Knowledge Engineering 2018

The Uses of Artificial Intelligence in Business

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"This text is meant to plant the seeds of knowledge about a young but growing new field. In the pursuit of this new technology, it is important to remember that humanism cannot be denied..."

—from the Introduction to *Knowledge Engineering*

No matter who you are or what you do, *Knowledge Engineering* is a book you must read to understand the vast technological advancements coming your way—advancements that will impact how you do business... how you make decisions... how you communicate... how you live. It's your personal guided tour into the latest trends, issues, problems, challenges, and promise of our technological past, present, and future.

Beyond mere theory and speculation, you'll see firsthand the very real developments in Knowledge Technology Artificial Intelligence and Expert Systems Visualization Knowledge Networking Systems.

NOTE: This was originally published is now being updated and re-written. As such, many of the "date-sensitive" references may not be relevant now, however, many of the fundamental concepts are as relevant today as they were more than twenty years' ago.

Contents

2. Issues in Knowledge Engineering / 37

3. Expert Systems / 55

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Preface

In the beginning of any project there is a spark of inspiration that leads one to pursue the unknown. For the past five years, considerable research has taken place in the field of human-made machines that act or peform functions like humans. The goal of this book was to do the following:

1. Address the underlying problem that management and people are at the center of all concerns in the use and abuse of technology;
2. Recognize that communication and understanding are the limiting factors in the development of artificial or machine-based technologies;
3. Understand that technology has a social function as well as an analytical function;
4. Cope with the limitation that present technology is hardly more advanced than the Model T was in its time period and the technologies that will emerge even only 10 years from now will be as dramatically different as the jet airplane is from a candle.

Chapter 1, "Trends in Knowledge Technology," examines communications and information technology in business and business management. Topics include: the move away from the pyramidal business approach; the development of virtual management, which stresses the incorporation of new technology with humanistic concerns; the multidimensional management system which recognizes the individual employee as a data base management system in itself; and computer communication, networking, and computer-aided management.

Chapter 2, "Issues in Knowledge Technology," takes a look at various problem-solving strategies for use in business management, the limits of information in a machine as well as humans, the concept and limitations of time in business decision-making, and language as it relates to understanding. Important to this chapter is the emphasis on human/machine relations and how they work together, rather than deciding which is better than the other.

An overview of expert systems, **Chapter** 3, defines and explains the various aspects of this science, which is considered both a part of, and a separate entity from, AI. With an emphasis on reasoning about the knowledge underlying human expertise, as opposed to the emphasis on knowledge itself that characterizes AI, "Expert Systems" examines the need for establishing standards; inference, reasoning, and knowledge acquisition; commonsense reasoning; and natural languages.

Chapter 4 reviews visualization systems, systems capable of providing simulations or models of the physical world. Still in an early development stage, visualization systems, their current status, and potential are examined. A detailed look is taken at computer-aided programs and the current state-of-the-art in such systems. Specific topics in "Visualization Systems" include conceptual information processing, spatial reasoning, and communication and information theories.

Chapter 5, "Artificial Intelligence," provides a new look at AI. Most important are some of the philosophical developments that laid the groundwork for AI. Robots, as opposed to machines with intelligence, are also studied. This chapter concludes with a discussion of an architecture for intelligence. Here, the need for standards, an idea first introduced in Chapter 3, is reemphasized, and virtual processing, a mental gaming process that "devises ways to probe and enhance the abilities of both the brain and the machine," is introduced.

Knowledge networking systems are the subject of **Chapter** 6. Recognized as the technology that will probably cause the most dramatic change in business and business management, these systems are studied in relation to organizational communication and corporate management. Topics in "Knowledge Networking Systems" include human interaction, perception, organizational relationships, organizational networking, decision making, and on-line idea exchanges.

Chapter 7, "Metal Models," (that's correct, not mental models) review human mental and machine (metal) modeling, examining ambiguity as one of the most important characteristics that currently separates humans from devices. Thought-processing applications are discussed as they relate to the sales and marketing field, with a particular look at CROSS/POINT®, a program that "supplies the end uses with the building blocks for applications" such as project management, software management, financial planning, marketing, field engineering, and virtually any endeavor that requires manipulation, tracking, and communication of ideas between people over time."

"Future Trends in Knowlege Engineering," **Chapter** 8, concludes the book. Planning and methodologies for the practical applications of knowledge engineering are reviewed; a sample business plan and a short-term information resource management plan are also included. Anticipation technologies are discussed as issues for future users and designers of artificial intelligence. The text ends with a reemphasis of the need for a working relationship between the people and the technology: "The interdependence of technology and behavior cannot be overemphasized."

This text is meant to plant the seeds of knowledge, to instill that sense of wonder about a young, but growing new field. In the pursuit of this new technology, it is important to remember that humanism cannot be denied. *Knowledge Engineering* is meant to expand "human effectiveness and efficiency," not replace it.

Audience

This book is intended for those who are faced with management problems of all kinds and would like to think there may be some emerging technologies that can help solve them. Most importantly, for those managers who realize that communication is the most significant part of any working activity.

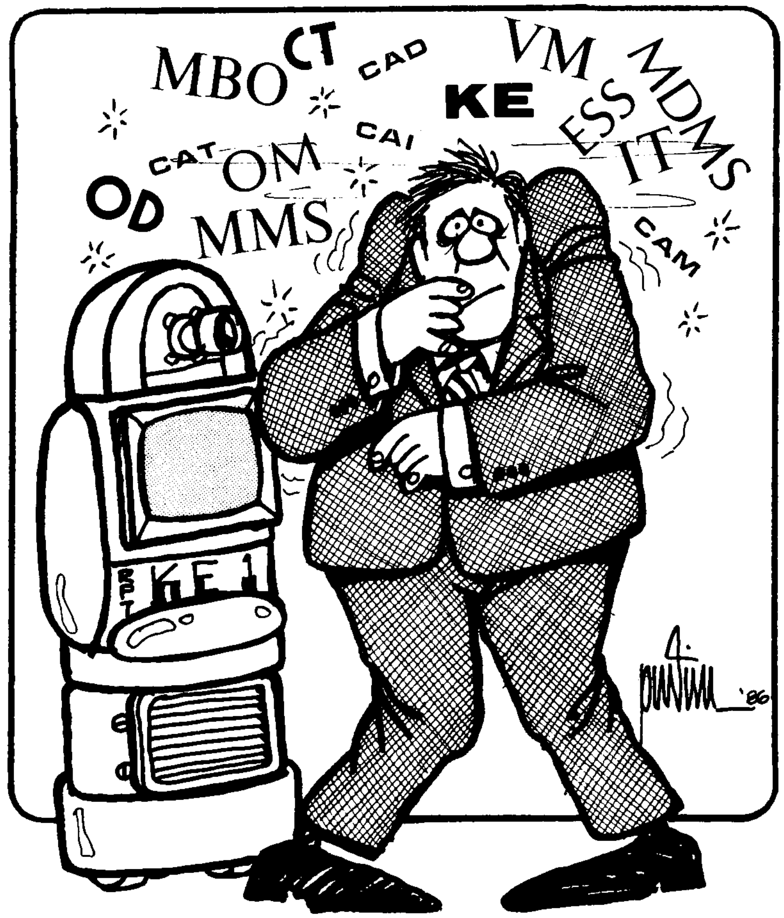
Expected Results

This book is to help begin the process of examining how computer-communication technology can help by:

1. Improving and managing time more effectively,
2. Enhancing communications among workers,
3. Lowering and managing costs, and
4. Simplifying management activities.

Chapter
1

Trends in Knowledge Engineering



Introduction

Knowledge engineering (KE) is the application of machine systems to problems of human endeavor. The purpose is not necessarily to develop systems that replace humans, but to allow the use of systems that increase human effectiveness and efficiency. The goal is to encourage humans to do what they do best, whatever this might be, at a time deemed appropriate, and to allow machines to assume the functions best suited to them, such as power saws, mechanical arms, and payroll computers do.

KE has many major functions that are discussed here. Some of the fundamental KE issues addressed are:

- Ergonomics: Human-machine interaction
- Problem-solving and decision-making
- Thinking
- Communication: People-people, people-machine, and machine-machine
- Dark-side problems (fear, conflict, privacy, etc.)
- Intelligence
- The future

These issues are woven throughout the book, supplying the topical glue between distinct discussion areas. Of course, there are other areas related to these issues that are not covered here. It is the purpose of this book to focus on the concepts and issues of KE that will impact on business management strategies, productivity, and the key element of any business—its people. Much like auto mechanics determined to increase engine speed, those of us engaged in research in these areas often fail to present adequate and informative reasons for such enthusiastic pursuit.

There are many humanistic and bottom-line reasons for explaining KE and its potential benefits to humankind. Experts, such as Herbert A. Simon, suggest that automation—the augmentation of manpower by machine power—is not the only way in which fundamental research in heuristic problem-solving is likely to contribute to productivity in our society. The most important productive resource in our economy and, very likely, the most important resource for generations to come, is brainpower.

We are now learning a great deal about how this brainpower operates—about the processes of human thinking. This subtle, yet key issue is fundamental to any research in KE. It is the pursuit of humanistic uses of technology that offers the greatest challenge and hope for improving productivity and performance, while also improving the quality of life.

There are no right or wrong answers, only new problems to be solved. In the past, machines held forth the ability to free people from mundane, tedious, and repetitious tasks and chores. KE promises to facilitate human communication and interaction in ways unavailable or impossible without these systems. Moreover, as these systems become more "intelligent" and more competent, they should gradually acquire the ability to make decisions on their own. The application of self-directed thinking machines offers mind-boggling benefits to education, quality control, and field engineering, to name only a few applications. The development of KE systems that can go places too toxic or otherwise unfit for humans is reason enough to pursue the development of such systems.

Knowledge Engineering Limitations and Possibilities

We now stand at the foot of the KE mountain, trying to find the most efficient path to the top. Today, the limitations of KE are associated with these general areas:

- Computing capability
- Problem definitions
- Machine languages
- Human knowledge ability

Of these four areas, the basic horsepower problems of computing "engines" is the easiest to tackle. Computer processing capability has crossed the billion-instructions-per-second barrier. Computer memory now exceeds a billion bits. Communications technology now easily exceeds a billion bits per second using fiber optics. Storage technology now often exceeds a billion bits in a refrigerator, and soon a breadbox; and so on, and so on. Technology has often exceeded most projections and expectations.

The processes of how humans approach a problem and how we explain these problems to machines are closely related. Although current human interfaces and programming languages offer vast improvements, still their development remains in the dark ages.

The ability of humans to adequately understand, define, analyze, structure, and utilize a machine model is also quite fundamental in its development. People have a hard time identifying problems and reaching solutions in a normal human environment. When you introduce the handicap of trying to explain a problem using today's programming languages, the task is even more difficult. It is, of course, a major fallacy of computer folklore that machines can, in any real way, replace people. However, this does not mean that the machines or systems of the future will not be as intelligent as people. Fears concerning these developments are both justified and unjustified. This seeming paradox portends that we can achieve all of our hopes for machines and for humans as well.

There is a dark side to computer advancement that corresponds to the dark side of humans. Despite their benefit to people, intelligent machines often become monsters of the id; they can be used in any possible way for war, invasion of privacy, and human destruction. In this case, machines are only extensions of humans and can be used as their warriors.

This issue both leads to and stems from the area of human knowledge ability. Humans must recognize their own frailties, inadequacies, and limitations, and how they affect the technology. This is different from the problem definition issue. Humans might not as yet be adequately equipped to understand all of the forces behind intelligence, thinking, or other human mental processes. We might need to evolve a bit further before we can develop machines that can be as intelligent in as many ways as we are. This is not to say that humans will not design, build, and use these "power tools"; rather, it might take a massive effort of machine power, human-machine interface, and new problem-solving methods just to develop machines that have an average IQ.

This book is intended to be an intermediate step between understanding the vast complexities of how KE works and realizing the practical effects it has on how we manage our business affairs. We might not need to know one to understand the other, but it could help.

Information Technology in Business Management

The technology of the office of the future is painfully emerging. As with children who thought they wanted to be firefighters and now are productivity analysts and systems managers, the office is emerging as a new entity. The people and the technology of the organization are restructuring the organization itself around information.

> Technology is becoming a survival issue in service industries like banking, brokerage, and sales. If you don't use the available technology to supply the same or better service than your competitor, you cannot win in the marketplace. . . -[1]

notes Robert C. Hughes, vice-president of business and office systems marketing for Digital Equipment Corporation.

Technology is rearranging organizational schemes from a pyramidal approach to one that appears flat. There has been a decrease in the number, and a change in the type, of management levels in the past few years. In essence, they have been declining, reducing, and shifting power throughout the corporation.

Management Styles and Information Technology

Matrix management was once highly touted, then almost forgotten. As with most products, timing is the absolute key to success. Matrix management's timing was off by a decade. It will re-emerge as information technology-based systems evolve to provide a communications-based organization. Matrix management was the first step in breaking the bonds of the old production organization. It forced managers and staff to look around and work outside of their closed environment. The matrix organizational chart was fluid, allowing projects, task forces, and internal consultants to operate freely. It was far more open to innovation than a reactive mode of waiting for orders from headquarters. Seeking creative business relationships allows people to excel.

This management style is needed more than ever today, with an increasingly independent, educated work force that needs to be challenged. Moreover, as the number of skilled workers declines with the "baby bust," X-type (trustless) managers (Y-managers trust their employees) will not be able to function effectively in the old top-down environment. According to Rosabeth Moss Kanten, matrix management:

> focuses a new style of management, because in the matrix you cannot order people around, you cannot command them to do what you want. You don't own the people and own their time, so you have to learn to persuade and once you learn that, you have to learn to sell your ideas. And that, by the way, often means that you need better ideas. Of course, you don't need a formal matrix to do that, just an acknowledgement of cross-functional collaboration.[2]

Matrix management probably needs a new name. In this book, I use the term **virtual management (VM)** to describe a management system that thrives on new technology combined with humanistic concerns. VM, like matrix management, relies more on communication than information. It uses both the technology, such as knowledge networking, and the styles of management that keep people "in touch." VM focuses on the human ergonomic issues, recognizing that all organizations are societies of people.

Professional/career and life-style associations

In a paper I wrote about five years ago, called "Organizational Marketing (OM)," I projected that future society would fall into two major environments: professional/

career associations and life-style associations. If people need a job, a professional/ career association helps them find one. In addition, this association creates new opportunities for faster recognition within the company, especially for aspiring women. It is surprising to talk to men and women about their involvement in these professional associations and to discover how significant they are to these people.

The other major association is life-style. In Boulder, Colorado, for example, people are more often identified by their life-style than their occupation. Occupation brings in the money; life-style exercises freedom. Life-style associations run the gamut from sports to religion, from exercise to PC users' groups. Indeed, in today's mobile young communities, such associations often play the role of an extended family.

Life-style associations are the "soft side" of humanity. Not just in good deeds, like Boy Scouts, but in terms of art, culture, music, and play—the enjoyment of the world around us and its beauty. These associations have existed for thousands of years, mostly involving games and sports. Many emerge and become popular only to die off, and others like chess, the Olympics, and dice exceed the life span of some religions.

The distinction between career and life-style associations is blurred. Certainly, there have always been the gypsies, beatniks, hippies, punkers, and other groups of people who seem to only have a life-style. Others, however, such as Mo Siegel of Celestial Seasonings Teas®, have made careers worth millions capitalizing on life-style, and there are hybrid career/life-style associations, such as the Peace Corps.

Business associations are used to further the life-style interests of business associates, and life-style associations often provide opportunities for striking up casual business acquaintances. The ability to create associations of any kind is important, and understanding their significance and their role in the corporate culture of tomorrow is critical for corporate survival. Matrix management, virtual management, and professional associations are corporate cultures at work. They must be assimilated into today's operations and tomorrow's planning for corporate growth. IBM is famous for its corporate culture. It is also famous for its success. There *is* a correlation.

Yet one must always be wary of these "cultural" aspects. Remember that the industrial age had its own style, and with the rapid growth of new technology came new labor unions that were not based on corporations but on specific professional abilities and skills.

These associations now number in the thousands and include, for example, the North American Society for Corporate Planning, the International Facility Managers Association, and one that I helped start—the International Tele/conferencing Association (IT/CA). These associations flourish because they provide members with the information they need and contribute esteem and awards to people who are often unappreciated within their own company. To many, professional associations are at least as important as the company they work for. Corporations need to understand that the information age will evolve, will possibly become more communications-oriented, and therefore will need a different corporate culture than has previously existed. It will not be enough to use the new technologies to build a better mousetrap. The corporation must use technology to help manage the people who build, sell, and support the mousetrap.

Management Sources of Information

Computer communications technology helps expand problem-solving capacity by reaching beyond the limitations of time and space. This is a capacity found in the very technological foundations of computers (large memory capacity, high-speed calculation, integrated control functions) in an on-line, real-time system. One of the most advanced problem-solving systems of this kind is the forecasting, evaluating, and warning system. It provides quick discovery of problems in rapidly changing circumstances, forecasts future trends, evaluates the degree of danger created by these problems, and issues a warning when danger appears. To allow use of this technology, some special information management styles will emerge, peddling a variety of sources of information.

The principal management sources of information will be in the following areas:

- Information providers
- Information organizers
- Information users
- Power brokers

Information providers

Information providers are those involved in the creation of intellectual values. Information providers will decide what information, or raw data, should be made available to users. They arrange information in a data base for future access.

Information organizers

Information organizers, or facilitators, will operate computer systems that assist people in at least three ways beyond merely locating information. The systems will be of the following types:

- They will be proactive; they can detect a problem before it becomes serious. By analyzing present tendencies and predicting future trends, these systems can present potential alternative solutions.

- They will discover hitherto unknown problems. Humans tend to find the familiar patterns, and machine systems can consider all possibilities in their calculations.
- They will be able to solve problems that are complex and protracted; for example, the contamination problems at Love Canal or a nuclear missile crisis.

Information organizers will help build bridges between users unfamiliar with the vast corporate or external warehouses of information. They will manage the acquisition of that information and its condensation into digestible bites for consumption. The growth of information centers as the means of managing, controlling, accessing, reviewing, and moving information will fuel the growth of the organizer's role as a vital interface in corporate management. This manager will have powers similar to a White House adviser. The President must base decisions on the information boiled down and presented by his advisers. The very act of synthesizing information is itself a policy decision.

Information users

For the information user, new trends are emerging that solve old problems and create very real new ones. The user community is changing rapidly. Computer technology is, on the one hand, fueling this change by providing users with vast amounts of information to increase productivity and, on the other, creating an information "gap" in managing and controlling information because each user is information-autonomous.

Users want information, namely their information in their personal computer, and have little regard for corporate integration, protocols, standards, and capacity requirements. The user is a moving target, and in all likelihood is working at home, on the road, or on the move. In response to this phenomenon, some corporate organizations now have personnel who are experts in user needs in both business and life-style.

This new breed of user is creating its own data bases, without regard for eventual interconnection to co-workers. The user's principal concern is problem-solving, or decision-making, which involves devising a way to eliminate risks and uncertainties that might stand in the way of accomplishing goals. It also appears that the user does not allow anyone in the organization to stand in the way of acquiring the technological tools necessary to perform the desired task. In many instances, an individual has brought a microcomputer, with some personal software, into the office before the corporation has supplied these tools. Tomorrow's corporation must spot such trends, analyze their impact, and quickly respond to them.

User aggressiveness is starting to have a far-reaching impact, not only on the organization but on society in general. The computer is opening new, complex possibilities and creating new social values simultaneously, without regard for economic, political, management, or labor conditions. Thus, the user might be the most complex issue facing management.

Power brokers

The power brokers, those organizations involved in the technical production of computing, storing, and communicating information, will provide the impetus for the proliferation of telecommunications and information technology. Information generation will be a critical focus in the years to come, whether computer facilities are available for large- or very-large-scale processing.

