable introduction of features not present before to the solution pool. Varying the rate of mutations would mean controlling the rate of innovative ideas/designs appearing. Many problems intriguing researchers are now on the verge of their solutions: piping network problems to aerospace design, pharmaceuticals to agricultural machinery have. Technology managers in most industries can benefit from GAs. They should keep an eye on the development of this research to give them a competitive advantage in the areas of new design and decision making.

Future Trend

It is clear that GAs will find their way into every field of engineering and science. Making use of the possibilities GAs offer in management of engineering and technologies will become inevitable. One reason delaying the widespread use of GAs in the past has been the cost of computational tools. The rapid pace at which computers evolve and improve their performance will remove yet another boundary in the emergence of a new era.

Data Mining

Data mining is the process of extracting previously unknown, valid , and actionable information from large databases and then using the information to make crucial business decisions [13]. Data mining enables users to extract useful knowledge from large amounts of information. This automated process enables users to discern patterns in the information provided by a database. There are numerous approaches to utilize in data mining but all of them utilize mathematical equations or an instruction set to score a customer database [14].

Critical Issues

Data mining can be a valuable tool in taking the storage of data to becoming corporate wisdom. All companies have vast amounts of data stored in databases. A successful organization of the future will be able to extract insightful nuggets by mining this data. Before using a data mining software tool it is critical to "clean" the raw data. Cleaning is the process of validating data and aligning it in the correct format before a data mining software package is applied. Using an excellent tool on corrupt data will lead to erroneous results and, in turn, decisions. Eighty percent of staff time on data-mining projects at Charles Schwab & Co is spent preparing data and then carefully testing the results for accuracy, but the firm says the effort pays off by helping it better predict trading patterns and target marketing [15].

It is also important to make sure the correct tool for a specific type of decision is used. The Chase Manhattan Bank has had experience with data mining. The bank stubbed its toes on a couple of early findings that turned out to be faulty. The tools it used routinely presented results that were erroneous or useless. However, by matching the correct mining tools to their data, the bank has come up with strategy-changing results, said Mike Eichorst, vice president of predictive modeling and data mining at Chase Manhattan's Consumer Credit unit. For example, data mining overturned the conventional wisdom that people with multiple accounts were bound to be the bank's best customers. "We discovered that a lot of customers with multiple accounts actually are unprofitable," Eichorst said. "That totally refocused the bank on the way we sell products. The idea now is not just to cross-sell accounts to people like crazy" [15].

Data mining is an excellent way to discover patterns to consumer buying habits and develop marketing strategies for niche markets. However corporations using these techniques may infringe on privacy issues. Companies may need to put legal consideration into their implementation of data mining. Twenty four countries, including Australia, the United Kingdom and the United States have adopted the principles drawn by Organizational for Economic Cooperation and Development (OECD). The principles relate directly to anyone working with data mining in general, and specially to work that with deals with traceable, individual data records. It is important to be aware of these laws when implementing data mining techniques in an organization.

The ability to attach real business value to the new information is important to the success of using data mining software. In the research of truly known information, analysts are tempted to lower the level of confidence with which the data mining tools will report findings. In these situations, analysts often end up with asking themselves whether the information truly has statistical significance or reflects only a one-off occurrence due to overmining of the data [13].

Strategic Implications

The ability to integrate the new data mining solution into existing business procedures and applications will become an advantage for firms of the Third Millennium. Results of data mining should be integrated as a repeatable, streamlined process that will help build the necessary culture of data-driven business intelligence. Data mining is an excellent competitive weapon when used correctly. Effective market research can allow the savvy firm to discover new markets within and outside the current customer base to increase sales. Data mining can also be used to beat competitors to market by finding ways to streamline production. Unfortunately, being an emerging technology, data mining can lead an organization down an expensive and deceptive path. A mining tool sometimes bases its claim on a few random examples rather than a statistically significant group. One IS manager says data can be 'tortured' into telling a computer user what he or she wants to hear. Several corporations, such as Chase Manhattan and Bell Canada, say they have nevertheless used data mining successfully by taking extreme care [16]. It is important to use these new techniques with care and in conjunction with other statistical tools and common sense. This data mining use will help lead a firm to success. Not using data mining may place an organization at a great disadvantage. What are other banks doing in light of Chase Manhattan's successes?