Distributed processing enhances the overall system processing capability by matching it with individual user requirements, whether this takes place at central or remote sites. However, the limitations imposed by different computer operating systems, networks, and dysfunctional software systems will lead to gross shortages in global processing. The winners in this area will be those companies that are able to maintain a high level of processing as well as "broker" unused time to the outside world.

Corporate managers relying on global networking have key performance capabilities that transcend corporate boundaries. The ability to network globally will be one of the critical factors in future success. Like Roman legions who were strategically located in distant lands to check and supress uprisings or foreign invasions, networking can electronically bring the equivalent focus at any point. Information gathering can also take place to gain a better understanding of the forces that are needed in any given area. Information gathering points are an important part of this process.

Information Processing

As previously stated, information providers are the information-age gatherers and farmers of specialized information and data. Information gathering and processing are complex processes. If you gather the wrong information or gather the right information but process it at the wrong time, you end up with the familiar "GIGO": garbage in, garbage out.

In market research, most companies gather information in two years, then project by using the growth or decline of the product or market. This is referred to as **traditional linear projection-making.** There has been a tremendous amount of controversy, however, over strategy versus basic market statistics. It has been argued that market statistics are reflections of "real" sentiments and pressures of the marketplace and/or customer in actual terms. Strategic information, though, has to do with taking the raw data and building the product with it. This question involves more than market demographics because an understanding of market wants is often ahead of the market itself.

Strategic planning is the flip side of market statistics. This market consumption of information yields a diminishing value of either strategies or demographics. IBM is both a strategic and a statistical player. It develops in advance the products that can give it a competitive edge. The company is then capable of waiting, due to its size, for market pressure to build to the point where the statistics clearly demonstrate that IBM will probably be able to totally dominate the market.

Information organizers also need to be concerned with the processing and packaging of information. Processing information into viable strategies takes on new meaning because of the vast amounts of information being created every day. Over two million words are available every day to a newspaper editor; thus, processing and conveying meaning becomes complex as well.

What information is important? And to whom? Do we develop better packaging of information to facilitate its understanding by users? Do we keep it generic or organic, that is, developed without additives?

Information Processing Innovation

Processing of information in the future might lead to better attempts at innovation. There is some evidence in our own company's development of software, and that of others, of what has been called mindware. This is similar to computer-aided design (CAD) for the mind and ideas. Like product innovation using a CAD system, computer-aided thinking (CAT) might yield the sales strategist new approaches to sales and marketing. These types of systems will, in all likelihood, allow managers to model scenarios and concepts formerly unthinkable for computer simulation. For example, what would be the impact of reduced retirement age requirements on "baby bust" job availability for top-level management positions in recessionary conditions? This example again reflects a balanced approach to information—statistical and strategic. Statistics are needed to give fundamental baseline information, and strategic players can analyze and give their opinions about impacts or outcomes.

Another example is the role IBM will play in the emerging computer-aided communications market. Presently, market forecasters have projected major growth in full-motion video teleconferencing. The subtle issue here is that IBM's product is still-frame video, not full-motion video. IBM understands, among other things, that managers communicate at their desks or in nearby meeting rooms; in other words, managers communicate close to people they know well. There is little need for a picture 30 times a second because most forms of management communication and presentation use transparencies or slides that do not move.

IBM developed an innovative product that fit in with their product line and dramatically changed the computer-aided communications market. Although IBM guessed correctly, those companies that put all their eggs in the full-motion video basket did not. This points out how strategic marketing can fail. It has been said that if you think you know what is going on, you are probably wrong. Market forecasts might not truly reflect the market. Remember, even **IBM** forecast relatively few units of its IBM PC to be sold as executive add-ons to its installed base of larger computer systems.

Users, or **end users,** as they have become known in the computer industry, become more of an enigma every day. Their information needs differ greatly during the course of a day. Their work habits change as frequently as their offices move.

Generally speaking, the proliferation of personal computers has occurred as a result of the ability of certain types of software to automate frequent or redundant activities. Reports, including status or action-item updates, and financial and profit-loss statements can now be automated easily by using word processing or spreadsheet software systems. **(Automate** is used here to describe the mechanical aspects of the function, such as adding or subtracting columns of numbers or correcting spelling and grammar in text.) The expanding base of personal computers has slowed, and will continue to do so until new software systems are developed to assist managers with the less automated, or more complex, aspects of their jobs.

Managers and information processing

Table 1.1 demonstrates that the majority of a manager's time is spent in communication, followed by telephone conversations, desk work, and thought. It is in the areas of desk work and thought that information technology needs to address issues different from those available today. Simulations and projected outcomes of today's events in the future are typical issues most managers work with. Statistics might not give enough insight to be definitive. The strategy might be too vague for an agreement on the assumptions in the projections.

This is the information dilemma faced by most managers: an overload of information that is not filtered well enough to be appropriately used in any definitive way. The role of information technology in creating more data is thus suspect and, in many cases, frustrates managers to the point of blaming the technology for bad decision-making.

The other area where information technology is rapidly affecting the end user is in communication. This is discussed elsewhere, but a slightly different issue is at stake here. Information in the form of communication is thought of as electronic text mail. Voice, image, and rapidly approaching video frames are altering the types of information found in many offices today. The packaging of these new types into effective plans and presentations will change the overall nature of management communications in regard to meetings, presentations, and conferences. All four types of information managers discussed will be required to put together such a gathering and presentation of material. The corporations that start gearing up now for these events, from a technological and a management viewpoint, might find

TABLE 1.1 Manager's Distribution of Time

Current manager's distribution of time	
• Communicating information transactions	
Meetings	30%
Telephone	20%
Travel	20%
• Seeking information transactions	
Desk work	30%
Future manager's distribution of time	
Establishing communications/information transactions	
Performing people interfaces	40%
Meetings	
Presentations	
Audio conferencing	
Video conferencing	
• Traveling	10%
• Seeking information transactions	
• Performing system interfaces	50%
Dictation	
Telephone-voice mailbox	
Computer conferencing	
Viewdata-data systems	
Decision support systems-assisted "thinking"	
Computer-assisted retrieval	

themselves in a powerful position in the information brokerage marketplace of the future.

The challenge for KE will be to manipulate these new communication forms into traditional paper-based management functions. New types of software are emerging that have been called visualization systems. In artificial intelligence (AI) terminology, this refers to machines that can relate visually to their environment in a way similar to humans. These systems relate to users as the user desires, rather than as the machine dictates.

In designing software systems for end users, a number of issues are present that are generally not considered by most software designers. An entirely new approach to ergonomics (human-machine interface) is needed in designing and using software. A flexible approach to understanding the needs and desires of the changing user is demanded. Software must be able to learn and adapt to the user, rather than the user learn and adapt to vague, uncertain, and complex command key sequences. The trend toward manual-less software and hardware systems with the documentation available at any time on-line is important, but unlike most of today's on-line systems, it must be more than putting the paper version into an electronic text file.

It calls for a reorientation, a rethinking of human communication, and a dynamic interpretation of how a human can relate to a complex machine. (See Foeher and Cross, *The Soft Side of Software: A Management Approach to Computer Documentation;* John Wiley, 1986.)

Multidimensional Management Systems (MMS)

The concept of matrix management was introduced by organizational theorists because, among other things, technology was beginning to offer new ways for workers to communicate. As opposed to the traditional management structure, workers could be linked in more than one reporting function. Workers adapted to this management scheme much faster than had been anticipated because it offered the opportunity for excellence in a number of different pursuits rather than in those few pursuits available within the conventional job description and classification. For example, a worker interested in acquiring the skills for managing software programmers has a better chance of doing so in a matrix management system because the structure is more goal-oriented than the traditional control-oriented management systems. Matrix management recognizes and encourages the growing diversity of the new information age work force. VM is the next step in recognizing the role of technology within the corporate sphere.

Multidimensional management structure is another hybrid concept in the continuing evolution of management systems. Multidimensional systems are square, round, rectangular, or almost any shape other than pyramidal. Multidimensional systems are not necessarily hierarchical, relational, cross/pointlike, or networklike in their information relationships. There are no roles, just challenges.

Multidimensional systems already exist in a number of corporations, and many more are now testing the concept. In multidimensional management systems (MMS), each employee or staff member is recognized as a human data base management system, to use a conventional term. See Figure 1.1 for examples of some emerging management approaches. Each employee might also be called a node, a little less human-sounding, but, nevertheless, an appropriate term for describing the relationship of the person to the network.

When management's role was primarily to oversee a worker's actual performance, the necessity for being close had to do with physical proximity. In information-age environments, this idea is outdated. In our organization, for example, we have had people telecommuting during their entire work life. Occasionally, they have worked in the office—at their option, not the company's. Some have even worked "on the road" like Charles Kuralt.

Technology has changed all of the rules. In some cases, technologically-based organizations have no physical proximity to their workers. They have closeness in

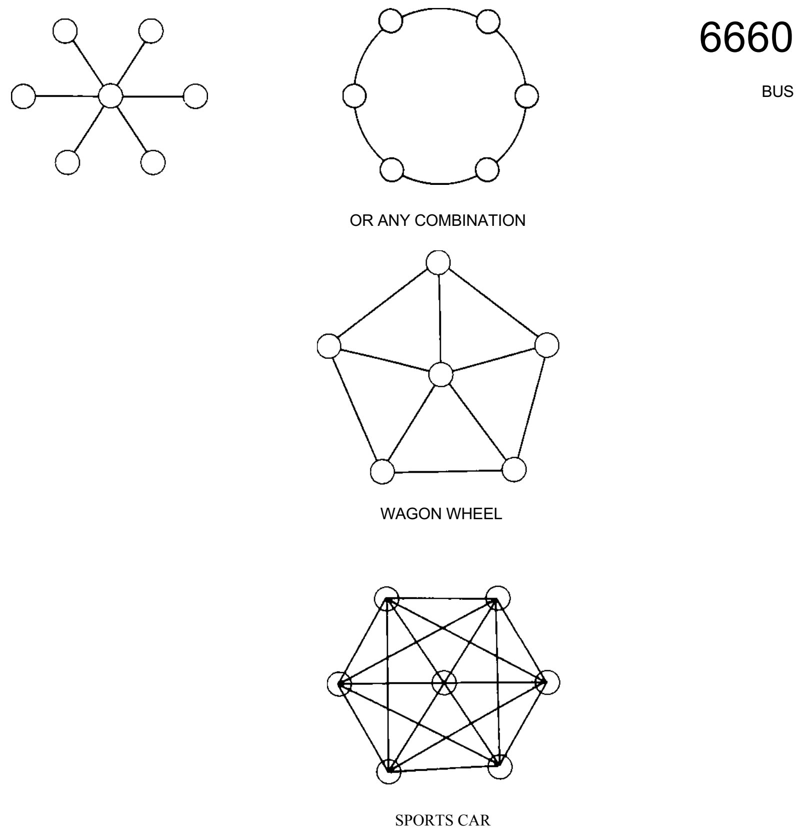


Figure 1.1 An example of multidimensional management systems.

another sense, through electronic communications. A similar closeness to the customer can also be established. MMSs are an extension of this concept, yet are appropriate for large organizational systems where staff size numbers in the hundreds or thousands.

The MMS organization looks like a network, not a chart. Upper management is more figurative than literal, more dimensional than linear, more spatial than physical. MMSs are innovation-driven rather than management-driven. Because of the relative amount of freedom offered by the communications links, each staff member is allowed the opportunity to explore and interact with anyone at their own time option.

Management responsibilities continue in the areas of keeping projects on target and maintaining accountability for individual contributions. However, the optimum manager facilitates and does not dictate, only advises and motivates. Already, this concept is strongly emerging, with an increasing number of employees functioning as telecommunications consultants. By definition, their role is advisory to corporate departments. The concept of the information center is almost a user-support function. Many companies are forming other internal user-support groups or clubs to aid users with problems related to the new technologies.

In this role, network management takes on a new dimension. It functionally organizes conferences and study groups of people with similar interests but who are in different locations or time zones. In this way, the network is optimized, providing not just information but human resources as well. Managers recognize that the information needed can change daily. The network can act as a multidimensional expert system because most problems have more than one dimension and, therefore, many potential outcomes.

Computer-Aided Decision-Making (CAD)

The development of computer-aided decision-making follows the basic principles of CAD systems for airplanes, cars, or buildings. It supplements, rather than replaces, human effort in performing a process or task. CAD systems for design and their counterpart, computer-aided manufacturing (CAM) systems, perform a myriad of repetitive tasks at the lightning speed of computers, leaving the most complex and difficult problems to human analysis.

It is an understatement to say that CAD systems can be used for solving management problems of nearly all types. This is totally a matter of need. In the discussion of MMS, the role of technology as a management team member takes on new meaning. It will only be a short time before some, if not most, of the functions of management will be automated, supported only by analysts monitoring functions similar to field engineers maintaining a disk drive today. The underlying forces behind this activity are the need to:

1. Optimize decision-making efforts
2. Increase the speed of decision cycles
3. Reduce costs and time
4. Improve decision-making performance
5. Simulate case studies for training
6. Eliminate personnel costs
7. Increase span of control
8. Reduce levels of management
9. Automate personnel skills

The development of computer-aided decision-making systems might be considered complex and infinitely difficult due to the nature of most management positions. However, there are automated telephone sales systems, automatic teller machines, software packages for psychiatric self-diagnosis, and systems for a range of other functions that even a few years ago would have been thought impossible to automate. Many people are wildly enthusiastic about these devices or aids. Children enjoy computer-aided instruction (CAI) because it doesn't scold them, is infinitely patient, and is never tired or bored. You don't have to worry about whether development and implementation of CAD systems will or won't continue; it is only a question of how fast this phenomenon spreads!

On the bright side, CAD systems eliminate many of the mundane and repetitive functions that keep productivity low and jobs boring. There are three basic areas of CAD systems: inductive, deductive, and intuitive. Models can be easily developed for inductive systems (thermostats, pocket bank tellers, and so on), and systems that perform deductive reasoning are being widely developed today (self-help, brainstorming). Intuitive systems offer the greatest challenge because they attempt to solve problems before they occur, or are proactive in their thinking.

Methodologies are needed in order to design these CAD systems. The scope of designing a CAD system consists of the following issues:

- Collect relevant information about the problem
- Separate data elements into as many distinctly different, yet significant, subcategories
- Develop a matrix or network of these components or building blocks
- Test components individually and as a group, or simulate actions until systems match a level consistent with human counterparts
- Graphically present simulations
- Incorporate tests with an overall model
- Test in real-life situations to monitor human decisions
- Develop procedures for updating and maintaining a system as a regular activity to include outdated, unimportant, or irrelevant variables, as appropriate

The issue of decision-making involvement is a matter of great debate. Most theorists suggest that the expert is the means to the end, that is, you need the doctor to understand the diagnosis. Others conclude a thorough knowledge of the diagnostic results is all that is needed to make recommendations.

This is a similar argument to heuristics and computer-modeling processes (i.e., linear programming, regression analysis, queing theory, etc.) versus delphi computer conferencing and other humanistic tools. Neither approach is totally correct. As with many decisions, the consequences are long-term rather than immediate.

Moreover, much of the development of CAD systems has to do with the immediate—today's management activities rather than tomorrow's, where outcomes can be rather vague and dependent on uncontrollable outside variables. CAD systems are seen as a way to do more with less, to become less dependent on human judgments that, for better or worse, are often inconsistent or vague.

Much of the research and resulting models are designed primarily for training purposes, where the costs are rapidly rising, instructors are in short supply, and materials are increasingly complex. Also, as the velocity of corporate decision-making increases, static models become quickly outdated. Issues concerning these decisions also become obtuse and difficult to decipher in components for the model to evaluate. Needless to say, CAD systems are arriving with many benefits as well as pitfalls. They will, according to my research, be executive assistants rather than true decision makers. This is due to the fact that most problems require that the decision maker extend beyond the present environment, such as implementing a new system, acquiring a new company, or reorganizing a division. However, as the data base grows, a history of management emerges that can be used as internal "case studies," aiding new managers in their decision-making processing and programmed into the minds of the machine-based executive assistants.

Organizational Marketing

Organizational marketing (OM) was originally developed in the late 1970s as a marketing strategy for a major Fortune 500 computer manufacturer. At that time, a new approach to marketing goods and services was needed. Even then, computer systems were reaching a level of resistance on the part of users because of the delays by the systems development department or in programming. There were delays of years and cost overruns that are similar to those found in military projects. Users were taking matters into their own hands as well as seeking technological solutions to labor-intensive and time-delayed projects.

Certainly there are no easy answers because engineering development has both labor and time dimensions. The notable situation of a low labor component and an infinite time component has produced major innovations throughout history. However, with most corporations, when the time factor goes askew, the only thing they seem to do is to pour in more labor and hope the problem will go away or correct itself. This is seldom the appropriate solution.

OM is more of a concept than a methodology. It is a leadership issue. Today, OM is referred to as entrepreneurship, strategic business units, or corporate venture projects. OM has evolved over time into VM, the next generation in management. VM is truly a 1990s corporate management strategy. Just as technology evolves in waves, eras, or generations, so, too, does management. For example, there are people who believe that the computer trend will fade away. Many, if not most, corporate management systems that were developed in the 1950s still exist today. Like new children, new corporations created today operate under vastly different principles than those formed last year or a decade ago. OM is a system that works with marketing-oriented corporate management. It is based on the simple concept of selling to users, not manipulating them.

A few recent books provide examples that are helpful in getting this concept across. In *Teleconferencing: Linking People Together,* an underlying theme is that this powerful technology is underutilized because the manufacturers of teleconferencing hardware and services fail to provide the "driver education" critical to happy users. The analogy is similar to automobile manufacturers selling cars without driver training and thousands of users killing or maiming themselves. You would wonder why people would drive at all! People do not teleconference very much today because they don't know how. This will change as users teach themselves how to teleconference.

In *The Soft Side of Software: A Management Approach to Computer Documentation,*[4] the theme is as simple as the title. Software is what the user sees, interacts with, and unfortunately, has to live with and has little or no control over. Sometimes called the "user-defined screen," it allows users to arrange the screen in a way that suits their needs rather than have the software program control the format. Software is beginning to be designed that enhances the intent of the user rather than demands great amounts of mental energy from the user trying to get "help." Software should be strategic in the sense that it develops with, learns about, and provides the user with strategies for its effective use. Case studies, applications, and tactics that propel and compel the user into action rather than stall the user with complicated software systems can each be integrated into the software program.

In *Intelligent Buildings: Strategies for Technology and Architecture,*[5] the approach is to bring together off-the-shelf technologies into a systems approach to office environments. Nearly all of the technology needed for intelligent buildings exists today. Local area networks (LANs), CAD systems (CADs), voice-data digital telephone systems, and energy management are all billion-dollar industries, yet few of them work together in a manageable fashion. It is clearly a situation that is driven by vision of the designer.

Developers and facility managers are tired of having technology for which they are responsible go in many directions at once. They expect—no, demand—not only that all of the information and building technologies work together, but also that they be integrated with the chairs and furniture. They have to arrange for all those power, telephone, and computer wires to get from all parts of the building to each individual desk, and are certain that someday the ceiling is going to collapse under the weight of all those cables. These users are taking charge, and they will have their way because they represent billions of dollars of office business.

Each situation represents a different user problem and a different technological issue. This suggests that technology is changing toward, rather than away from, user needs. People are slow to adapt, but technology is always changing, often at a rapid pace. It is usually not the user's fault that something is wrong; the user probably does not have enough time to truly understand the usefulness and effectiveness of the technology. OM takes a similar approach to encouraging users to invent new products themselves. OM was conceived as a sales and marketing approach to understanding user needs. OM is user-driven rather than product- or engineering-driven. This concept assumes that users are reluctant to use technology they are unfamiliar with.

If corporate technology departments such as office automation, data processing, telecommunications, and so on don't understand how their technology is going to benefit the user, the technology will always fail, except under very compelling circumstances. The sales and marketing of technology is as critical to internal users as it is to the manufacturer. Now you can see why there is a lot of technology sitting around unopened, gathering dust.