Future Trend

As software companies compete in data mining market, powerful, easy-to-use data mining tools will become available. New software technology will allow data mining tools expand capabilities to offer the fault tolerance and high availability required for order entry, supply-chain management and other mission-critical online transaction processing (OLTP) applications. They will support parallel processing, thin clients, Web application servers and Web site content management. They must also support diverse replication architectures, electronic commerce,

data warehouses, very large databases, data mining, online analytical processing (OLAP), object-oriented functions, and special extended data types. OLTP systems entail concurrent data-entry connections, while OLAP systems involve ad hoc queries for decision support [17]. Data mining could be a very competitive tool for business, but only those companies with strong financial capability can afford to clean its data and derive knowledge from it. Current data mines are very vertical, targeting specific industries such as the insurance and medical fields. A kind of pecking order emerges as those who have access to data have all the power, regardless of whether they can make the right decision. It will be interesting to see which new firms use data mining correctly.

Software Expert Systems

Expert systems are computer programs that exhibit a degree of expertise in problem solving that is comparable with that of a human expert [18]. An expert system is intended to provide help to solve problem within a certain domain. Expertise is accumulated and programmed into the software and is used to create scenarios. The scenario with an optimal solution will be found. Problems must be well defined in order to use this software. Early expert systems were oriented toward the development of large, complex, and stand-alone applications. They required specialized hardware and knowledge engineering skills. Today's expert systems are oriented toward the solution of smaller rule-based problem [19]. They are designed to be useable even by those who may not have special training in knowledge engineering. There are many areas that use expert systems, such as manufacturing, accounting, marketing, total quality management, and risk management.

Critical Issues

In order to create software expert systems, human experts are invited to share their knowledge through training programs, seminars, or lectures. This effort is not always productive; thus leading to wasted time and excessive expenditure. It is important to structure these knowledge gathering sessions effectively. Also, a single human expert is not able to provide comprehensive expert advice to meet all requirements [20]. It is important to be sure that the correct information is being gathered to create the software "experts".

Another key to success of expert systems depends primarily on the careful and proper determination of the domain within which the expertise is required. Expert systems are good problem-solving tools for very specific domain. They are unable to provide good solution if the domain is ill defined or not isolated [18]. Expert systems have difficulty in solving new problems that they have never encountered before. They can not judge external changes nor adapt to new problem domains. Expert systems require frequent updates in order to fit into new problem domains and changes.

Decision support systems are another tool that is used in decision making in conjunction with expert systems. Unlike expert systems that required well-defined problems and domains, decision support systems provide standard models and computations that a user can input various variables of problem domain. Expert systems require a problem and a specific domain, to find the scenario with optimal solution. In the other hand, decision support systems provide tools to analyze the situation that user wants [21]. With the ability of expert systems to find the optimal solution and the flexibility of decision support systems to use various domains, a combination of both can lead to a better system to solve problems that engineering managers are constantly dealing with.

Strategic Implication

The use of expert systems is primarily for problem diagnosis, design problems and decision-support systems. A hybrid system of expert system and decision support system does not require frequent updates. It is a user's task to input data or information to reflect the changes. Expert systems can help decision support system users in selecting a model, provide judgmental elements to models, enable friendlier interface and provide explanations for decision support systems output [21].

Expert systems might not work well in uncertain situations such as those that engineering managers face. Within an environment that is full of uncertainty and changes rapidly, a hybrid system might provide a good support for decision making and forecasting.

Expert systems can be utilized to provide education and training in addition to its main purpose of decision support. Employees with little education will be able to do "knowledge tasks".

People who are highly educated will be able to access and use information from many fields. This will allow engineering managers flexibility in work assignments and training issues. Executives will have at their fingertips the know-how of a tremendous array of experts to help make their corporations competitive powerhouses. For training professionals, expert systems will empower bottom line workers effectively and efficiently. Workers can find answers of problems and learn by using expert systems [22]. Expert systems not only help to make better decisions, but can add ease to reallocation of human resources and lower training costs.

Future Trend

The use of expert systems will be integrated with other systems that form an integrated software package, such as hybrid expert systems. Expert systems will be more flexible and adaptive and they will be able to handle more problems within more loosely defined domain. The capability of expert systems has been improved by integrating decision support systems. It will be improved more by integrating fuzzy logic to address the issue of implementing expert systems in an environment that has high uncertainty [23]. Tomorrow's low-cost assistant to a manager could be an expert system in a personal computer [24].