Technology and design are becoming inseparable. This includes the design of the organization in terms of workers and environments. The advent of the personal computer has enabled many jobs to be performed both automatically like automatic teller machines and autonomously like persons working from home. In terms of the organization, changes in terms of how work is performed and where it is performed will have dramatic effects on how the organization is managed and grows. In this sense, the ability to create environments that are dynamically or virtually adaptable to operate under machine control is becoming essential.

Corporations can no longer respond to wildly changing world market conditions on sheer intuition. The extension of machine technology to an organization becomes an organizational issue itself. The machine restructures the company that employs it to seek a new equilibrium from which to act. The machine-human interface sets the stages for modeling simulations from which key management can respond to, rather than be confronted by, disturbances on the economic front. The computer can model and simplify complex conditions into relatively simple "user-friendly" human-machine ergonomics. Therefore, allowing the computer to manage rather than respond is not only viable but will become a strategic weapon in the not too distant future.

Virtual Management (VM)

New management approaches seem to emerge on a daily basis. At the same time, some experts tell us that keeping an eye on customers and spending time with employees is a time-honored, commonsense, proven management system that works. The problem with both the new and old approaches is that they fail to understand the new employee: the computer! The computer has been an employee for over three decades, but few of us recognize this, in spite of the cost justifications when computers took on human tasks. Perhaps we should have given them performance reviews all along.

The computer, for some, became an extension of their total personality, allowing them to play electronically with other unknown faces out there in the network. (Even *Ms.* magazine has published an article on the "Electronic Lover.") Computers were thought of as "power tools," electronic saws that replaced electric motors with electronic microchips. Few thought of computers as people, but computers were now starting to act like people, even if they were considered to be electronic pets.

At this point, computers as a species are hardly 30 years old, but what an evolutionary pace—from dinosaurs to domesticated animals in a fraction of the time it took Mother Nature! Computers are now able to simulate brain cells, emerging as one way to help cure mental problems and illnesses. They will be designed to simulate business processes, taking on management style and performance. The automated factories of today are only the beginning in a race for the automated business enterprise.

This change is slowly taking shape; the footprints in the sand are emerging management styles following an evolving view of employees. Management is looking at employees as capital expenditures, and employees are starting to have a product-life-cycle approach to their existence.

Management by objective (MBO), organizational development (OD), and other cause-and-effect management strategies use performance evaluation techniques that are not very different from output measured in instructions per second. As computers are expected to take on challenging management problems, they will also take on a management style of their own. This is not to say that they will be great managers or that they will be much different than the "experts" they are modeled after. It is only to say that expert systems, thought processing, and AI systems will start to replace human functions in much the same way that bionic organs have. It is also safe to say that computers will become more reliable, precise, and manageable than humans. Boredom, tiredness, and concentration are words that do not apply to a computer. In the early days, computers replaced women who connected telephone calls; now they have replaced even the president of the company.

GE says in its company slogan, "We bring good things to life." Creating expert systems and AI applications might just bring the electronic manager to life! It will be curious to see which company first announces automated management and can supply it.

Today's automated office requires new forms of management that can recognize how the rapid advances in electronic office systems and information technology (IT) are coupled with a changing society. VM is just such a management system. It provides three important benefits:

- VM is adaptive to technological and societal changes. As a management style, it affords managers the ability to lead and direct employees from a distance, with a sense of immediate involvement in office affairs.
- VM promotes the application of traditional sales and marketing techniques by telecommunications managers within their own organizations.

• VM achieves a balanced control of technology between managers and end users.

VM is not just a management theory but an evolving management process that adapts technology to changing business demands and user requirements. Figure 1.2 shows a VM organizational chart.

Many traditional organizations isolate upper management from employees, allowing information to travel slowly up the hierarchy of decision-making levels. Consequently, the larger and more authoritarian the organization, the greater the chance that higher decision makers will receive distorted information.

The development of microprocessor technology and electronic office systems has fostered the trend toward decentralization. Consequently, management structures are changing rapidly to adapt to this reality. There is also a trend toward smaller operating units, independent field operations, and a rise in entrepreneurial companies. These new environments are based on technology and the premise that everyone, including top management, has access to the electronic system.

The virtual manager will need improved human relations skills. Two trends underscore this point: (1) electronic office communication is increasing and speeding the flow of information, and (2) professional staffs are growing faster than clerical staffs. Thus, a larger amount of information to communicate will be generated and result in more work for the manager.

Surveys show that professionals spend the majority of their time communicating with each other. This factor, combined with the decrease in clerical staff, means that managers will spend less time managing in the traditional sense. Because professionals require more management interaction, feedback, and motivation, the manager will become a mediator and a consultant to the organization.

The managerial organization within companies will also gradually shift from a vertical structure to a horizontal structure as professional staff numbers increase. Smaller operating units will thus enjoy immediate communication between management and employees. Because professional staff members will have greater interaction with supervisors, there will also be less-frequent distortion of information in the course of decision-making.

It is important to note that managers will not control the process as much as facilitate and participate in the flow of information. Indeed, one of the functions of management is to integrate information flow with an organization's objectives. Too often, the failure to identify goals, define needs, and select the significant information is the cause of organizational failure.

Knowledge can only grow in an environment of free interaction, and control reduces the flow of information upon which knowledge depends. Because much of today's business product is knowledge, much of the corporate product is contained within the minds of workers rather than in company warehouses. This point is not often understood by traditional, larger corporations, whereas smaller entrepreneurial organizations understand it very well.

VICE PRESIDENT — TECHNOLOGY MARKETING

MANAGER OF TECHNOLOGY DEVELOPMENT
This person will be responsible for the review of new technological innovations on a global perspective. For example, how do weather or biorythms affect employee output? Can solar energy provide a new communications network?

MANAGER OF STRATEGIC ECO-PLANNING
This person will be increasingly important in managing resources coupled with a serious concern for environmental and societal impacts. For example, is the location of a new plant going to radically change the requirements of the community? What will the company's image be if we proceed along these lines?

MANAGER OF PRODUCT DEVELOPMENT
This person provides the design and technological planning for new systems. For example, what are the new features we need for a word processing system? What are the human engineering factors required for working in mines or space?

MANAGER OF PRODUCTIVITY PLANNING
This person provides the management auditing to supply the needed systems and human factors engineering for company integration.

Reporting to each of the above departments would be:

MARKETING SALES TEAMS: these people provide the internal interface to other departments seeking to solve needs, problems, and create new opportunities to serve corporate departments.

MARKETING SUPPORT: after the system is installed, these people provide the necessary on-going enhancements, additions, and reconfigurations of the systems.

PUBLIC RELATIONS: these people provide executive management with reports, presentations, training aids, and other information.

REGIONAL PLANNING: this team approaches the global problem of sharing ideas and approaches with other cities — domestically and internationally.

QUALITY OF WORK/CAREER OPTIMIZATION: because of the need to train and, more importantly, to keep employees, this area is vital to human resource management.

Figure 1.2 An example of how a virtual management organizational structure might exist. Copyright © 1987, Cross Information Company.

The small operation recognizes that it is the "management team" that determines the success or failure of its organization. Venture capitalists have long acknowledged that the five most important factors in any successful start-up are (1) management team, (2) management team, (3) management team, (4) product, and (5) market. An atmosphere of excitement exists in these fast-growing enterprises because their small scale and relaxed work atmosphere facilitate the flow of ideas.

The VM Manager

The VM manager will act as a consultant to the division in the new office. Ensuring that needed information and resources reach the employees will be only one required management task. Another task, requiring adaptive skills, will be to decide how the new IT (information technology) systems should be designed to support the individual rather than the organization. This task becomes difficult as job specialization increases. The need for corporate standards and control must be balanced against the user's individual needs. The virtual manager must negotiate with the professionals in his or her charge.

Some organizations can be overwhelmed with information. As William L. Dunn, president of Dow Jones Information Systems, believes, the increase in communications and information retrieval will require a program to filter the financial data his professionals need from the avalanche of data available. Such a program ". . . would scan fundamental information to find out what is influencing price movement. At the same time, the system would monitor the movement of selected stocks, alerting the user to sudden increases or decreases in price." This same premise applies to IT systems. If memos can be originated at a moment's notice and conveyed throughout an organization instantaneously, who will decide the limits of such information movement, its security, and privacy? The possibility of being overwhelmed with too much information is very real.

Other issues will grow in importance as well. On the one hand, professional workers will require more available information. On the other hand, increased corporate security in the knowledge industry will be an ever-growing concern. The virtual manager will be required to impose security limits on the professional staff without depriving them of needed information. Computer crime specialists say that companies face greater threats from internal company personnel who have legitimate access to information than from outsiders. Thus, the risk of the theft of ideas, as well as the threat to privacy, grows each year.

Meanwhile, the concept of the office is changing. The traditional corporate structure regards the office as a physical place. In contrast, the diversified, decentralized organization of today regards the office as a system, a network, or communications arena. This difference has had a profound impact on the atmosphere of the modern work space. Even the physical structure containing the office has been affected by technology. The concept of the intelligent building brings to mind yet another view, that of the "communications nervous system," not iron and glass, as the determining factor.

Today's fast-paced environment frequently requires the manager to be out of the office. Mobility is a major characteristic of today's manager, and being away from the office for several days must not be an obstacle to communication. In fact, some face-to-face meetings requiring managerial presence can be accomplished by meeting electronically. Teleconferencing, for example, can provide direct and immediate contact. This electronic interaction is known to enhance both management and employee involvement and productivity.

Users as a Key Factor in VM

VM promotes employee participation in systems design. In the past, computer experts made all major decisions regarding the acquisition of machines. The inclination of users to resist technology stemmed in part from the imposition of systems ill-suited to their needs. VM philosophy suggests that managers not impose systems upon users, but that they act as consultants who involve users in analyzing their own needs.

Although clerical users are dependent on experts for determining equipment needs, there are increasing numbers of professional workers stepping out of a passive, assistance-only role and becoming active and assertive. The telecommunications analyst's position will become like a salesperson's position: The analyst must use traditional sales and marketing techniques to motivate the users rather than present a mandate.

Human goals have become an important aspect of office systems design, increasing the resistance to technology-led design. The emergence of CAD will help personnel design their own environments. The time will come when offices will have totally modular furniture systems that people can move themselves. This modularity is made possible by the use of smaller and vastly more portable personal computers.

VM helps managers and end users achieve a balanced control over technology. In this new approach, it is desirable to merge both human and organizational goals in selecting new equipment. Human factors, often considered to be subjective and difficult to analyze, are brought to the forefront in VM. The problem today—and an increasing one in the future—is not so much the pace of technology but the pace of understanding and using it. Productivity will be measured by how well technologies develop the means to increase effective and efficient office production, not just factory production.

Users want the tools to communicate effectively with their superiors, subordinates, and colleagues. But, possibly due to inexperience, they are not always careful to examine those tools closely before implementing them. New visual factors must be taken into account, such as color accuracy and its effect on personal appearance. As has often been the case in full-motion video teleconferencing, people take on a magenta skin color. How does this "magenta manager" look to the people on the other end? Do they evaluate the person's appearance or the content of the message being communicated? Does the content count more than the communicator? Does the velocity of electronic information overcome the political circumstances of the people involved? Again, these questions point out the importance of the human factor in developing and using new technologies. These very personal responses are factors limiting the spread of enhanced communications in organizations. As I discovered in researching *The Soft Side of Software,* there remains uncharted territory in getting the message delivered properly, much less understood, by users of most software programs. Communication carries a high price tag in business. It has a dark side and a soft side as well. Companies that master these issues will increase their organizational velocity to excel and best their competitors. Keeping lines of communication open and fluid is an important aspect of VM.

Steps Leading to Virtual Management

The following steps lead to a VM approach in managing information systems:

- Understanding the company and players in the market/company—the strategic position
- Evaluating the impact of tele-information systems on the company
- Establishing a tele-information historical base point
- Instituting zero-based or profit-center financial planning
- Performing an inventory and establishing value of service
- Instituting a management information program
- Developing short-term and long-range strategic plans
- Developing organizational market concepts
- Monitoring impacts with continuous customer studies
- Becoming involved in top management
- Understanding human resource motivation
- Marketing tele-information throughout the company
- Marketing to other companies through career associations

The underlying basis for VM in some cases is the need for a new entrepreneurial spirit. VM creates a small business within a large business approach, much like the village within the large state. This allows managers greater freedom and opportunity for innovation, experimentation, and marketing for new products and services.

Management Operation Centers and VM

The trend toward implementing centralized processing areas for office work has developed over the last few years. These "task-processing centers" have been the focal point for management reorganization. These centers resulted from technological advances in management control and sparked the development of office automation and other new technologies. Now the task is to expand services outward to the plant, to the field offices, and eventually to homes. These communications options will allow people greater freedom to communicate and move ideas and documents throughout the corporate network.

These task-processing centers represent information tools in intelligent environments. The management/processing area will be devoted to the management, control, and distribution of decisions. Document creation, management, use, and storage play a key role in this important task in the organization and, therefore, are valuable tools to the VM manager. Without internal forms, contracts, purchase orders, and so on, the corporation would cease to operate in less than a day. Rapid document and communication movement into the arena for the organization, review, and evaluation of decision-making is equally critical for survival. Hence, the need for technology-aided information flow.

The office, whether physical or electronic, is a tool for processing information and moving it from one place to another; for example, the personnel department communicating to accounts payable about filling a vacancy, or the purchasing department responding to a request for parts. Such information itself can be a tool to measure transfer of tasks. These information-transfer or task-processing functions do not require paper, oral communication, or real-time contact, but rather can make full use of the communications network in an intelligent building. Memos, reports, telephone calls, and mail are office tools with which any bureaucracy works. Some of these tools, such as action items, coordinating calendars, memoranda, and similar office task documents, are being developed on totally automated systems.

Budgets are also a tool for measuring office activities. For example, zero-based budgeting and profit centers are used to measure departmental productivity in dollars. Each departmental activity is measured against dollar performance. The dollar performance of office functions, ranging from public relations and employee recreation to community activities, can be difficult or impossible to measure. Simulation software can be developed for many of these environments. This kind of software helps evaluate office activities by establishing games for managers to play. The results of the simulations can form the basis for career or financial advancement. Computer-aided communications and viewdata systems also create new management systems.

New information managers, using the VM system, will use all of the tools suggested. In addition, corporate "war" games, played in war rooms, will help the leaders find the next generation of corporate executives as well as determine strategy against the ever-present competition. With the development of these new information systems, **information float** will become a measure of management productivity. Float is the unused capital that sits while information is transferred back and forth, that is, is not actually in use. Information float in a large organization is much more damaging than financial float. Information technology (IT) can generate significant increases in the organization's pace of activity, thereby reducing information float. It is a fair guess that a company that fails to achieve its plans is afflicted by a management information gap. In closing this information gap, the following objectives must be clearly established:

1. Managers must define the information needed to supervise current activities, and plan and direct future operations.
2. Information flows and organizational structure must be integrated so that information is directed exclusively to those who need it in their work.
3. Superiors and subordinates must communicate with each other, using current information, as a regular feature of their work.
4. From the CEO down, employee skills must be mobilized to participate fully in achieving the company's goals.
5. Information must be managed as a major resource, with responsibilities adequately allocated and costs in all departments planned and controlled.

IT will cause new perceptions of what is needed, required, or even desired. In many cases, it is assumed that the future will largely take care of itself, but it does not. It evolves gradually and every so often deals the unwary a sharp blow.

Before organizational changes can take place, managers must understand that all business activities are a series of relationships that can be identified, analyzed, and resynthesized as needed. It is essential to define those activities and relationships in terms of business objectives and work content, as well as design methods for conducting and managing them. Information is the only medium through which activities and relationships can be coordinated.

Virtual Management Activities

Once managers have developed a feeling for this new approach, their activities will include the following:

- Specification of users' needs
- Selection of information elements that will identify and monitor trends in the content of each information base
- Coordination of information flows throughout the organization for security and privacy reasons
- Guidance of information flows to each user or user group
- Progressive feedback of and reports on information flow patterns to maintain the future perspective of the organization

Few management systems exist today that can accommodate such activities. In the traditional organizational pyramid, the underlying problem of information flow restriction from top to bottom remains. It is clear that future organizational structures must consider other information structures; lateral networking among individuals using office automation technologies will play a large part. Technology and marketing will become the two focal points of management.

As technology and business evolve, the following components of changing management structures will emerge: (1) multidimensional management structures; (2) technologically-based management systems; (3) independent business units; and (4) computer-aided management.

Benefits of Virtual Management

By introducing a new management system such as VM into these new components, the following benefits can be realized:

- Management of business information as a major resource
- A large reduction in internal numeric data, with a corresponding reduction in the cost of collecting and processing
- A substantial increase in external information
- The identification of issues to be managed, and the ability to continuously monitor progress in managing them
- Revised awareness of the realities of business enterprise, and the opportunity to respond to rapidly changing market/product/service conditions
- Increased creation and development of understanding, which comes from knowledge, that is, in turn, the product of information
- Greater integration of activities of people
- Increased communication, of which information is the foundation and substance
- The ability to establish common bases of knowledge and understanding between people, an essential prerequisite for coordinated activity

In essence, VM allows the efficient use of information systems. Only with the advent of such high-tech management can the systems be effective in meeting the needs of improved productivity.

VM is but one management structure. Other options might be viable, depending on the type of organization and industry (banking, transportation, and so on). The most important consideration management faces today is preparing to face all technologies, not just those known today. Technology cannot be separated from the organization, especially from the type of management used within the organization. Through the past century, successful managers have realized that it is the organizational structure, not the product or service offered, that is the critical success factor in real growth. As technology plays an increasingly larger role in organizational management, it too will play a significant role in how successful an enterprise will be. Moreover, with the development of artificial or machine-based systems, these devices will become line managers. And, in the case of executives, even marginally sophisticated systems may be more affordable to the entrepreneurial corporation than a "live" executive.

Computer-Aided Management and Communications

The real and rapidly increasing cost in a business office is for communications. That is to say, the cost of sales to product delivery depends on effective communication. Within this cost of communication is the personnel factor. Order taking, closing the sale, purchasing, and filing the contract all depend on human communication. Communication is vital in the areas of proper performance and timing. Performance depends partly on the communication of tasks, goals, and the tools at hand during employee training. Scheduling people, locations, and events is a major function of electronic communications. When availability and needs are known, timing is much easier to gauge.

In a high-tech office, you often find "open plan" furniture. There is as much argument and controversy over this particular furniture approach as there was over the introduction of closed offices 100 years ago. The raging issue is not over such things as comfort, desk height, or chair back support; it is over communication, whether too much or too little is facilitated by this type of furniture. An important side note is the issue of noise. Noise is inherent in all communication; whether noticeable or not, it is always present. It might be more apparent with open plan or movable partition furniture than with closed offices, but it is present and always will be.

Communication transactions occur when words, memos, or images are moved physically, verbally, or electronically by computer. This communication element is critical to managing, as well as improving office productivity. In a communication audit, a thorough analysis of all communication takes place before the office systems are installed. Communication not only sets the traffic flow of people "wandering around," but guides the organizational structure as well. Obviously, in most corporations the flow of communication rises to the top of the organizational ladder and then lowers back down again. Yet in most successful corporations, communication that flows around and out is the most effective form. This spreading out of communication tends to diffuse the impact of its intended consequences. However, this diffusion increases the perception of involvement of more people.

Too much communication from the top or bottom results in overload. For example, in situations where too much communication takes place, a word has been used to describe the tilt or overload factor; it is called glaze. Under these circumstances, much of this type of communication results from pressures above or below the glaze level. People often comment that the manager's eyes "glaze over" when he or she cannot cope with any more information. However, information is not the problem; dissemination is.