Personal computer based expert systems will be more widely used by people who do not have special knowledge skills. Learning will not be limited to books and knowledge exchange between people. Expert systems will become effective learning tools providing knowledge and expertise to those who use them. There is, however, a danger in relying on expert systems. People could easily become machine-oriented rather than customer or business-oriented. People could be servants to the technology rather than its masters [24].

Emerging Internet Applications

Electronic Commerce

Electronic commerce (E-commerce) is the application of communication and information sharing technologies among trading partners to the pursuit of business objectives. E-commerce combines information and telecommunications technology with business processes to make it possible to do business in more efficient and faster ways. There are four interdependent types of E-Commerce [25]:

1. ***Information Access:*** The most common type of EC is information services like CompuServe, ABI informs. It provides search and retrieve capability for public domain and proprietary data archives.
2. ***Interpersonal Communication Services:*** They provide methods for parties with mutual interests to exchange information, "discuss" ideas, and improve their cooperation like customer and supplier design groups jointly working out product specifications.
3. ***Shopping services:*** They allow people to seek and purchase goods or services though electronic networks. EC can apply from retail sales to the purchase of used industrial equipment, commodities, or freight capacity.
4. ***Virtual enterprises:*** They are business arrangements in which trading partners separated by geography and expertise are able to engage in complex joint business activities, as if they were a single enterprise, such as true supply chain integration.

Critical Issues

A widely cited issue with on-line systems these days is security, although many specialists consider it to be a matter of perception rather than reality [26]. Nevertheless, customer perceptions are really what matters in terms of new technology adoption. Currently, most security systems are good enough and will improve. Another important factor is the organizational commitment necessary to successfully run an e-commerce system. Although it is true that the Web today represents a great way to test some commercial ideas with a low cost of entry, and thus is a great equalizer and a real marketplace for innovation, a working system very soon requires additional resources, in terms of technology and skills (e.g. professional design,

integration of legacy systems, process integration, etc.). E-commerce technology needs to be integrated in an organization. It must be embraced by management. It also needs to support a clearly defined and well-communicated business strategy. Another key to the success of an E-commerce system is certainly a wide customer adoption of such technologies. It is not clear when this will happen; and, although there are many benefits to be derived now, the mass-market adoption of such technologies will take a few more years. E-commerce takes the personal touch out of sales. It is very likely to lose customers for many reasons, such as: inability to present "products" electronically, a vast amount of transactions that customers need to go through in the sales process, the technological constraints and so forth. The decrease in human interaction with customers could also lead to a less sophisticated understanding of their needs. The key here will be to find a few widely accepted mechanisms, which can be used in all transactions. The recent agreement between MasterCard and Visa on a security standard for credit card transactions over the Internet is one step in the right direction.

Strategic Implications

Global sourcing and the global marketplace, combined with the communication potential of the Internet, are presenting businesses with wider markets and more competition [27]. The intertwined trends of outsourcing, fast-response manufacturing and supply chain integration will increase demands for collaboration and coordination technologies. Competitive pressures will increase manufacturers' needs for data integration and coordination-enhancing technologies. Information will become an ever more important competitive asset, much to the advantage of companies who can manage, manipulate, and mine their data. Furthermore, E-commerce has the potential to enable suppliers to improve the identification of potential customers and market segments. This also results in improvement of operational efficiencies. An engineering manager must be ready to take advantage of E-commerce and bring the organization into the global arena.

E-commerce systems definitely require business processes to be adopted and new business requirements identified. In this quest, engineering managers are likely to be given responsibilities to think of ways to take advantage of E-commerce systems and therefore turn them into core competencies. New technologies need to be aligned with people's understanding and capacity of dealing with them [28]. An example of the impact on the human resources can be seen while looking at the competencies required by the team designing and implementing an E-commerce

system. This team needs people with a strategic vision, an understanding of the various internal business processes which will be affected, knowledge of the legacy information systems with which to integrate the new systems, a strong technological mastery but also graphical design skills, etc. Engineering representation in such cross-functional teams is essential.

Future Trends

It is certain that more and more companies will be jumping into the bandwagon of E-commerce in order to take advantage of reaching their customers and suppliers. There is even a view shared by some experts [28] which advocates that organizations should build an electronic presence without regard for the benefits, as costs are (apparently) low. That view has often been caused by a difficulty to clearly articulate the real benefits which could be derived from being online. That is for sure that new technologies for securing these systems will be developed and made available to users in an incredibly fast fashion [26]. We will be hearing many e-commerce success stories only from companies that were able to integrate E-commerce systems into their well-defined and understood business plans. It will be interesting to collect data on those companies who really transformed their business model and customer impact through E-commerce systems, and derive critical success factors and sound business practices from them. These will be the companies of the Third Millennium.