Matrix Organization

The concept of the matrix organization supports this nonpyramidal approach. By networking people with like (engineers) or different (skunk works) co-workers, the organization can link people into effective strategic teams. With electronic networking, these teams can be expanded to the global level to attack global problems if desired. Too little information leads to distrust, as we all know so very well. Therefore, management of communication is a vital step in keeping people in touch within the office environment. As we move from a paper-based environment to an electronic one, the ability to expand communication into multiple dimensions increases. (Just a note on paper: I do not believe for a second that paper is going away. The computer is a "power tool" that allows knowledge workers to accelerate their ability to work, which means that even while there is a push toward paperwork reduction the organization is actually generating more because people are doing more work.)

As the British Post Office has found, most communication takes place in the form of exchanging information. The following table represents research completed by the British Post Office detailing the approximate content of business meetings:

TABLE 1.2 Content of Business Meetings

Type of Information	***Percentage of Meetings***
Seeking information	49%
Giving information to keep people in the picture	48%
Solving problems	48%
Discussing ideas	26%
Delegating work	12%
Negotiating	11%
Forming impressions of others	9%
Making policy decisions	8%
Presenting a report	8%
Inspecting a fixed object	7%
Resolving conflict	4%
Disciplinary interviewing	1%

Courtesy of British Telecom Annual Report.

The first four content areas are centered on some aspect of information movement, transfer, and communications, and do not involve highly personal exchange. The interesting aspect of this chart is the indication that the majority of the contents of most business meetings is relatively free of highly sensitive interpersonal interaction or communication. Very little activity is consumed by negotiation, discipline, or other types of communication. Computer-assisted communication also packages the communication for electronic manipulation. The packaging or multidimensional qualities of electronic communication generally take the form of:

- Editing and word processing
- Sending and receiving information
- Storing and archiving information
- Manipulating and analyzing information

Editing and word processing have to do with correcting grammar, typos, and formats. Sending and receiving allow for store-forward (time-independent) features that allow information to be retrieved as needed as well as appended and forwarded to another person, to the next desk, or around the world. Storing and archiving allow for filing, with the advantage of instantaneous retrieval. Some systems act like an electronic desk, yet save a tremendous amount of time in looking for lost information. Manipulation, simulation, modeling, and analysis are features that begin to act like CAD. They are like paintings reflecting the real world on canvas.

This manipulation is the first step in developing an effective decision support system, where the computer, with the help of the user, begins to analyze information and applies user-developed or software-provided heuristics (rules or formulas) as templates or overlays. The manager can then employ trend analysis or other techniques. Communications in this environment takes on new meaning. It is now a quantifiable element rather than a swirling mass of words or images. Computer-aided communications in this electronic environment are focused, targeted, and directed toward an outcome or goal. Communications can be managed for productivity, packaged for consumption, manipulated for different perspectives, and consumed in a meaningful form by the receiver.

The Electronic Workplace

As electronic communication supplements (not replaces) face-to-face meetings, new communication patterns will emerge. The ability to communicate with people previously unavailable due to distance or access often dramatically alters the known or expected communications pattern. Time and distance are irrelevant. Global thinking takes place. The earth is no longer flat, nor is it day or night. The world is immediately available to everyone, all the time. The office desk concept disappears.

The transition from physical to electronic space is taking place at a rapid rate. Open plan furniture concepts become blurred because their functionality is expressed in terms of physical space, and the need is for communications space. Communications space is similar to an office without walls. It can be everywhere at any time. Telecommuters were the early adoptees of this new approach to working, but have quickly applied it to other aspects of their lives. The office then becomes a social environment for training, presentations, and intensive human contact.

Many articles have been written on the isolation factor of people who work at home. According to our research, this isolation factor also applies to the office in relation to "X-type" managers, those who are known as tyrants. The home can be an escape from these types of managers and, therefore, a suitable working environment. The point is that the office is not necessarily the most suitable working environment. There are a large number of known locations for work, as well as many other less-obvious environments, such as neighborhood work centers or anywhere you can take a computer, that will emerge as communications locations or nodes. The notion of the work place will disappear, as work will also disappear as a function of physical location. The innocuous question "Where do you work?" will become more difficult to answer than ever. The emphasis on communications transaction as a definable and manageable activity will, therefore, emerge as a viable business operation. The VM manager must be able to manage people who cannot be seen. Thus the term "virtual."

Communications Technology and Management

Much is at stake in a corporation when communication is misdirected or ceases altogether. Remember, management spends the majority of its time in communication. As mentioned elsewhere, management is practically, by definition, unceasing communications which, hopefully, involves listening to the same extent as directing the information flow. **Communications technology** is an enigma because the transmission medium has little to do with the content of the message, in spite of what McLuhanists might say. However, for effective communication to take place, all elements of that communication must be considered. The transmission might be efficient, but the communication might not be effective. Communications technology must focus on the efficiency of the medium as well as its impact on how the message is packaged.

Communications technology remains one of the most illusive and least understood concepts in the executive suite. To determine how to manage communications at the executive level, one must understand the executive. Few understand how top management works, let alone ask what executives think about or discuss with their peers, or how they make their decisions. In an unscientific study of executives by Cross Information Company, it was found that most decisions are made after gathering vast amounts of information. Yet, these decisions are made by gut feelings, not by the numbers. Decision-making is a complex process. If we are to understand how to make better decisions, deeper analysis of how they are made is vital. Decisions take up only a small percentage of an executive's time, yet sometimes have devastating effects on employees and general policies.

Automating the decision is potentially an impossible process, particularly depending on the specific nature of the executive involved. One might argue that designing and building an executive decision-making expert system might discipline upper management to consider many more alternatives and to simulate outcomes prior to enacting the decision. It might also force executives to be explicit in explaining projected outcomes in terms of known "business cases." Although today's upper management might not concur with computer-assisted decision-making, just as they balked at too many MBAs running companies, it is a tool that can be used in the future to train new executives in a vastly complex world.

Companies will continue to seek and develop tools that increase the performance of middle management. The strategies, battles, and understanding needed to sail the corporate winds to success are clear to those who make it to the very top of the largest corporations. Advanced technology is not yet even a middle option in running large corporations, but it can and will be tested down in the divisions and departments throughout the ranks of middle management. Like the war games approach of the military, many companies use the competitive team approach to products and services. As in Monopoly, these companies test theories and junior management in maneuvers to get hotels on Park Place and Boardwalk. Contemporary management must understand its own product life cycle. It must know the stages of early "skunk works," or basic development, through "dog days." Management must evaluate its own ability to cope; to know when one has scored a victory or been shot in the foot.

Certainly much of this cannot be programmed in traditional ways. However, much of this process can be analyzed by computers, then turned into a CAI course, including "what ifs" such as Chapter Eleven and hostile takeover scenarios. These processes can force situations to the surface long before they occur in real life. Managers can develop their own approaches to corporate expenses over a rapidly increased time period; test intuitive applications; or be sabotaged by subordinates, labor strikes, or natural disasters. They can quickly understand processes it might take a lifetime to develop, and can cope with problems the CEO faces today to get a perspective of how management does, in fact, make decisions.

Management Strategies

These new advanced executive decision support systems can frame hypotheses by forcing the player to look at all the perspectives the CEO faces. Numerous structures and concepts could emerge for play by more than just the CEO. A corporatewide game of strategy can be played by managers all over the world to test new markets, products, services, or organizational strategies. These simulations can take the form of knowledge network applications like those suggested in the appendixes.

Strategies can be found in top-down approaches, those which are directed by top management but executed by new start-ups. Other bottom-up game plays can direct upper management into leveraged buyout simulations. The actual computer processing can be manipulated with independent and dependent variables forcing different controls on the players, in turn forcing new management postures and outcomes. Players can sign up for specific roles or wait for positions to open up by reason of expansion or player termination. Computational metaphors can be introduced at random or specific times to interject surprise and natural predictability into the game. Players, as in the real world, can work together as a team during one level and at opposite ends during intertwining events. (Another note: This is exactly what happened to the author in the formation of a start-up company.) Plays can be simulated by the computer during off-time periods to allow the machine to "understand" the events and project to the players recommended positions for the next play. Players can play a turn which can then be incorporated into future simulations.

Computers, like people, have generally no agreed-upon perspective about learning management problems unless they are taught, allowed to make mistakes, and allowed to correct them. There is certainly much controversy about methodologies for programming intelligence into machines. It requires that the teachers/ players instill into these machines their own real-life experiences which can be used with other players in the future development of management or other forms of human thought.

Group Decison-Making and Information Technology

Group theory and decision-making fall into the realm of psychology rather than pure business transaction. Much of the study of group activity comes from social interaction rather than the study of business. In fact, personal experience has demonstrated that it is rare to find in an audience any person with training in communication, meeting planning, management, or group theory. Group decision-making has been left to psychologists to determine why business is often so ineffective. One reason why computer-aided communications and other electronic meeting technologies have been so underutilized is that they dramatically enhance any shortcomings of either the message or the media. As a noted management consultant, Hal Josephsen of MediaSense in San Francisco, so aptly stated, "If you are boring face-to-face, you are still going to be boring in a teleconference." After all, if your information is shoddy, would you want it sent around the world in a microsecond? Yet electronic meeting technology is changing organizational communications patterns and, as a result, corporate strategy. When one can operate in an environment where decisions can be made rapidly, the "velocity," and so the impact, of any strategy increases.

The purpose of this discussion is to examine the decision-making process and to present some technologies that can improve the working conditions of most business meetings. Ideally, group decision-making should consider the capabilities and "people" resources contained in this body of group knowledge, efficiently structure the discussion to allow thought and consideration of all relevant points of view, and bring together the most viable solutions the group will consider in concert. It should also bring about a decision in a manageable time frame, debrief all of the participants to determine if they understood what the decision or outcome was, and place in document form a record of this activity.

One of the most important elements in any study of electronic meetings, or any business meeting, is the debriefing, where participants are asked to provide feedback about their understanding of what took place. An advantage of computer-aided communications is that debriefing is often incorporated as part of the activity and, as such, generates a higher understanding of what actually took place rather than what people thought happened. Ask yourself if you have ever been to a meeting and afterward, talking with a colleague, discovered the two of you had some significant observational differences about what actually occurred.

Meetings are generally confronted with, among other things, the balancing of ideas versus people. The issue to be dealt with is half-baked (off the wall) ideas versus planned ideas that come as a result of taking time or thinking it through. Personalities are another issue and generally represent the most volatile factor. We all remember meeting bullies whose only function was to have their way, right or wrong. These people have their own hidden agenda.

With regard to these issues, computer-aided communications has been shown in numerous examples to have a number of key advantages:

- They are organized, with the emphasis on the task or activity of the meeting rather than on the participants.
- They are generally planned ahead to a much greater extent than with face-to-face meetings. As a result, presentations by key participants increase the speed of the meeting.
- There is a balancing of opinions toward an agreeable outcome in much less time. The bully factor is balanced by the opportunity for shy or inhibited persons to have "equal access" to the discussion floor. It is possible, depending on the type of electronic meeting and particularly with computer conferencing, for subgroups to form to develop concurring or dissenting views on the main subject. Body language, or ergonomics, are, of course, a factor in all communications. (See Chapter 6, *Knowledge Networking Systems.)*

Computer-aided communication is a power medium of communications, electronically linking practically anyone in any location, at any time. As Birrell and White so nicely stated:

> As the telephone and telex (an early form of computer conferencing) have enabled great decisions on every aspect of business life to be carried out quickly and without the verbosity and obtrusive turn taking of exchanging letters, so may the teleconference change our lives. Perhaps, we will no longer have to leave a meeting with the impression that one did not get one's point across the right way or that so-and-so dominated the proceedings. However, people will always find a way to maximize the power and contributions, and in time, books on how to be successful in a teleconference will doubtless be compulsory reading of business management schools.[6]

Summary

The media might not be the message, but the organization that understands and utilizes such powerful media will be able to control and enhance the impact of that message. The company that develops management styles and decision-making processes that are applicable to the new technologies will have a leg up on its competitors.

Endnotes

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Chapter 2

Issues in Knowledge Engineering

Introduction

> The expectation of future consumption is so largely based on the current experience of present consumption that a reduction in the latter is likely to depress the former. With the result being that the cost of saving will not merely depress the price of consumption-goods and leave the marginal efficiency of existing capital unaffected, but may actually tend to depress the latter, also. In this event it may reduce present investment demand as well as consumption demand.
>
> —John M. Keynes

In everyday business, opportunities exist for gaining the competitive edge over other companies. The process for increasing profit, market share, or a desired goal is highly, if not totally, dependent upon information. Information is useless without some qualitative and quantitative analysis of the elements of this information. The quote from Keynes points out just how complex the relationships between some information elements can be.

Problem-Solving Strategies

Games, models, and simulations are tools used to design strategies which assess these information elements and which assist corporations in achieving goals. Games require players to follow rules that have been set up. These rules force the players to act in certain ways reflecting real-world situations. Games limit personal choice to keep players focused on topics or situations desired by the game's designer. A model, however, is an attempt to describe the world in a strict, linear, and logical fashion. Models attempt to bring order to chaos, often utilizing completely random elements, partial truths, feelings, and facts in systems or machines that can duplicate these events again and again. Computers, as opposed to humans, have the uncanny ability to perform millions of instructions per second only if the function is known. If event A occurs in situation B, then sequence C must be followed. A model allows very little personal choice, if any.

In designing strategies for success, mathematical models can conveniently be used where the elements are either specific options for the player or discrete events that are needed for other actions to take place. The game theory, in this sense, can be viewed as a tree, with branches representing points at which players can make decisions. At such points, the designer can allow a player to make a range of decisions as long as rules are obeyed, or the designer can require the player to follow a mathematical model at a particular point. If a game has extensive rules, player freedom is limited; the more rules, the less freedom of play in the game. A player's freedom under the rule structure is one of the most critical dilemmas. In some game theories, the rules describe the process of the game, and player freedom is mathematically defined. In principle, some of these theories imply that the outcome is not left up to chance and that only specified and certain outcomes exist.

In business strategy, the market leader subjects its competitors to few, if any, choices when market prices are lowered. In the case of IBM in the personal computer market, all but a few of the noncompatible and most of the compatible companies (too numerous to mention) have been eliminated. The moves made in billion-dollar markets can result in spurious activity in closely aligned markets (as with the dramatic effect of IBM's game plan on personal computers, software, and peripherals). For example, developers of IBM PCjr software quickly rewrote their software for other lucrative computers. Thus, the outcome of one particular game can cause complex changes in related and unrelated markets.

Designing not only the player decision points but also the trees requires both a particular strategy and a particular type of player. There is little value in letting a player have a wide-open set of options if the situation is restrictive. For example, many strategic planning systems use the portfolio approach. Each of the nine squares in a portfolio represents a particular and specific strategy. If a company is in the high-risk, high-reward square, the game strategy might only allow a few key moves for success. Another game design, perhaps equally restrictive, is reflected in the "dog" company position. A declining market position is commonly referred to as a dog. However, for the company whose position is in the middle ground, a large, if not infinite number of trees or options are available as strategies for success. Describing games in this sense makes it possible to define the strategies of the players in context. Trees can also be defined as networks.

Each solution to a game is unique, which makes it difficult to turn a game into a model. In nearly every case, a solution has key elements with characteristics that have occurred before, all of which are subject to gaming. These elements can be developed into mathematical models only if the outcomes can be proven repetitively. Those game elements that are proven repetitively can become models to force players through certain situations. However, designers can change models if they are too restrictive or are inaccurate depictions of reality. By their very nature, mathematical models assume a static universe, which does not exist.

When the model is a complex tree, a successful solution can often be used for other corporate strategies. Generally, tree models look alike until specific decisions made at key points are analyzed. In this way, the model represents a network of activities leading to decisions, outcomes, and successful goals. The tree can also depict certain behavioral models of the players, a key element in the process.

In the past few years, there has been considerable growth in the use of business strategy games for management study and other problems, such as examining land use or political and social processes. Gaming entails using scenarios, games, simulations, or models to provide a background or environment in which a set of individuals, usually referred to as the players, can interact. The environment is almost invariably a simulation or a model of a real environment. For example, in a business game, a computer model supplies the representation of the firms and the industry; in a military exercise, a sand table provides a model of the terrain. In some instances, the game takes place in a room that is a model of something else.

The chess board can be regarded as a model of a battlefield, yet chess is sufficiently abstract that it can also be described as a model of itself. Although one can draw analogies between chess and life, the formal rules of the game do not pretend to model life. However, chess can help players understand difficult and, in some cases, unpredictable problems that can be encountered in business. The same clearly goes for most card games, such as bridge or poker.

If one wished to study the effects on society of fighting a nuclear war, the scientifically accurate way would be to observe a nuclear war in progress. For obvious reasons, the study of a simulation of that phenomenon, even though it undoubtedly would be less accurate, is more efficient than a study of the actual event and, if done with care, should provide some insight into what might happen in a real situation. Such is the dilemma of many companies in designing and developing new products, from pharmaceuticals to automobiles to computers. Certain decisions and practices, if imposed on humans in reality, could have a disastrous impact.

One advantage of games is that they provide a basis for acting out management strategies without the players ever leaving the table. Scenarios, variations, and known facts can all be pushed against one another to the brink of conflict or battle, without losing lives or resources. They can also be used to test intuition, rather than the hard facts on the factory floor, and test responses to known complex management problems.

Gaming as Business Strategy

In contrast to simulation, gaming out of necessity employs human beings in a particular role, either actual or hypothetical. A gaming exercise can involve human beings acting as themselves or playing simulated roles in an environment that is also either actual or hypothetical. The players can be experimental subjects, or they can participate in the exercises for teaching, training, or operational purposes. When playing chess, neither the role of the player nor the environment is simulated, but when students are told to assume the roles of top decision makers in a computerized business game or war game, the roles of both the players and the environment are simulated. For example, one might have a business game in which a student is instructed to behave like the president of General Motors. In this instance, the student is playing a simulated role. In a military exercise a major can be required either to simulate the role of a general or to play the actual role of a major.

As noted, chess is one of the oldest strategic games in history. War games, particularly in the form of board games, are simulations of battles and invasions that have actually taken place. Games have a distinct place in history and strategic management. As Nicholas Palmer noted:

> Games were credited with a contribution towards a number of successes, notably the Japanese victory over Russia in 1904-1905, for which the Japanese had carefully prepared with war games. Most board war games now have a variety of scenarios, even in historical games, known as "what-ifs."[2]

For those of you who have been trained by Harvard and other business schools that utilize the case study method, board games are similar to case studies. Automating these cases is an effective and often rapid-fire technique for judging response time and mental dexterity. Certainly, this is not the only testing vehicle for judging the human decision-making ability because, according to my research, the process of real-time, face-to-face decision-making generally creates the wrong environment for learning. However, we are all confronted with crises that demand on-the-spot choices. War games can develop the behind-the-scenes learning experience needed to cope with these all-too-frequent occurrences.

Game playing is exciting. Balancing resources and troops with tactics requires both a short- and a long-run approach. Obtaining the end goal is always at stake. Game designers play on human frustrations, allowing victors to win strictly by playing according to subtle rules. Certainly, there exist countless success stories that can only be attributed to random and unaccountable reasons: luck. Games offer a challenge as well as a nonvolatile way to learn about a multitude of situations. Some executives hope games will teach more about playing by the rules, if the players are disciplined, intuitive, and foresighted enough to make educated guesses about the future, the results of which can then be translated into real-life corporate strategies.

These games, as Palmer points out,

> combine some of the virtues of each of the other types: They hinge on the actions of individual regiments and divisions, but they have strategic goals and usually simulate some important battle; most people find it fun to compare the game outcomes with what really happened.[3]

One of the issues associated with war-gaming is strategic planning. In some ways this is the passion of the game. It is well known that there are 10^{120} possibilities in chess; the nearly limitless number of possible move sequences contributes to its being such a universally challenging game. At the same time, there are only three universal outcomes: win, lose, and draw.

There are a number of strategic moves that separate the novice from the expert. This passion for strategy moves the player from a resource manager to a strategic opportunist. Players who excel at tactics might or might not excel at global situations. Gaming is one way managers can identify players who are good strategists, and those who are tacticians. This can be helpful in determining potential career paths. Modeling these games is an exciting challenge to the designers. The inventors of chess have left a legacy beyond even the works of Plato, Freud, or Sartre. They have given each one of us the chance to simply play and lose, or to win and come back again and again.

Business strategy has been considered by many to be the corporate equivalent of war games. For example, in *The Glass Bead Game* by Hermann Hesse, the key to all societal values is portrayed in a game. The concept is fundamental to the development of the highly abstract gaming model as both an all-encompassing and intellectual exercise. At the same time, the book presents a dangerously sterile gaming procedure for modeling representations of human affairs:

> These rules, the sign language and grammar of the Game, constitute a kind of highly developed secret language drawing upon several sciences and arts, but especially mathematics and music (and/or musicology), and capable of expressing and establishing interrelationships between the content and conclusions of nearly all scholarly disciplines. The Game is thus a mode of playing with the total content and values of our culture.[4]

In the applications of gaming, whether they involve economics, war, societal affairs, or teaching, the conflict between mathematical abstraction and simplicity on the one hand, and societal richness and historical content on the other hand, is always present. Neither a purely literary nor a wholly mathematical approach to scholarship holds all the answers.

Models *of Reasoning*

Model- or scenario-building is a process for developing reasoning approaches to problem-solving. In the classical business school approach, the following elements are considered when solving a problem:

Problem definition
Is this a marketing, production, or management problem? Also, is the problem solvable?

Selection of alternatives
Is this a problem that can be solved economically, legally, politically, or socially? There are usually solutions to problems, but at what cost?

Recommendations
Statistical analysis often yields some solution, but might not always consider "wild cards" or "hunches."

In applying this humanistic approach in the world of artificial intelligence (AI), there are equal approaches that arise as well. These include:

Definition of problem

This definition is expressed in terms of generally accepted symbolic or neutral languages, including syntactical and semantic adjustments. This is not to say that problem definitions must be configured in packaged formats, but any environmental similarity or uniformity of approach can yield a higher probability of success.

Reasoning environments

In any world, an underlying base of information exists from which people operate. Generally, this is called experience. In machine worlds, this is a data base of information, operating rules, patterns, formulas, heuristics, variables, and constants, as well as known case histories. In other words, this is a machine history from which reasoning can take place.

People take their own reasoning processes for granted and, when asked how they reached those decisions, usually have little or no idea. Reasoning is thus a mystery to most people. Logically, one cannot expect a machine to have a reasoning process when most humans do not.

This represents the heart of machine reasoning. For example, the sky is blue, except on overcast days when it is gray or at night when it is black. And then what color is the sky when it is snowing? This is hardly a challenge for a person to deduce, but what do machines know about snow? Certainly, some computers are programmed with information about snow, but is yours? The variables, options, and choices become too complex for machine processing very quickly.

Strategies for solutions

Within multiple reasoning environments, strategies exist for organizing all of the possible alternatives into viable solutions. For example, examine the patterns of a sales strategy or purchase order process, deduce by searching the data base if any occurrences exist, and present options. Another strategic option would be to perform a series of laboratory experiments or consumer tests to determine which particular customer group is most likely to buy the product. Other strategies include: games, flowcharts, analogies, known solutions, maps, charts, and guesses. Figure 2.1 is a graphic depiction of knowledge engineering development process.

At this point, the machine might not understand the problem, but it possesses the ability to input the problem and compare it within given environments from which possible solutions might or might not emerge. The "do-nothing" solution should always be considered as a viable option.

Learning

For an entity to grow, learning must take place to reinforce reality. Watching a product fail is a completely desirable means of gaining reasoning experience. The learning process is also a key to reinforcing such an activity; for example, finding a better searching scheme, a different kind of test, or a deductive approach. In certain cases, the process suggests an overall corporate management philosophy.

For example, most city councils and many nonprofit boards operate under

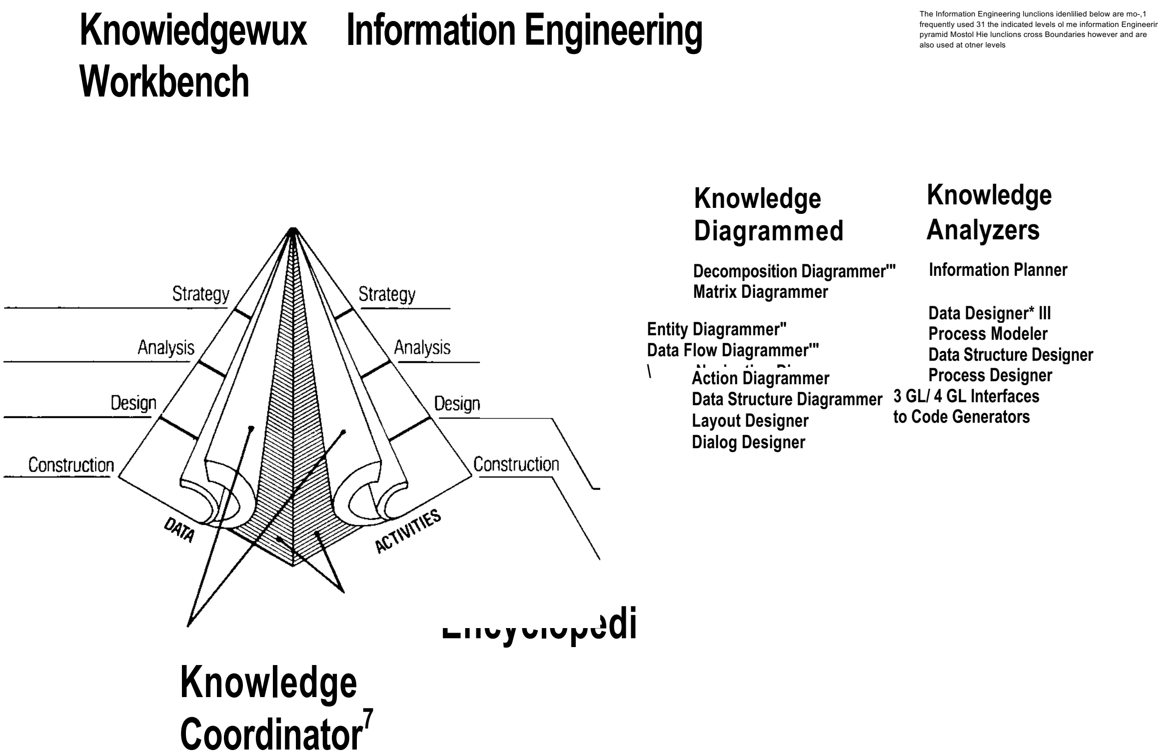

Figure 2.1 The strategic issues in a knowledge engineering process. Copyright © 1986, KnowledgeWare, Inc.

generally accepted rules of order. Many corporations should consider this standardization of rules as a means of organizing and processing complex and difficult problems, allowing for extensive reasoning, and creating viable solutions and strategies for solutions, all taking place within an agreed-upon process.

The learning process can also lead to future problems being solved at a faster rate. (Faster might not always be better, however, as a number of possible consequences can result.) For example, a system can simultaneously track similar problems and solutions, as well as refine existing methodologies, thereby lowering problem-solving costs. This process is often called feedback-feedforward, meaning improving old ways while allowing new ways to direct future activities. Few users of word processors would deny that these devices allow them substantial savings by not having to retype long boiler-plate documents just to change a few names or to correct typographical errors. The user is then free to concentrate efforts on new documents or grammatical or content improvements of old documents.

This same strategy can be applied to complex problem-solving, for example, using computer-aided design (CAD) to reduce design-to-completion cycles. Problem-solving can be automated like any other management activity, and this type of AI system will probably emerge in companies to supplement existing management's ability to expand the business without additional labor.

Guessing

In designing any AI system, there is a balance between using a hard approach, which takes the form of heuristics, algorithms, or other prepackaged material, and the soft approach, which involves hunches, guesses, or hearsay. The emphasis of many expert systems takes the form of rule-based phenomenon. Cold, calculated, known approaches appear to be the most successful strategies for expert systems. This is due to the need for precise and either logical or fact-supported experiences.

Training, as education, is a technology-transfer issue, where ambiguity in the communication channel is least desired. In other applications, ambiguity is a plus. Guesses can be necessary where few facts are known. Guessing can broaden the analysis, thereby allowing more options to be considered. In designing machine-based information structures, wild-card guessing features need to be an integral part of the architecture. The need for examining diversity rather than specificity exists as both an exciting and more efficient alternative to rule-based systems. Yet how is guessing to be designed into the consideration process? Various systems have various means for coping with hunches and guesses.

One approach is to provide a system with an electronic whiteboard similar to one I developed, named CROSS/POINT. This system allows ample opportunity to create what might be considered machine-based thought patterns. Each data element can be interconnected with any other data element and formed into a large-scale network. This is somewhat more sophisticated than a semantic network; however, there is a need to design systems that offer idea networks which are more automated as well as more self-sustaining and active upon themselves.

Expert systems take generally known facts and figures and organize them into congenial, interactive processes that can be queried by a student or user. Thought-processing systems offer the other end of the spectrum: a whiteboard that allows ideas to be noted, discarded, or linked together in any fashion desired, logical or not. Guessing might, in fact, come in either a logical or an illogical process.

It can be argued that many reasonably intelligent people already have enough expertise to perform at the level of most machine-based expert systems. However, it is in these high-level complex situations where a corresponding high-level expert system is needed that machine-based technology is most fragile or limiting. It is here that new approaches to expert systems are needed.

This kind of problem-solving might be more in the form of a facilitator than a provider of concrete solutions, which might create situations where guesses do not arise from the user but from the machine. The machine might be designed with guessing programs or guessing networks that allow users to have their thoughts probed in an attempt to gather necessary facts. Once gathered, these facts can form into a similar known solution that can be suggested to the user.

Guessing in this manner might be the most viable means of problem-solving. Rather than assuming a preconceived notion about the problem, machine-driven guessing can bring out the widest range of possible solutions. This system also has the interesting side effect of being able to catalog guessing sessions. This might give rise to analyzing guessing patterns that can become feedback to the user, or that can guide the user toward different guessing patterns than before. Moreover, it allows the user to explore more options than ever before. As with CAD systems, many different guessing situations can be simulated before selecting the desired solutions.

As guessing systems become sophisticated, many situations can be processed simultaneously, and beyond this, the guesses can be tested or simulated against one another. In other words, the machine plays against itself or other machines.

Guessing, hunches, and intuition are all necessary and dynamic means of human problem-solving using machine-based technology. For many, machine-generated guessing systems can offer creative solutions to problem-solving.

Practical Limits

Estimates for the digital storage capacity of the brain vary from 10^{12} to 10^{1S+}. Some estimates include the concept of redundancy (interconnection of neurons); thus, for practical consideration, there are far fewer bits of storage available. Of course, applying computer terminology to brain processing is somewhat ridiculous because they are altogether different systems. At present, computers process one or two activities at a time, but the brain is quite capable of great levels of multiple processing. However, such activity is handled much faster with a machine than with a human brain.

There are limits to the size of a human brain. This could change, of course, through evolution, but only over an extended period of time. Presently, there are millions of instructions per second (MIPS), millions of floating-point instructions per second (MFLOPS), parallel operations per second (POSPs, usually measured in millions), giga POSPs (GOPs), and others emerging every day. As a comparison, the human brain uses far less energy, is mobile, and can cope with an infinite (or nearly so) amount of ambiguity.

In defining practical limits, the issue is not whether a machine is smarter or faster than a human, but how machines and mankind can work together to solve problems and expand the human capability. Many theorists pit man against machine, but at this point, a cooperative approach is needed. Computers are often solely relegated to performing mindless tasks, such as processing tax forms, payroll checks, or other appliance-type activities, but there is an untapped gray area in which computers can be integrated with human activities to perform as "power tools" to extend humans beyond their present performance capability.

Children are fascinated by computers, toys, and robots because they do not have preconceived notions about the capabilities of these machines. They accept and tolerate the device for what it is and expect nothing more from it. Although it is not the same process to instruct a child as it is to instruct an intelligent machine, there are practical application limits with both. Although children get restless, bored, and are in constant need of amusement, while machines have no such needs, both are limited by the environments in which they operate. Without going into the physical limitations, each has an ability that is programmed into it—by nature in the case of the child, or man in the case of the machine. Each is capable of learning about the other, and each acts according to the limits of its environment.

Practical limits have more to do with the solving of existing problems than the expectation that a machine will converse like a human or that a human will act intelligently. At times, humans prefer machines, and machines would probably prefer themselves, too! British scientist Alan Turing defined the conflict standard that pits human being against computer, which is also setting practical limits of inquiry. Turing hoped that machines would eventually compete with humans in all intellectual fields. He might as well have argued that compassion and tolerance should be the first areas of development in machine intelligence.

As a paradox, problems, almost by definition, are limitless. There are no limits to existing or future problems, either anticipated or unanticipated (See the cartoon at the beginning of Chapter 8, *Future Trends in Knowledge Engineering)*. For example, all of the world's computing intelligence could not solve world hunger or the immense suffering caused by violence.

There might be limits to using machines to solve these problems, but from the research conducted in nearly every aspect of automation, when systems are applied in gathering sufficient data, solutions can be found. It is almost a truism that in understanding data, new approaches are needed to improve the comprehension of this information, whether in lowering costs or increasing performance. Moreover, at what point do you stop accumulating information? Are the limits in this sense the trivial, sublime, or often inconsequential bits of information that abound in the daily work place and throughout the universe?

The Systematic-Intuitive Approach

As the complexity of *a* problem increases to the point of abstraction, machine technology must share the same limitations as the human mind. Should a problem be approached by paring it down to its core, and then arranging the information associated with the problem according to how the core is analyzed? Should the layers of information be peeled back from the outside, thus exposing the core? To address this dilemma, the nature of information in process needs to be examined.

Channels of Distribution or Span of Control

As information flows, it accumulates, among other things,

- Speed
- Density

- Force
- Time
- Space

One of the areas worth discussing is the capturing of information at any moment in time and viewing it, if possible. Information in the mind of a person is only a glimpse of an ongoing process. Information in machines is static and moves only at the direction of a human. Consciousness thus offers radical viewpoints, depending on one's perspective. Information passes only in a moment, and its value changes as though it knows time is part of the process. What we want to create is a concept of information that fits both human and machine environments.

In a machine environment, it is as though the machine takes on human qualities and begins to understand some of the elements in order to be irrational enough to be humanlike. Humans must conquer themselves in order to create environments in which their activities are more competitive with machine systems. It is not a question of capturing human thought, but rather of reducing the noise and abstraction of life, if only to examine what abstraction really is. The question of control span or distribution channels has to do with the human ability to approach greater levels of abstraction simultaneously.

The span of control in the mind is complex. It is like a storm passing through various regions at random. Randomness is due to the origin of the problem being considered; it expands throughout the brain, depending on its span of control or channels of distribution. The span of control is quite an active framework with respect to the problem. The channels of distribution are the avenues the problem uses when traveling through the brain. The framework is like a storm (span), and the channels are the land over which it travels. The framework alters and changes course, depending on the complexity of the problem and its movements throughout the brain.

It is the approach of reverse AI or differential AI (DAI) that might provide greater clues into knowledge processing. As in adaptive differential pulse code modulation (ADPCM), the information is analyzed not from similarities but from differences between what was and what is.

It is quite possible that the mind takes the same approach toward information. It only reacts significantly if the information currently being received greatly surpasses previous information. The mind, in this sense, is only really interested when complex information models are created. Again, rather than conserving energy or mind-processing capability, the human brain creates more and more processing when it is excited. This is similiar to virtual memory in that the machine provides memory when needed.

The machine design focuses, however, on conserving energy rather than providing limitless capabilities of the mind to dream. The mind seeks out complexity rather than monotony. Designing a machine that deals with complexity and abstraction is a perplexing problem. Perhaps we cannot design such a machine. However, if we cannot, it will be difficult for existing machines to cope with people who are increasingly more complex. This is a catch-22 situation, with machines expected to be real experts while, at the same time, people or the problems become more and more complex than they were before such devices came into being in the first place.

Real Time: Can Machines Think?

Much of human behavior has nothing to do with time, and much of it deals solely *with* time. Time separates "now" from "then," and "now" from "when." It is generally accepted that there are day people, who work well during the daylight hours; and night people, who experience their best at night. Time is the structure that separates events into those occurring simultaneously and those taking place over an infinite spectrum of time. Much of brain activity takes place constantly, although activities also exist that have specific time requirements. This is the paradox of time.

For example, sleep generally takes place at night when one is tired; therefore, night might be a factor in triggering sleep. Yet, in another sense, the brain is active all the time in order to keep us alive during sleep. Thus, the brain is always operating in real time and is constantly at work. Machines, however, are generally at rest, except when called upon by humans to work.

There are many theories about this active sense of the brain at work, but little is known about how much work is actually being performed by the brain, with the possible exception of research into the understanding of dreams. It is this concept of dreams and their associated representational approach to the brain that is intriguing as a way to understand a larger view of behavior and thinking.

Various types of activities, from physical motor activities to speech and language, are all available spontaneously to humans. Humans can stand, sit, yell, or perform an infinite variety of functions without thinking about them. Essentially, the software or program behind these activities has been well written and debugged. What is not provided genetically, we program in ourselves.

In many areas, the program code is waiting to be written. Learning how to ski, write a sonnet, or fly an airplane is something that we program ourselves to do. These types of activities represent a step beyond the level of merely replacing an activity that is known with another that is unknown and communicated to us. Figure 2.2 shows some of the steps in a knowledge engineering system.

Under consideration is the issue of **real-time thinking.** One might ask, What is the comparison? There is a new genre of research that suggests that nonreal-time activity opens a new dimension in offering humans contemplative time. In fact, real-time communication is quite interruptive and even disruptive. This represents

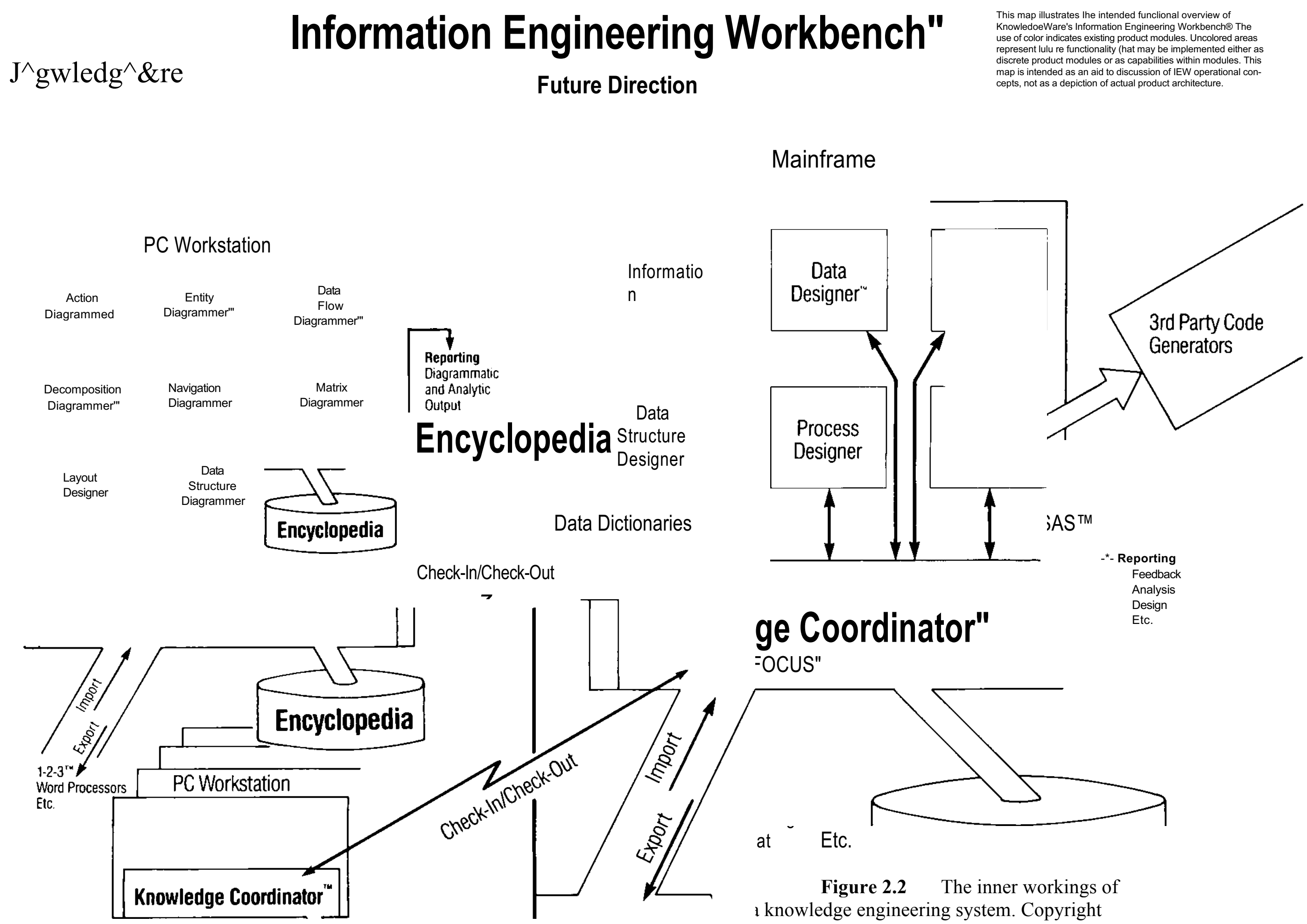

Figure 2.2 The inner workings of a knowledge engineering system. Copyright © 1986, KnowledgeWare, Inc.

a complex area of research; there are increasing arguments that humans might operate better in nonreal time than they do "live," although it is certainly difficult, if not impossible, to imagine football or any other sport taking place in nonreal time.