Distance Education

Distance education is any learning that takes place with the instructor and student geographically remote from each other. Distance learning may occur by surface mail, video, interactive or cable TV, satellite broadcast, or any number of Internet technologies such as; message boards, chat-rooms, and desktop video or computer conferencing [29].

Critical Issues

The critical factors that have driven online learning to become an important part of today's and third millennium's national education agenda are: the rapid growth of the Internet, streaming audio and video technologies, and the expansion of the non-traditional adult learning market [30]. However, this rise in demand for distance education has been surrounded by issues. One such issue is the absence of technology standards which makes some systems incompatible. Another factor is the need for "personal touch". Some people believe that teaching effectiveness

is diminished by the lack of "physical" relationships at the time of teaching. Education quality is an issue that should be closely watched. There is a potentially large market for firms offering courses online. With this, many companies will spring up looking to "cash-in". These low quality education programs should be quickly weeded out, especially if reputable universities take the time to establish guidelines for distance education.

Strategic Implications

Online education's advantages include: increased student access to learning without time and place constraints, improved collaboration, convenience, reduced cost, and the ability to serve new types of learners, such as professionals from industry [30]. Training employees is one of the most critical issues for engineering management in technology driven companies. Employees who have access to this type of knowledge either at the workplace through video conferencing or on the Web at home will increase their value to an organization. Employees distributed around the world can share and educate each other. Technology managers need to encourage participation in distance learning. Those who do will be rewarded with a highly knowledgeable workforce ready to innovate, moving the company forward.

Future Trends

The popularity of distance learning is expected to increase at an exponential rate. Distance education allows students to access information at any time, anywhere and that's redefining teaching and learning. By the year 2000, 97% of all educational institutions will rely on online learning in some form to meet the needs of their students [30]. It will be more accessible to users as providers of distance education start investing more in such technologies to overcome technological problems associated with it. This will definitely help turn distance education into more of a "commodity" product. The emergence of this market has opened up a new and potentially lucrative opportunity for a whole new industry – online course developers. Since adult learners, who generally can best afford the cost of higher education, are the number one users of online education, the trend will continue [30]. In the third millennium, this technology will become ubiquitous.

Distributed Virtual Teams

A "virtual team" consists of members geographically dispersed across buildings, cities, states or

countries, who are brought together through an electronic information infrastructure to work collaboratively toward a common goal. Client-server networks, local area networks (LAN), wide area networks (WAN), the Internet and its associated broadband facilities, routers, and hubs form the basic information technology infrastructure which has been in use for more than a decade. "The infrastructure is no longer an overhead item to be depreciated and used; it now is a vital information and knowledge transport system critical to the success and often the key to gaining a competitive edge in the marketplace" [31]. Its widespread acceptance has achieved critical mass and emerging applications such as video conferencing are spawning new and innovative business strategies, further fueling the fires of change. Virtual teams can be assembled quickly, and the search for talent need not be constrained by geographical proximity. The team can be disbanded just as quickly once the product is brought to market. New teams can be created for new products in on-going development cycles. With teams located in different time zones passing work from location to location, development can literally progress around the clock. Another benefit of "virtual teaming" is cost reduction attributable to lower staffing levels due to outsourcing, reduced office space requirements, and the ability to perform work in regions with lower cost structures.

Critical Issues

Virtual collaboration poses a number of critical issues related to the systems dimension of engineering and technology management. Kocaoglu [32] identified the six subsystems consisting of: Human, Projects, Organizational, Resource, Technology, and Strategy. While issues abound, this discussion will highlight only the most salient points of each.

The Human subsystem is perhaps most profoundly affected of all. The critical issues of sense of identity, belonging, and motivation cut to the heart of the human experience. Self-esteem and social development are defined primarily within the context of work. With diminished face-to-face (FTF) contact will the virtual worker become isolated? How might technology be used to foster trust, teamwork and a sense of esprit de corps extending beyond time and place? In what ways will workers satisfy their needs for status and territoriality in a virtual workplace devoid of the traditional symbols of power such as dress, office size, location and décor? All of these issues must be addressed by the virtual manager.