Yet the issue being discussed is thought and the thought process, with the question arising of how to design a machine that thinks. An examination of how we think might supply better answers for the design of a thinking machine. The cognitive behaviorist would be more excited about a better-thinking machine than a faster-processing machine.

It is fascinating to note the interest in nonreal time by theoreticians as the environments of real and nonreal time offer new views in the world of thinking and behavior. Few machines presently operate in real time, although the concept of foreground and background (performing one activity while you are doing something else) real-time processing is emerging quickly. In machine terms, nonreal-time processing takes place as background processing. The subconscious is sometimes associated with background processing, in some cases putting the real-time events into their own perspective.

Some say a dream is a representation of how the mind viewed the world that day. In effect, a dream is not what the person actually saw and experienced, but a delayed broadcast of what the mind perceived throughout the course of the day. This dream reality does not reflect how the conscious mind remembers the events, but rather how these events fit into a personal scheme of inner reality, a reality of which we might not be fully aware. In such a reality, time might be subjective, although very real in some personal sense.

Looking into real time and nonreal time can provide insight into how the mind views thought images in the midst of constant activity and then catalogs the images until the person is ready to act. Examining each of these still-life pictures and evaluating them is part of determining what thinking is. In other words, like oil paintings that depict real scenes in nonreal time, mental images are software systems, some constructed in real time and others in non-real time. Over periods of real time, these mental images process the past as well as imagine the future.

Language and Perceptual Models

In developing systems that interact with the real world, the use of models is a common ground where ideas, theories, and devices can be tested, usually without harm to people or objects. However, the difficulty with developing thinking models is that there are few trustworthy models with which to test the "real" world. As is often the case, models of future events or new inventions have few commonly accepted terms or conditions.

In fact, language often fails to come to grips with new concepts. Consequently, language becomes too complex for the lay person to understand, and a technocratic language emerges for discussing the new technology. In general, the language of perception is also limiting. There are few accepted approaches to the development of experimental activities. In this sense, language reflects the evolution of ideas away from reality.

Perceptual models for machines can be possible if the process of communication between human being and machine can be designed to minimize error and maximize experience. How would these systems emerge, and how could they be used for such sophisticated activities as thinking for themselves?

A better understanding of language is a first step toward such development. One of the underlying assumptions is that language becomes experimental and individual. There is no basis for a single universal grammar or alphabet. As systems become complex, they develop their own way of experiencing the world. Machines interact with one another in increasingly defined and unique ways. As devices seek higher levels of interaction, there become more unique means for determining a hierarchy of that interaction. Master chess players can test one another in only a few words, a demonstration of body language, or some other frame of reference. This type of interaction is generally more limited by language than enhanced by it. Language is only a medium to support a limited form of activity, and often fails to describe the nearly infinite variety of activity taking place.

Language becomes difficult to use in the development of sophisticated experimental models. Certainly language has a wide range of practical applications. However, futility follows from the assumption that it can be used or even developed in a universal way.

For example, there is probably an infinite variety of uses for the color red and, in combination with green, an infinite possibility of variation. Is this infinite times infinite or infinite^2? Moreover, this does not explain our feelings about red or green, which can expand the possibilities even more.

To take the opposite approach and assume that language provides only a cataloging process makes more sense. For example, I have more words than you, or you used fewer words to provide a perceptual model for falling rain. Or your model of falling rain nearly reflects the behavior of water under gravitational stress or pull, or your holographic simulation captures the physical and experimental activities of water but lacks the reflective qualities that light exhibits in this activity. In other words, one wins technically but fails emotionally to understand the event. Dr. Mark Zimmermann, a computer scientist, reminds us that "poetry may be an optimum means of communication using language as the transmission medium."

Currently, we stand at the modeling equivalent of the beginning of biological time. Our ability to model is almost as primitive as the single-celled creature is in comparison to fully evolved humankind. In this sense, language is at the stage at which this simple creature can barely cope with its environment, much less evolve into a higher species.

The concept of universal machines for solving universal problems seems on the surface to be a desirable goal. Much has been written in support of this approach, but there is strong evidence that a very different approach might be closer to the way life really is. Although the brain has certain areas devoted to specific functions, evidence is accumulating that memory seems to be everywhere; that is, the mind takes a distributed approach to memory. The mind makes connections in life not just by a single approach, but in a complex, distributed way. It places ideas, concepts, and models in many areas, forming complex associations. This allows experts to recognize one another by only a glance or a gesture of speech.

The development of perceptual models is critical to advancing the development of machine technology to a higher level. However, because of limitations similar to those associated with our own language, new approaches are needed to allow this development to take place.

Understanding

Much of what we call meaning is an internal translation of information into a definition that fits with our view of the world. To say, "I understand," requires an enormous background of feelings, thoughts, emotions, and data. Moreover, all this has to be organized in a manner that makes sense. In many cases, the computer scientist's view is to say that it is basically a computational model where the scene and the players change, but the underlying elements are the same. These elements are models, formulas, and rules that can be preprogrammed.

Understanding might be more than the mere conveyance of words from one individual to another. One might want to approach the problem from the viewpoint of the sender rather than that of the receiver. What were the sender's intentions or meanings behind the words? Is there a context in which I need to know the background before I can understand?

In "A Computer Scientist's View of Meaning," Daniel Keysen indicates that there is no actual point of understanding per se. There is "no clear-cut criterion between a state where the message is *not* understood and a state where it /'s understood."[5] The need is to be able to know definitively, beyond the technical communication itself, that the receiver can act upon the message sent. Keysen provides four examples:

- Ask the sender to repeat the message. Any type of recorder could perform this function flawlessly.
- Provide paraphrases. Skillful story-writing programs could provide an adequate rearrangement in order to satisfy this requirement.
- Respond through some act or activity. Again, a computer could be programmed in order to deduce the desired function. Keyser notes that "several

messages may correspond to a single action, and many messages correspond to none."

- Use tests to understand. Testing could measure the ability of the receiver to retrieve information and then act appropriately.

The computer scientist is faced with a complex philosophical dilemma similar to Goedel's theorem that some propositions can neither be proved or disproved. The criteria for understanding might be rather in the area of having the appropriate response, depending on the context or condition. For example, just because you call the fire department does not mean that your house is on fire. Just because you are hungry does not mean that you will eat stale bread. And so on.

Much of the computer modeling that is performed has to do with the designing of products (cars, chairs, buildings). The computer in this context is not asked, required, nor desired to understand the meaning or purpose of the activity; it merely responds.

Summary

Throughout this chapter we have focused on many of the dilemmas that face the development of knowledge engineering systems. While machines become smarter and smarter, so it seems, do the problems encountered that need solutions. At the same time, the knowledge engineering industry often professes to be able to solve even the most formidable problems. The executive faced with the development or use of such systems must be "real" about what these systems are capable of now and in the future.

Endnotes

1. John M. Keynes. *General Theory of Employment, Interest and Money.* New York: Harcourt Brace Jovanovich, 1965, p. 210.
2. Nicholas Palmer. *The Comprehensive Guide to Board Wargaming.* New York: McGraw-Hill, 1979, p. 17.
3. Ibid., p. 33.
4. Hermann Hesse. *The Glass Bead Game.* New York: Holt Rinehart & Winston, first translation 1969, p. 273.
5. David Keysen. "A Computer Scientist's View of Meaning." *The Mind and the Machine.* West Sussex, England: Ellis Horwood Limited; New York: Halsted Press, 1984, p. 172.

Chapter

3

Expert Systems

Introduction

In simple terms, an **expert system** (ES) is a computer program or system that organizes knowledge within rules or procedures to solve problems for a particular problem or task. If properly designed and maintained, an expert system can perform at or near the level of a human expert. The key issue is that an expert system is a machine. Current systems often have the constraints of the background and limitations of its creator-designer, and the skill and knowledge of the person who uses it. Presently most expert systems fail because (1) they require too much expertise from the user—it takes an expert to use an expert system—or (2) they solve only certain classes of problems—help you make chicken gumbo soup but not cream of chicken soup.

An expert system must have a diverse background reference to be effective, as opposed to an incredible ability to be efficient. Expert systems reflect the rule-based side of decision-making; mathematical models, formulas, algorithms, and heuristics can easily be applied, allowing expert systems to be developed and efficiently utilized. Where management or office procedures dictate a certain realm of finite possibilities to the decision makers, an expert system can be a vital management tool.

Expert systems are more like productivity aids than truly intelligent software systems. They are tools that help managers improve the flow of information. These computer-assisted "power tools" provide an effective means for improving understanding, problem-solving, or decision-making. These capabilities suggest that a wide range of expert systems will be developed to guide clerks using payroll systems, help engineers with design, and aid doctors in diagnosis. A manager might also use such a tool to develop new models for organizational development, training, and policy analysis.

The July 1986 issue of *Computerworld* lists 17 expert systems "worth the cost" of development. These systems service the areas of business, computing, engineering, finance, geology, manufacturing, medicine, resource management, and science. The expert systems did everything from providing estate planning and investment advice to selecting auditing procedures, configuring computers, diagnosing infectious diseases, and assessing problems with oil wells.

In comparing expert systems with other knowledge technologies, the term "expert system" is used to describe rule-based technologies where the information is packaged or premixed. The term **knowledge network** is used to describe a network of people in a thought-processing system. There are writers who use knowledge engineers synonymously with expert system engineers.

To define a point of reference and to signify the role of people in the process and the resulting differences, **knowledge networking** refers to human-based activities. This is not to say that expert systems are nonhuman. The difference is subtle. In an expert system, experts program their knowledge into a computer.

There are extensive applications for this type of system in business and industry (see the following). In many instances, an expert system can save thousands of dollars by training a new worker, performing tasks that can solve a factory floor problem, or preventing a nuclear power plant from going down.

What if?

An editorial in a 1985 issue of *PROTO,* an AT&T Network Systems Group newsletter, posed the following question:

> "What if you could make an automobile engine that could do four times the work but run on half the fuel at the same cost as an engine of approximately the same dimension?
>
> Which of the following would you do?
>
> - Build a car that would go faster.
> - Build a car that would go farther.
> - Build a car that would carry bigger loads.
> - Build a car with lots more power accesories.
> - Do all of the above . . . and then some."[1]

If you could make such an engine, you might want do to all these things and revolutionize the automotive industry. However, this particular hypothesis is not likely to be road-tested because of the boundaries of mechanical engineering and the limitations of the internal combustion engine. A problem with so many value-loaded, subjective possibilities might not be appropriate for an expert system to consider.

Certainly, scale is a factor in applying expert systems. That is, the size of the problem determines whether it should be solved by an expert system. Some problems are so large or so complex that it will be years before computer technology can process the information in an acceptable amount of time. Time is also a factor. Waiting 24 hours for a weather report is no help to a ship caught in a hurricane. Complex situations or "what if" problems—for example, the boiler temperature rises beyond the normal range; how can we lower our costs?; what should I do under these circumstances?—are valid issues for an expert system.

One of the most common criticisms of some expert systems is their lack of sufficient real-life experience in task management, problem-solving, or decision-making. In addition, many such systems are hardly more than advanced data base management systems (DBMS). With the use of such programming languages as LISP and Prolog, these systems aid in the development of expert systems. As noted in Chapter 2, *Issues in Knowledge Engineering,* users have widely varying needs and applications for expert systems. Even in well-known systems that were developed for medical applications or sales-ordering processes, quantifying management tasks is a complex, if not impossible problem.

Because management decision-making follows few rules, expert systems are generally used in situations where tedious and repetitious tasks produce human error. Such errors often happen with disastrous results in medical or sales-ordering applications. In other, complex applications, the process goes beyond simple commands and rule assignments. Activities where thousands of dollars are at stake in managing certain tasks might justify the cost of developing an expert system.

Most expert systems, in fact most software programs, are designed by relatively few people. Certainly, it can be argued that committee decision-making is less than perfect. Yet developed or well-considered decisions more often emerge from committees than from single experts.

There are numerous examples of corporate policies and procedures that can be automated. Handling, executing, or designing functions might include sales-ordering procedures, travel voucher processing, purchase order management, management approvals, telephone allocations, room size as a function of management position, and rules concerning the use of the executive dining room. The underlying key to designing successful expert systems is the ability to have and maintain sufficient rules and procedures that can then be used in a timely manner.

The present state of increasingly complex management problems justifies the development of the expert system; the need to update or maintain these rules warrants the ongoing maintenance and use of such systems. Expert systems are most viable (1) within narrowly defined parameters, (2) have a long historical basis within the organization, (3) are least likely to change in the foreseeable future, and (4) can easily be updated.

The successful expert systems are those which are used constantly and thus checked for error, redundancy, and task-solving capability. Just as it is important for a system to capture the thoughts of a genius, it is equally important that it be able to change or delete the knowledge as it evolves or is proven wrong.

Expert Torque

An expert system's value is measured in many ways. For example, the smoke test evaluates, Can I solve my problem or make a better decision with the help of a "whizbang" expert system, or can I do it faster and better myself? Time is the pressure point here, as it is in most instances. Anyone who has reached a certain level of experience in his or her occupation can make decisions rapidly and with a high degree of confidence. By focusing on the point of use rather than on the scope of the decision-making, expert systems are viable tools for business. Any person, whether a wine merchant, telecommunications network engineer, lawyer, or doctor, can pinpoint and solve specific problems in a moment. This is certainly the beauty of the mind. For example, a firefighter doesn't have time to ponder a wide range of options when he arrives at a fire site. An expert system can prepare the firefighter beforehand to take appropriate action at the fire.

The following is a brief analysis of various forms of computer-assisted management power tools that are being developed:

- Known-decision tools provide users with step-by-step methods and directions for making decisions when the correct decision is possible.
- Gathering tools provide users with names, numbers, codes, and words to organize documents, thoughts, and so on.
- Training tools provide users with step-by-step methods to follow when decisions are not required.
- Wild-card decision tools provide users with a step-by-step method and some criteria for making necessary decisions when the correct decision is not always possible.

This list only suggests that these functions will eventually be computerized. The fields of artificial intelligence (AI), expert systems, and productivity aids (PA) will develop rapidly as management's needs are recognized as critical to the planning and operation process.

Standards

Standards is one of the numerous issues in the knowledge engineering (KE) field that has received little attention. Standards might not be required in a system except where expert systems are networked together with other similar or dissimilar systems between plants or offices. However, the issue of standards in regard to decision-making cannot be underestimated. The more accepted a standard becomes, the more it is used. This applies to all industries, from manufacturers of soup cans to carpenter nails. It is particularly true in technical industries such as local area networks (LANs), electronic mail, telecommunications networks, and computer operating systems. Furthermore, the faster standards emerge, the more quickly society in general can utilize the technology.

The electronic mail X.400 standard is an approach to developing methodologies for communications systems that applies to expert systems as well. Essentially, X.400 is a transport system whereby messages are packaged in standard ways, moved to distant locations, then unpackaged to suit the receiving party. The standard is not concerned with the content of the message transmitted. Like an automobile highway, it is indifferent to the type of car that is driven on it. One of the long-term goals of the standard is to interconnect different electronic mail systems. Given the architecture of the X.400 standard, it could also be used to interconnect expert systems. Much of the knowledge could be packaged for transmission from one expert system to another. In a global context, systems will range from small-scale PC-based expert systems to large mainframe expert systems, including international systems addressing global issues. The concept of an expert system or AI standard will eventually help speed the development and the library, or base, of information that experts can draw upon.

Within each expert system, there is a base of knowledge that can be shared. This would be useful in most professions where the work activity is similar. For example, weather experts around the world could test and model their own expert systems as well as teach weather concepts to students, compare models, and gather information. The information that is transferred from one knowledge system (whether artificial intelligence, expert system, or other technology) to another might be in the form of digital data, analog voice, digital video, and other technology currently in existence.

In the X.400 series standard, there are a number of key elements that apply to an expert system environment. A wide range of information can be transferred, and it is possible to interconnect similar knowledge systems using the X.400 standard. However, overlying data (goods) in the appropriate format (boxes) with standard templates (boxcars) is a difficult technical problem for interconnecting different systems. This suggests that expert systems should be designed for connection and communication to other expert systems.

Inference, Reasoning, and Knowledge Acquisition

There is another level of interface beyond the point where the machine controls, manages, and processes data. On this level, the machine operates on other processes and can be called the **inference engine.** The inference engine is essentially the "assumptions" or "reasons" software that provides much of the machine's information processing. In human terms, the inference engine can be compared to the involuntary nervous system that keeps a heart beating, digests food, and automatically performs a myriad of other functions without the mind consciously thinking about them.

The human software required for these automatic functions has evolved over millions of years. Duplication of these processes is the challenge undertaken by today's computer scientists. That is, they are striving to develop systems that perform a myriad of functions intelligently without the need for constant human support. (See Figure 3.1 for an example of a system designed to help people develop an expert system.) Mental functions such as problem-solving and decision-making will require advanced software because of the often ill-defined or changing nature of tasks such as creative thinking.

Game theory, such as in Monopoly or video war simulations, can be a useful tool in developing systems that allow for solving larger problems or managing detailed projects. Inference engines need to be developed within a behavioral framework. One approach is to develop systems that "learn" about the user-player and begin to solve problems in "their" way, rather than to solve problems in the traditional linear process.

Most expert systems are like very young children. The basic building blocks are there: the muscles, neural networks, and mental management resource support. Data are assimilated at a rapid rate, and the mental processes react and are capable of acting at an ever-increasing rate on their own. Networking of data by the brain organizes the child's words, actions, and emotions into speech and movement. It is a network approach that makes this work.

Any human activity depends upon coordination of many muscles and muscle groups. This is one type of human "knowledge system." Each person's knowledge system or personality forms the basis for their approach to the world around them. As has been demonstrated, often dramatically, a key person such as Lee Iacocca or Gandhi can change the entire scope and purpose of an organization or country.