The Projects subsystem typically involves tradeoffs between objectives relating to scope, schedule, cost and quality. With virtual project teams these issues become increasingly complex

as participating team members originate from within other organizations, strategic business partners, or in some cases, even competitors. How will the virtual manager walk the tightrope of *co-opetition* (cooperation and competition) while still balancing internal organizational needs with those of the coalition? This delicate maneuver is made even more precarious by the greater autonomy that characterizes virtual teams, in which decision making power is de-centralized.

The Organizational subsystem, like the Human subsystem is also under siege. What characteristics of organizational architecture can provide a framework resilient enough to adapt to this rapid pace of change, yet still provide sufficient continuity and structure to avoid disintegration into chaos? How can the organization transmit the "soft technologies" i.e. common goals, values and culture necessary for "virtual workers" to develop a sense of corporate identity and their place within it? Will the "virtual manager" deal with the less hierarchical, informal, and self-directed virtual work structure by imposing control over it? Or is the answer to simply let it run itself? These are a few of the paradoxes the "virtual manager" must deal with.

Resource subsystem

As the emphasis shifts from vertical to "virtual" integration through outsourcing of all but a few select core competencies, how will the "virtual manager" develop a systematic methodology for guidance in making effective sourcing decisions?

Technology subsystem

If knowledge is the strategic asset of the information age, how will the "virtual manager" protect this valuable asset in both its explicit (codified) and tacit (non-codified) forms? What strategies will the "virtual manager' employ to convert these knowledge assets to competitive advantage in the market? Finally, how will the "virtual manager" incorporate customer knowledge and successfully leverage it to create even greater value?

Strategy subsystem

In an environment of constantly shifting markets and rapid technological innovation how can the "virtual manager" chart strategies to achieve and/or maintain a competitive advantage?

Strategic Implications

We stand on the threshold of the information revolution, with an impact equaling that of Gutenberg's printing press, which is supplanting the established hierarchy of the industrial revolution. In the new economy, knowledge rather than manufacturing efficiency is the key element for creating value. This new era will require the engineering and technology manager to re-examine and redefine some of the traditional roles and functions and their impact on the systems dimension. These strategic implications are summarized for each subsystem in the attached tables, and are discussed in greater detail below.

In the Human subsystem, the "virtual manager" will need to add one additional function and one role in order to deal successfully with the challenges of a "virtual organization". The new function is that of ***Communications Planning***. This is not merely a subset of the planning function, but separate and distinct due to the complexity and mission criticality of the communications process within the "virtual organization". The "virtual manager" must carefully envision and plan all aspects of the communications process due to the decrease in communications through FTF meetings and increased reliance upon "virtual" communications. As the "virtual organization" evolves toward the unstructured and informal, more formal and structured communications will be required to maintain cohesion. The communications plan must address the issues of: who, what, when, how (choice of media), frequency, and workflow routing. The "virtual manager" will be challenged to incorporate within this structured logistical framework, the "soft skills" of tone, humor, and emotion that are an integral part of traditional FTF communications. These planning skills will help teams work more effectively, and individuals to feel more "connected" within the "virtual organization".

The essential new role for the "virtual manager" within the human subsystem is that of ***Team Builder***. The "virtual manager" acts as a "systems integrator" of persons, using multiple skills to integrate a group of individuals into a "team solution". In many ways, this is perhaps the "virtual manager's" greatest opportunity for value creation and will contribute toward individuals feeling a sense of belonging despite the separation of time and place.

Within the Projects subsystem the new function required is again that of ***Communications Planning***. The new role required is that of ***Strategy Agent***. In order to walk the tightrope of concurrent cooperation and competition within the "resource coalition" the "virtual manager" must be a consummate Strategist. The ability to think many moves ahead, formulating offensive,

defensive, and contingency plans based on in-depth knowledge of technology, customers, and markets will differentiate the winners from the losers.

The Organizational & Strategy subsystems, will also demand the "virtual manager" to exercise the ***Communications Planning*** function. Two new roles are identified for the "virtual manager": ***Knowledge Agent*** and ***Strategy Agent***. First, an understanding of how the "virtual" nature of the organizational structure will transform strategy is helpful. The "virtual organization" will focus on knowledge and intellectual assets in order to create value. It will employ a strategy triad of ***Customer Interaction***, ***Virtual Sourcing*** and ***Knowledge Leverage***. ***Customer Interaction*** will focus on understanding customers' needs in order to develop highly successful products and services. ***Virtual Sourcing*** will focus on outsourcing physical products (especially mature technologies) while controlling the intellectual and intangible knowledge assets that contribute most to value creation. ***Knowledge Leverage*** will build upon the previous strategies in order to parlay the customer knowledge and technology understanding into a sustained competitive advantage in the marketplace. From this perspective, the role of the ***Knowledge Agent*** is to understand, protect and grow the technology and customer understanding in order to execute the ***Knowledge Leverage*** strategy. The ***Strategy Agent*** role is to understand and implement these strategies in an effective manner as they relate to the management of engineering and technology.

Resource & Technology subsystems will also require the "virtual manager" to assume the roles of ***Knowledge Agent*** and ***Strategy Agent***. There are three strategic points essential for the "virtual manager" to remember: 1) Intellectual assets create value; 2) Control intellectual assets; and 3) Outsource products.

Future Trends

Virtual operations is the concept of anywhere, anytime tasks, deliverables, processes and general work [31]. Verifone, a global credit card verification company epitomizes this concept. All corporate information is available on their network, updated in real-time. The network is the primary meeting place for its dispersed workforce. Occasional FTF meetings occur, but most communication is accomplished through email and chat sessions, or by audio and video conferencing. The organization is capable of operations 24 hours a day, 7 days a week anywhere in the world. They have established highly automated business processes for improved productivity and morale, while workflow systems maintain business process structure. Teams

are formed and dissolved as needed and information is disseminated via departmental and project web pages.

Federal Express is another example of a company that has adopted a virtual operations strategy. They created a web site to allow customers to track their packages online. In this way FedEx improved customer communications and intimacy, as well as increased productivity by allowing customer self-service while saving over $ 2 million per year.

Virtual Organizations consist of a more or less permanent inner core of executives and managers surrounded by concentric rings of interim managers, project leaders, consultants, outsourced services, and temporary employees [33]. This efficient, variable cost staffing model provides the flexibility, responsiveness and speed required in today's competitive environment. As virtual organizations move from an industrial economy to a knowledge economy, they focus on creating and deploying intellectual and intangible assets, while outsourcing physical and tangible products.

Virtual Sourcing as defined by Venkatraman and Henderson [34] outlines three "virtual sourcing" strategies: 1) Sourcing modules; 2) Process interdependence; and 3) Resource coalitions. Sourcing modules involves purchasing standard products and assembling the components to deliver a superior system. This approach is based on the concept that the greatest value-adding role is as a systems integrator and solutions provider. The process interdependence approach involves outsourcing services to external firms that command expertise and economies of scale in specialized areas such as accounting, inventory control, customer service, or logistics. The last approach, resource coalitions, focuses on establishing a complementary network of resource capabilities. Nike is an excellent example of this strategy, coordinating a resource portfolio that includes Asian production subcontractors, advertising agencies, web support, retail outlets, and exclusive contracts with athletes and universities. In this strategy, the goal is to maintain control of the intellectual and intangible knowledge base while outsourcing physical and tangible products to the resource coalition, thereby controlling the threat of competition from within the coalition and creating a formidable advantage over external competitors.

Virtual Communities consist of geographically dispersed members who share a common interest and are brought together by the information infrastructure. These communities may be composed of suppliers, customers, business partners, industry focus groups, or technical and professional groups. Market leaders of all types will be differentiated by their ability to position

themselves within this network of communities, playing the appropriate role in each circumstance in order to achieve their strategic objectives.

Conclusion

Fierce global competition is the driving force behind increasing product complexity, time-to-market compression, and the unending search for productivity gains. Sophisticated analysis and decision making tools such as data mining, genetic algorithms, and expert systems in conjunction with increased computing power and enhanced Internet communications applications such as e-commerce, and distance learning are quickly becoming the building blocks of a new competitive strategy for the information age. This strategy depends upon a "virtual organization" structure which focuses on the importance of knowledge and intellectual capital in creating value rather than on the traditional industrial revolution model based on economies of scale. An engineering manager must recognize emerging technologies, be selective and have an implementation plan. It is also important to match a technology to a firm's business strategy. Additionally and no less important, is to rally support throughout the entire organization. It is only companies that can accomplish this type of integration that will be successful in the Third Millennium.

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