Generally, an expert within a company falls into the same domain as the key player or leader of some specific activity. At one level within a company, an

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Figure 3.1 Personal Consultant Easy is designed for people who are just getting started on expert systems. Photograph courtesy of Texas Instruments.

engineer works in a research lab to solve complex technical problems. In contrast, the company president manages and coordinates organizational policies as well as determines long-range planning. The base of knowledge for each of these activities is quite different, as are the rules by which they operate. The inference needs of these users are, therefore, greatly different. A company scientist might operate in the realm of the laws of nature, whereas the organization's president might operate under human laws.

The winning plan or outcome of an activity might be evident far more rapidly when a purchase order is approved than when a general manager decides to update the company's employment opportunity policies and project the number of women who will become executives over a five-year period. See Figure 3.2 for an example of the numerous outcomes of even a simple task. In the latter instance, trend patterns, subjective gut feelings, and middle-management attitudes toward women can be the key interface issues available. Inference stategies alter the outcome or play of this game.

The quantity and quality of knowledge needed are also different. With product testing, lifetimes of information on failure rate, mean time to soft failure, or critical failure (life-and-death issues) require different methodologies for consideration and development. In contrast, in a knowledge networking (KN) system where humans interact with one another, the user determines both the relative and absolute values of the information because the data have been digested by people. Many expert systems are often a fancy data base of facts or figures.

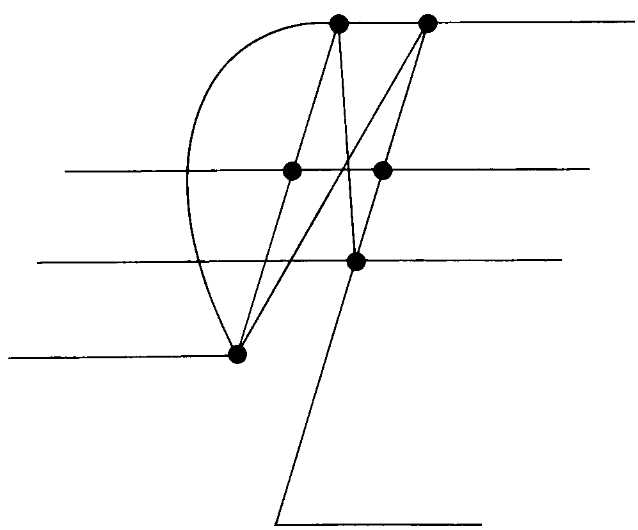

Figure 3.2 An example of management options for steps in processing orders or allocating staff. There are over 600 possible combinations posed by six major choices.

Harvesting Expertise

Experts rarely disseminate all of their knowledge to other people. Increasingly in the information age, expertise is the only product that a consultant or executive might have to sell. Teachers and university professors are reluctant to use advanced technologies because doing so might diminish their salaries. For example, few professors use electronic meeting technologies to distribute their lectures electronically. Information packaged in the form of books, records, and tapes does not generally reflect the scope and nature of expertise. In simple terms, an expert system is another packaging process. Yet, as society becomes increasingly complex, the need for rapid decision-making increases.

Where technology is the driving factor, expert systems might give one company a competitive advantage over another. Companies are using technology to reduce travel time, improve decision-making, enhance communication, and reduce other management costs. A complex decision by the United States Army was reduced in decision-making time from two weeks to two days through the use of computer communications. There is no question that companies are becoming technology-driven.

In essence, the harvesting and packaging of information must have some commonly understood concepts in order to be effective. This is one of the inherent limitations of information: There is little or no known standard for its construction and content. Certainly, sentence grammar and the alphabet impose definite rules on English usage, but few rules or standards apply to the content of the information.

Robert T. Fertig, an AI consultant, notes that

> an expert system manipulates the substance of knowledge. It took computer scientists many years to figure out how to write down knowledge. The challenge was similar to that of finding a choreographic language to write down dance steps. The basic substance was familiar, but how to document it was not so obvious. An expert system thus contains knowledge bases which were built up over the life of the system.[2]

Whether knowledge can be packaged like canned goods remains to be seen. Each kind of contribution might have its own distinct dance step that applies to particular types of work. However, successful new cookbooks are published each year, so we should remember that problem-solving, like collecting recipes, knows no bounds. The process of deciding whether to employ an expert system involves many of the same steps as designing the system itself.

Information gathering can take place through a data base management system. The first step is to analyze the information, keeping in mind the user's needs or problems to be solved. When a decision can be made more quickly by a human than a system, why automate a particular function? Therefore, a healthy, skeptical approach should be taken when an organization decides to build or buy an expert system. Does the system really solve specific problems or just general problems? Beyond critically viewing such a project, a company must also consider the scope of the project, including the tedious, routine tasks that are usually labor-intensive and often require extensive communications to be understood, much less acted upon.

Heuristics and Mathematical Models

Models have certain key elements; one example presented by Oskar Morgenstern consists of four requirements. First, a model should necessarily reflect or be "similar" to reality. The key words here are reality and similarity. In some cases, reality is only a subjective condition, as is the case with mathematics and economics. "Similar" can also refer to artificial environments that have no sense of reality.

Second, the model should be free of inner contradictions. Here, heuristics (rules of thumb), axioms (laws), and concrete logic are essential to allow the player maximum freedom within a given and known set of parameters (for example, chess or Monopoly). This freedom gives rise to the ability for adequate testing of a new product or service, such as nuclear weapons, prior to actual use. The problem: How can you know all of the conditions of a product, service, or game without actually using it or playing it to see if the rules are fair and true?

Third, a model must be neither too complex nor too simple. It must offer a challenge but not overwhelm or intimidate the players so that they cannot play the game effectively. This also suggests, though it does not imply, that tools might be desirable or necessary in certain games to allow one player the maximum advantage over the other player(s), or over the game itself. Moreover, weapons or user strategies such as bargaining or cheating often make games enjoyable or inspiring in an emotional sense.

The last element is the ability to compute, or the need to establish the rules as nearly absolute. In essence, the processing is workable, though not necessarily by computer, to derive meaningful outcomes. The focus on the ability to compute is founded in the need to establish factual reality or the validity of the assumptions. In many cases, these heuristic models are difficult to quantify, much less design within workable systems. In addition, there are laws that are valid under certain and sometimes absurd conditions. The problem then becomes knowing when to use these rules, if at all.[3]

As has often been observed in natural evolution, gaps and disturbances appear between even two successive generations of animals. This is, in part, because evolution does not always take the best solution; rather, it takes the first solution that rolls along and fits the opening, which can produce side effects. These conflicts, particularly in computer programming, often result in system failure, inconsistent computer responses, or, in the worst case, in lost files or information.

Nature has a cruel but efficient means of eliminating its mistakes: extinction. Because the development of the computer is still in its early stages, there has been little need for extinction, until now. As higher-level operating systems emerge and indications of newer and more powerful languages arise, it becomes necessary to phase out older programs.

Older computer programs often cost more to maintain than new programming developments. Moreover, the key to complex systems is in developing them so that they can solve new as well as old problems. Systems need to evolve or become extinct. For this reason alone, it is critical to either abandon or improve old systems. The situation is quite imposing on the development process. As N. M. Asomov in *Modeling of Thinking and the Mind* so aptly notes:

> Complex systems with great capacity for self-organization can execute the same general programs by different means. Complexity is not merely the quantity and diversity of elements and subsystems constituting a system, but the diversity and complexity of programs of behavior as well.[4]

This diversity of systems is another reason why expert systems will evolve in many directions. Some systems will solve specific problems, and others will solve diverse problems. Modeling can take place at any stage of expert system development. In simple systems, reactive devices respond to changing environmental requirements, just as thermostats react to changes in temperature. Other systems provide us with deductive reasoning, and still others are **intuitive** and rules cannot exist. In Asomov's terms, "the purpose of the brain is quite diverse." As yet, it is impossible to imagine all aspects of an expert system's future utilization. However, here are a few ideas:

Technological mechanisms can be created that can replace humans to varying degrees. These mechanisms might be robots suitable for hard physical labor and the control of other machines, or machines intended to control human behavior in the sphere of economics.[5] Asomov compares the reactive systems both in machines and humans. This **reverse order,** which is based on the machine being a clone of humankind, fundamentally changes our view and approach to machine technology. Since the dawn of machines, they have been described in terms of enhancing human ability, accelerating human influence over space, and changing human perception of time.

Machine-human environments

Because of the profound impact changing time is having on global management, a new approach to management is taking place. A machine creates a different structure and order of thinking and forces management activity to move from a real-time to a nonreal-time environment. Consequently, management is now effectively controlling and managing time by moving from synchronous (immediate) to asynchronous (contemplative) activity. This change causes our thinking to approach the problem from a new and completely different perspective. For many years, human beings thought air flight would evolve from designing machines that worked like birds, but air flight was developed using a completely different approach to the problem.

In this sense, machine-human environments have an opportunity for even more profound change. Examples of this are rapidly becoming evident as artificial body organs and computer chips are being developed to control disease. Computers that aid and assist humans offer countless opportunities for curing diseases and enabling the disabled to walk, talk, see, and hear. They are also useful in applications with plant and human genetics.

Humans can be perceived as machines of a sort, having been designed and built from the useful and commonly available resources found on our planet. The belief has also existed that animals are nothing more than machines, incapable of feelings, and, therefore, incapable of perceiving mistreatment. If we were to design a system to have certain abilities, such as to perform tedious tasks or to work in totally uninhabitable environments, that system would be designed specifically for the task at hand. By using computer-aided design (CAD) machines, we might be able to design a device in less time that would specifically fit a niche and perform more efficiently than Mother Nature could. We would not wait for the fittest to develop; our Darwinist selection is predetermined at the keyboard.

Heuristic models and programs of the mind

Another of Asomov's factors involves heuristic models to investigate hypotheses concerning programs of the mind. These include programs that would study the mechanisms of mental disorder in search of treatment methods. The adage "Necessity is the mother of invention" means more than that creation arises out of need. It also means that needs require action to mitigate the problems which cause them.

Heuristics are extremely valuable if linear thinking is possible. However, heuristic frailty often results from diseases, decisions, or other issues that are too narrowly focused. Unlike even simple problems like ordering lunch, which may have thousands of choices, these types of problems cannot be solved by merely entering key instructions or commands and receiving a printout recommending the action to be taken. Moreover, when problems are simple, a child can often deduce the answer in less time than a computer.

Heuristics are best used when the decision-making process requires the elimination of extraneous information. This process of elimination leads to the solution: Colonel Mustard killed Mrs. Plum with the candlestick in the library (as in the crime-scene game Clue). However, the lateral side of thinking has been described as similar to a cocktail party. Here, information is gathered and dispersed randomly. Another approach might be the vertical or data base approach, which places more importance on the chain of events leading up to the decision than on the decision itself.

Long ago, humans developed rudimentary technologies that portrayed decision-making in business and daily life. Many of these technologies were visual, such as drawings, hieroglyphics, and sculpture. In their design, these constructions reflected the structure and order of organizations and provided the groundwork for a history of the times. (See Figure 3.3 for an example of a system designed to help prototype or create an expert system.) Each of these technologies also had certain attributes that more or less reflected the process.

In modeling, one of the many issues is the ability of the model to reflect precisely or, in some cases, not reflect the original design or concept at hand. In present computer modeling, such as CAD systems, precision and design are reflected graphically and have underlying mathematical models as the support structure. Simple models generally reflect limited design issues. However, as the complexity of the models increases, the level of design interconnection increases as well.

The mind reflects the same modeling issues and levels of complexity. Yet the difficulty of modeling the mind lies in a number of factors, which include tools, error, limits of design, and application. Such weaknesses bring up underlying and fundamental structural issues. For example, one of the most frequent comparisons of mind versus computer is that, although the computer is much quicker and

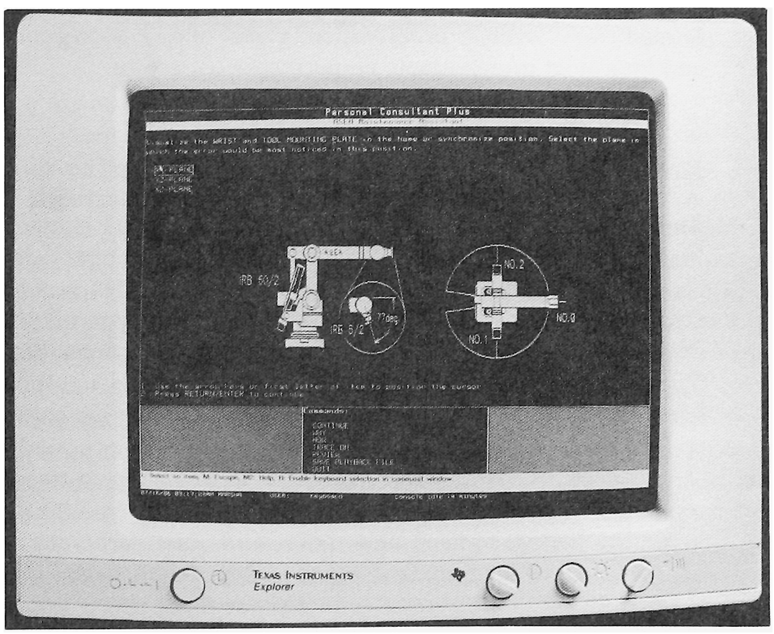

Figure 3.3 For sophisticated users. Personal Consultant for the Explorer takes advantage of the extensive common **LISP** environment. Photograph courtesy of Texas Instruments.

unyieldingly accurate, unlike the mind it has no imagination, tolerance, or desire for ambiguity in its processing. Moreover, at present and probably for some time to come, it is difficult for computers to process more than one issue simultaneously.

Conceptual models, such as three-dimensional graphics, allow the viewer to see the concept from as many perspectives as needed to solve the problem or make a decision. Visual models enhance the written description, not necessarily in the quantitative but in the qualitative sense.

The written word is similar to mathematical models in its ability to definitively capture the issues at hand. Sentence structure is a precise method for organizing and thus communicating information in a commonly accepted and understandable manner. Visualization systems embrace the expression of the relationship of issues as well as the form and art of communication and messages. This method is less precise because it allows and encourages issues to be discussed in as many different forms as possible. For example, mathematical or heuristic models are not easily understood as long as they remain in a conceptual framework because only a physical model or construction represents the reality we know. The inherent problem in moving from the industrial age to the information age is that the models are numeric or computational rather than physical. Laboratory tools have changed in many ways because models can only be created inside of a machine rather than on a workman's bench. The need for large-scale, organized expert systems is the next step. They can provide solutions to very large problems, such as balanced foreign trade, nuclear proliferation, global telecommunications network standards, and improved multinational corporate management.

Data Base Management Formats

The concept and organization of information or data elements is fundamental to a management environment, even if that environment is not computerized. A data base or **data base management system (DBMS)** is the organization of those elements (data) contained within a place (base) or structure (library). Definitions referring to the nature and structure of the informational elements abound. Typically, they are called **records.** These can be subdivided into even smaller areas, sometimes called fields or data attributes. Super records can be called **files** or **libraries,** and contain many different areas of information.

As various data bases expand within an organization, there is a natural tendency to combine these systems, such as combining personnel files with inventory lists, telephone directories, and other corporate records. For reasons of economy, as well as access, security, and accuracy, the issue has become one of maintaining each element or record in one place rather than having them scattered over many places or even in different computers.

For these same reasons, these systems have also failed. Personal computers have only served to fuel the fire by allowing users to maintain data in their own computers without regard to other departments, locations, or the corporate information structure.

The design of a data base system is another issue that can be critical to getting information in, out, or through advanced knowledge engineering systems such as expert or AI systems. At present, there are three fundamental data base design methodologies: network, hierarchical, and relational.

- Network systems allow information to be networked in a vast number of ways, although a large number of connections can be too complex. Network and hierarchical systems are tree-trunk systems. The systems vary in their ability to move the user from one branch to another throughout the system; as in thought-processing systems, one-to-one, one-to-many, many-to-one, and many-to-many configurations can occur. It is this linking, interweaving, or networking of records that can confuse the designer. Important elements in the process include flexibility, the ability to search, the integration of new records, and the accommodation of new levels of data relation.
- Hierarchical systems offer a top-down, layered approach, like a cake. Getting from the top down or from the bottom up can be relatively easy, but adding layers can mean baking a new cake.
- Relational systems are like a housing development designed with rows and columns. It can be easy to modify such structures, but it is a slow process to search through them.

Figure 3.4 provides a graphic example of various data base systems.

Each of these systems represents an approach to inputting or gathering data as well as processing, printing, or presenting it. The different types are various attempts at balancing software and hardware. Data are stored on a disk or other media. It is the software that allows the access and manipulation which is at issue here. Older DBMS systems were closely aligned to the physical hardware that was used. Most current DBMS systems offer some machine independence: They are easier to transport, and as the uses become increasingly complex, the systems are becoming faster and more versatile. The trend is clearly toward independent systems. Thus, future data management system designs might take on new forms to accommodate new data types, including video, graphics, images, and symbols.

In expert system environments, efficient retrieval capability depends on the type of data management system that is used. It should be noted that redesigning a system to accommodate new kinds of information can nullify expert information content.

In considering future data management systems, an infinite matrix multidimensional system is expected to emerge that will offer a mindlike capability, though not necessarily as powerful as the mind. The mind currently offers a fast-retrieval data management system. In the blink of an eye, it can remember the name of a person one hasn't seen in ten years, as well as forget what you ate for breakfast.

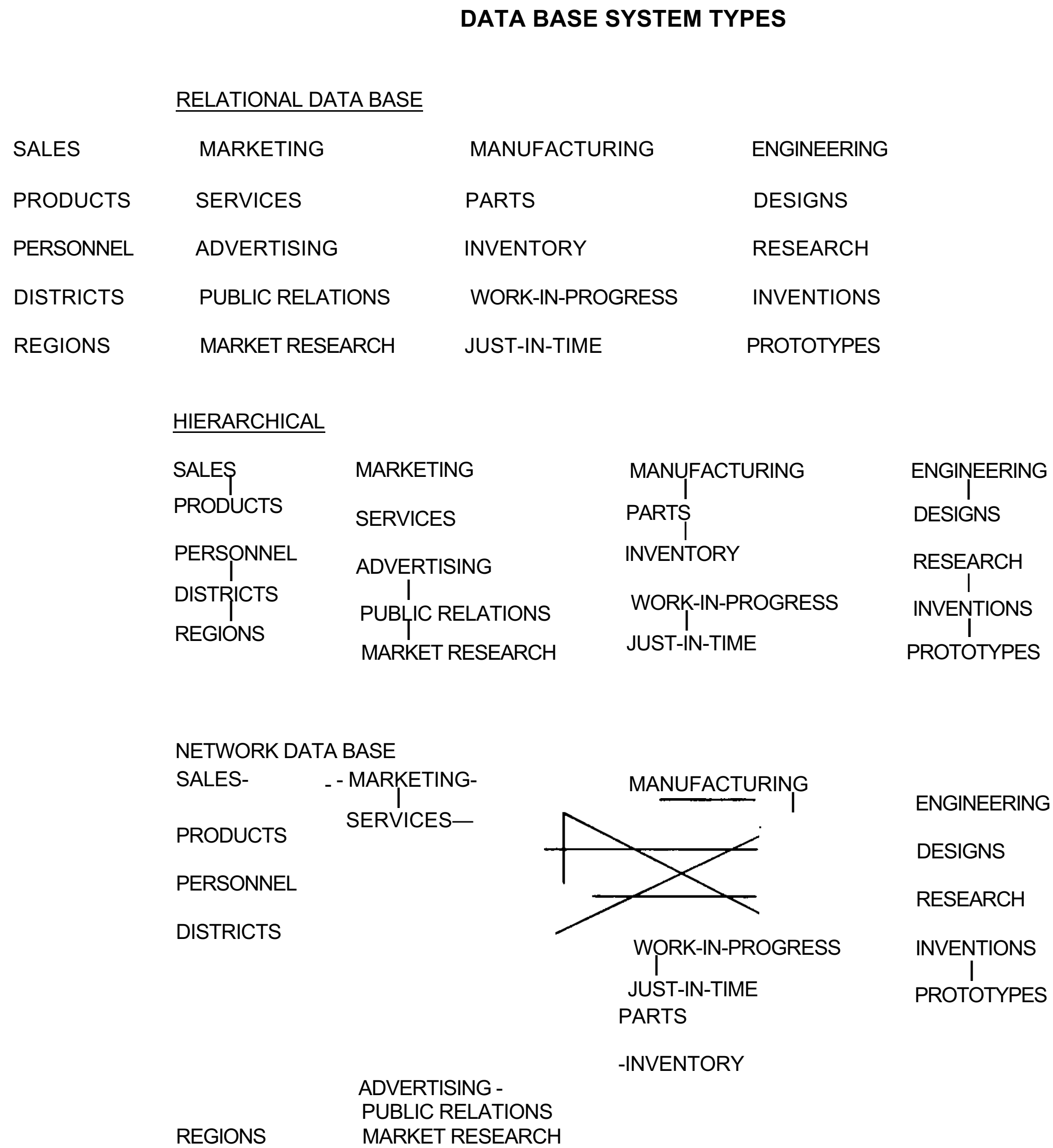

Figure 3.4 Various examples of data base management systems

Machine technology can be effective and appropriate for managing inventory, payroll, and airline reservations, where sheer size is necessary to accomplish the task. Design concepts are presently emerging wherein each data element (reservation, name, and so on) is relatively independent and, as required, can be easily reconfigured by the user into new relationships.

Data management design is running parallel with the creation of inference and interface environments, which are becoming increasingly complex as a vast body of information grows. At the same time, the means of communicating information to the user is changing. Data management systems are using English or the new generation of natural language to communicate with the user. This will eventually allow users to move beyond computer language commands to simple words and the construction of complicated sentences that request specific information. When users can finally link sentences into paragraphs (or even stories), they will develop a total conceptual approach to information gathering. Incorporating this approach into expert systems will make them far more definitive and allow them to function like the individual expert in understanding the changing world.

Parsing

Parsing means to break down a sentence so that it can be better understood as a whole. At issue in machine intelligence systems is the amount of communication necessary for a thought to be transmitted and understood by the recipient before an action is taken or a decision is made. Some theorists suggest that in human communication a cultural element is transmitted along with the language, which gives information a contextual importance. This suggests that the context is a template or an overlay of communication (box), and language is only its transport vehicle (boxcar). In a sense, AI systems, which rely on language rather than context, fall into this trap. Moreover, language can be more critical in a technical sense than in a human sense, and the basic issues of language, redundancy, and translation remain as well.

There are innumerable problems associated with language translation. First, there is not always an equivalent for each word, much less for metaphors and phrases, in another language. For example, there is supposedly no word for "love" in Chinese. However, there are Chinese phrases that convey affection, which may be more desirable to use than the single word "love." In such an instance, the amount of communicating necessary would be extensive. Where it is necessary to instill meaning or feeling, certain kinds of communications vastly exceed others in different languages. Language that includes more than information, such as feeling, sentiment, or judgment, is sometimes referred to as **metalanguage.** The metalanguage approach to communicating can fail to be sufficiently explicit for general communication, and even less so for common business transactions. The mathematical approach, which can be too rule-based or heuristic and rigid, completes the spectrum, but it also can fall short of conveying information or understanding that applies to human needs or factors.

The computational linguistics approach to machine-human communications creates a pseudolanguage by parsing sentences. This is a rule-based procedure of breaking sentences into phrases, much like a grammarian would. The key to parsing is dividing sentences into logical parts, applying the rules and context (packaging), and rebuilding the sentence in terms the machine will process, though not necessarily understand. The obvious application is foreign language translation.

The goal is to have machines break down or parse problems and then solve them. Current limitations are caused partly by machine capacity limits, processing, and storage. These problems must be overcome to provide a cost-effective trade-off between human and computer translations. The architecture of simple computer programs in a step-by-step linear fashion, rather than in a simultaneous multiple-processing fashion, can open new approaches to the parsing process. At the present level of development, however, some machines would still translate the term "water buffalo" into "hydraulic ram" or the phrase "out of sight, out of mind" into "invisible idiot."

There are many theories about how the brain works; one is that the brain stores information, ideas, and emotions in many different places. This creates a distrusting fail-safe system as well as one that allows for different paths to the end result. As mentioned earlier, the brain has billions and billions of nerve cells, an insignificant number when compared to the potential connections between them, which is estimated to be 10^{17}. Given these capabilities, the brain can separate or network images, words, languages, emotions, and other inputs in ways that we are only beginning to understand. Although the brain can look over this entire page and potentially grasp in a glance much of the meaning, machine-based parsing can only compare a few letters; it could never understand their entire meaning.

Considerable research is required to cope with these vast problems. At this point, given that entirely new technologies can emerge which will change our fundamental approach, it is necessary to design current systems with foresight. The situation is similar to one faced at the turn of the century when cars, not traffic jams, were predicted.

Language Mapping

Language mapping (charting) can yield both an effective methodology for language processing and a flexible approach to machine understanding and AI. Mapping takes language out of the linear mold as well. Using language, like reading these words, is a relatively slow process that forces the reader through a step-by-step progression with minimum allowances for deviation. It is difficult to choose the following:

- A convenient means for starting and stopping
- Time indifference, the reader's choice of when to read
- Random searching, the reader's option to jump around in the text, front to back, or in any other way
- Convenient packaging, large amounts of information that can be moved over great distances with or without human assistance
- Extremely explicit dogma or propaganda, the exactness and completeness of the communication process
- Other issues that range from ambiguity to fantasy

The point is that although language formed by words has many key and important advantages, it does not reflect the full communications process. It does not convey how humans or other creatures understand, process, or consume information. Humans process concepts, not words. Concepts can include everything from hieroglyphics to integrated information processing.

Computer analysis of language (computational linguistics) is the application of machine intelligence to problems, issues (thinking), and communications, rather than to the machine translation of foreign languages. It is often found that communicating fails, except by chance. Applying machine technology offers little hope of creating systems that can cope with the technical aspects of communication, much less with the more complex issues of understanding and the resulting rational action to be taken. However, the aim of language mapping is to develop models that explain both technical and human aspects of communication in terms a machine can accept as well as use to produce output as a human does.

The first challenge is to analyze the existing language; an alternative approach is to abandon old languages for new ones. Without exploring language at this point, the process might simply be to design a metalanguage that adds valued meaning to phrases. More precise, however, is a metalanguage that a machine can process. This is not to say the machine understands as a human does. It assumes only that the language is processed, like a payroll system for example. Theorists have sought to create systems that rise above language, an approach that seeks to cope with context, which is difficult to do. The purpose of this metalanguage approach is to define what words actually mean; for example, the words "offensive reaction" have a dual meaning: striving forward or obnoxious. The context of the sentence determines which definition is appropriate.

Another approach is to define language and understanding as computational entities, and to process these entities through an architecture and its associated building blocks. Computational architectures are combinations of single cells that together construct programs which start to "think." Organizing these programs in other than a random manner allows the computer to consider the elements, or cells, contained in the system. As more and more elements are organized into systems, languages are developed with inherent models that have meaning associated with them. The arrangement of these cells clarifies the context of individual cells: "Mad" with "dog" = "rabid"; "mad" with "at him" = "anger."

When numerous elements are networked, the complexity vastly increases, and the system develops its own behavior. In the case of computer modeling of psychological processes, networks of behavioral elements are organized, just as they are in most games. Some early systems using this approach were reactive in the sense that they only responded to changing conditions and required no intelligence. Their response could be compared to that of a thermostat for a home heater.

The next level is found in current computer programming technology. If-then-else statements allow and-or-not approaches to problem-solving. This process expands beyond the on-off stage to allow for branching, that is, choosing among options.

The next stages might approach thinking, where complex formulas, models, or computational heuristics evolve into seemingly intuitive thinking systems. At this level, there will be few, if any, rules; there will only be appropriate, if not humanistic, approaches to the issues at hand. As theorists have discussed, one person's meat is another person's poison.

Expert Systems and Artificial Intelligence

AI has achieved considerable success in the development of advanced expert systems since the mid-1960s. AI has concentrated on the construction of high-performance programs in specialized professional occupations, on issues, or on domains (concepts). AI is a pursuit that encourages emphasis on the knowledge underlying human expertise, and simultaneously decreases the significance of specific problem-solving abilities. Thus, a new set of principles, tools, and techniques has emerged to form the basis of this knowledge engineering.

The study of expert systems, however, details methods and techniques for constructing human-machine systems with specialized problem-solving expertise. Such expertise consists of knowledge about a particular domain, an understanding of the problems of that domain, and skill in solving some of these problems.

Knowledge in any specialty is usually of two sorts: public and private. Public knowledge includes the published definitions, facts, and theories of which textbooks, journals, magazines, seminars and conferences, hearsay, and references are typically composed. Expertise usually involves more than just public knowledge. Human experts generally possess private knowledge that has not found its way into published literature.

Private knowledge consists largely of rules of thumb that are called heuristics. Heuristics enable the human expert to make educated statements when necessary, to recognize promising approaches to problems, and to deal effectively with erroneous or incomplete data. Boiling such knowledge down into pieces a machine can "understand" and utilize is the central task in building expert systems.

Knowledge Versus Reasoning

Researchers in this field suggest several reasons for their emphasis on knowledge rather than on formal reasoning methods: (1) difficult and interesting problems resist precise description and rigorous analysis; (2) knowledge is possessed by humans; and (3) knowledge has its own intrinsic value. In sum, expert performance depends upon expert knowledge, another reason that most complex problems originate in social or physical contexts. Examples of such contexts are planning, legal reasoning, geological exploration, medical diagnoses, and military strategy. These problems generally resist precise description and rigorous analysis, and cannot be described with mathematical formulas that can translate into solutions.

Furthermore, contemporary methods of symbolic and mathematical reasoning, which have limited application in the area of expert systems, do not provide the means for representing knowledge, describing problems at abstract levels, allocating problem-solving resources, controlling projects, or organizing resources of knowledge. These activities depend to a significant degree on the ability to manipulate problem descriptions and apply relevant knowledge selectively. Expert systems use symbolic representation (images, graphics, and pictorial displays), inference (assumptions), and heuristic search, for example.

Expert systems are, therefore, distinct from AI tasks in several respects. First, they execute tasks at expert levels of performance. Second, they stress specific problem-solving strategies over the general strategies of AI. Third, they employ self-knowledge to reasoning in their own thought processes and provide explanations for the conclusions they reach. Last, they solve problems that generally fall into one of the following categories: interpretation, prediction, diagnosis, debugging, design, planning, monitoring, repair, instruction, and control. As a result of these distinctions, expert systems represent an area of AI research that involves paradigms, tools, and system development strategies.

Another pragmatic reason for emphasizing knowledge rather than reasoning is to evaluate human experts who achieve outstanding performance because they are knowledgeable, not necessarily because they are logical. If computer programs embody and use human knowledge, they should also attain high levels of performance.

This has repeatedly proven to be true in the short history of expert systems. AI systems have attained expert levels in such tasks as mineral prospecting, computer configuration, chemical structure elucidation, symbolic mathematics, chess, medical diagnoses and therapy, and electronics design.

The final reason for focusing on knowledge is its inherent worth. Knowledge is a scarce resource whose refinement and reproduction require an increasing amount of effort. Traditionally, the communication of knowledge from a human expert to a trainee has generally required lengthy education and internship. Gathering human knowledge and converting it to computable forms can greatly reduce the cost of reproducing and analyzing knowledge. At the same time, the process of evaluating knowledge can be expanded. In short, expert performance critically depends on expert knowledge.

Because knowledge is the key ingredient in solving important problems, it has specific key features. For example, it can justify possibly expensive mining operations that require efficient, effective technologies in order to be developed into new products.

Expert Systems: A Definition

Expert systems differ in important ways from both conventional data processing systems and systems developed in other branches of AI. In contrast to traditional data processing systems, AI applications generally involve symbolic representation in addition to expert system components of inference patterns and heuristic rule search. In fact, each of these features corresponds to a well-studied core topic within AI, and a simple AI task often yields to one of the formal approaches developed for these core areas.

Expert system designers are faced with the problem of attempting to automate a process that is nearly impossible to automate. Four reasons explain why this is so. First, most complex and difficult problems do not have simple solutions that can be either explained or organized into a computer program. Many of these problems are policy-oriented, and social and political in nature. These problems can exist simultaneously and with many different levels of certainty, but the process in which the problem is found requires immediate information to operate efficiently.

Second, humans are humans. Humans operate through a broad spectrum of knowledge and ability. Ambiguity is necessary to human activity. In fact, as a human becomes more expert, increasingly complex problems are sought in order to further expand the experience level.

Third, knowledge is transitory. Today's news is tomorrow's trash. Knowledge in itself has a number of characteristics that make it incapable of being computed. These include the following:

Historical value

Some information, like antiques, increases in value over time, and other types of information decrease in value rapidly.

Future value

Information of future events, from stocks to fashion trends, has increasing importance to business. An important key is the ability of people to act on this information. Certainly, there are experts who forecast future events by extending known patterns or trends. Others leap into the future and become known as futurists or science fiction writers. Capturing this information is vital to the success of nearly all types of automated expert systems.

Information velocity

It is not known how fast most information moves, nor are there any known measurement devices or parameters to judge its speed. However, being the last to know some piece of information, such as a product announcement or a management promotion, catches us all with surprising frequency. It is embarrassing to tell someone something you think they already knew, and they in fact don't. Needless to say, it is evident to all of us that the flow of information is speeding up.

Information volume

The amount of information available to the general public has increased to the point of inoperability. If humans are barely able to cope with this information explosion, certainly a machine would have a difficult time as well. However, could information be filtered in order to be managed by a machine? This filtering process might eventually become another category itself.

Within this area of information volume comes the issue of transmission. Getting information from point A to point B might utilize enough data for appropriate action to follow. There are many other characteristics of information, however, such as gestures, body language, and premonitions, that are so subtle they are too difficult to comprehend.

Fourth, machine technology is rapidly moving to the point where hardware and software are becoming biotissue- (micromechanic control systems is a rapidly emerging industry) and light-based or some other form of technology much like human hydromechanics.

It is this automation challenge that gives rise to newer forms of systems which fall outside the present domain. Expert system designers often complain more about the limitations of programming languages than the difficulties of capturing the vital information of the human expert in a program.

Designing an Expert System

Expert system designs are as varied as impressionistic paintings, but they do share some general characteristics that fall into categories similar to oils or watercolors. The principal issue has to do with what might be called a subconscious. Inference engine, justifier, interrogator, and other terms are used to describe, evaluate, and present in understandable terms the actions or recommendations of the expert system.

This machine subconscious is what differentiates an expert system from a simple DBMS. In some expert systems, the processing, refining, filtering, or understanding takes place behind the scenes. Like the subconscious, it operates in real time and works constantly in order to understand and justify its actions. It also acts in order to understand what it is supposed to do.

As discussed in the section on natural languages, expert systems communicate with the user in a commonly accepted language with generally accepted words. The expert system breaks down or "parses" the language into understandable concepts, and can test the communication in order to ensure validity. At present, nearly all expert systems operate in a text-oriented communications medium. The ability of machine dialogue to take on graphic, visual, or verbal dimensions is critical to its utility. See Figure 3.5 for an expert system development tool.

Now that we have briefly discussed two of the elements of expert systems, a subconscious and a user interface, the next issue is function. What is the intended purpose of the expert system, and how should it be developed? The strategy of an expert system can be confined to the subconscious. In most expert systems, this process is programmed before the system interacts with its first human.

Certainly, the program design impacts the system like the body design of an

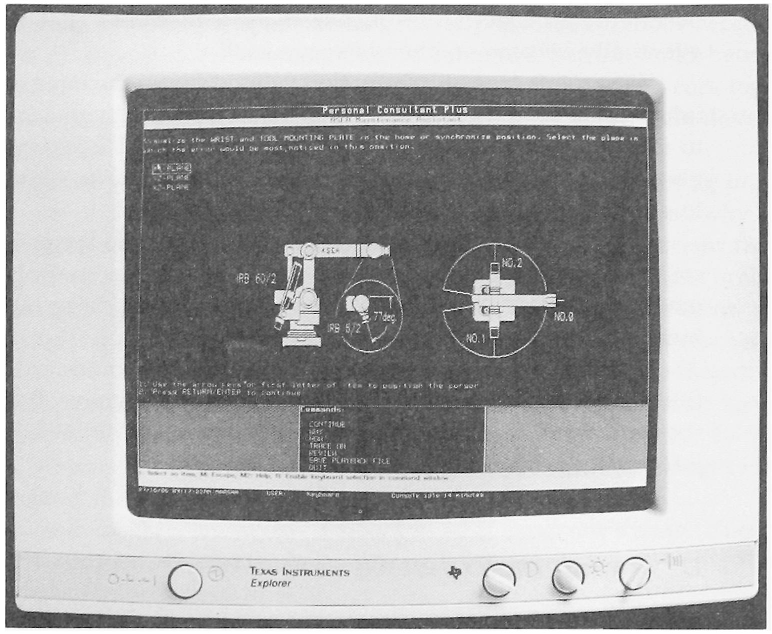

Figure 3.5 For sophisticated users. Personal Consultant for the Explorer takes advantage of the extensive common LISP environment. Photograph courtesy of Texas Instruments.

automobile. However, it is the driver with whom we are concerned at this point. How does the human expert develop the peculiar aspects of an expert's knowledge in conjunction with a machine?

The question of bottom-up or top-down processing is a valid one. There are certain types of experts who examine all the details of a problem before even asking the first question; others act immediately on each piece of information as though it were on fire. Expert systems are no panacea for programming. In the future, they will be designed around the expert rather than the problem to be addressed. Expert system building blocks are needed to build whatever system is needed. It is the design of these blocks that is the design bugaboo. Hypothesis, deductive reasoning, and educated guesses or rules of thumb are all elements in building blocks. It is these humanlike procedures that have been termed heuristics, which form the basis of the machine's subconscious.

AI and Commonsense Reasoning

Models and strategies for reasoning emerge in many forms, most of which are based on concepts, such as symbolic calculus, that are difficult for the lay user to understand. Some of these concepts translate natural languages into mathematical terms that can then be computed. Thus, an AI system lacks common sense in understanding itself in purely human terms.

Humans, however, although expressing a considerable distaste for ambiguity or change, are designed primarily for just that. The entire body is designed for rapid change. Humans, although built for disorder, constantly demand order. It is a never-ending battle to create constancy out of chaos. Moreover, the problems found by a person in any one day are completely different from those of the next day, no matter how hard we try for consistency. Problems are solved at random in spite of all attempts to bring rules and procedures into play.

Common sense is not a process. It is a method of reasoning that defies description. It is experiential and strives to cope with today's problems by an understanding of, but not a total alignment with, the past. Common sense assures that there is no model or pattern of reasoning, and if there were, it probably would not work with the problem at hand. Common sense can allow for natural processes to take place; however, we must always be on guard for unnatural occurrences at any moment.

For example, within a group of families there should be an equal distribution of women and men and, as a possible subset, girls and boys; and within a week, there are days, hours, and minutes. This explanation might sound simplistic. Try explaining this to a machine; this is classic logic. By deduction, Sherlock Holmes solved crimes; he never guessed. In this way, proof leads to other proofs, and so on and so forth. Does common sense play a part in this, or is there some greater logical process at work?

It seems that from here to there you must go by way of this path. This type of process is the tree or branching approach. It is often thought of as different from deductive reasoning, but at times they are one and the same. If you go east from Chicago, you eventually get to New York, which can be a tree branch (or trunk root) approach. The problem lies in using this system to deduce whether New York exists at all.

Some might also call this example forward chaining, an attempt to project a future event (project a lunar trajectory) or conclude a past one (solve a mystery). There can be rules (the amount of gasoline consumed by an automobile), laws (speed of light), and limits (no money budgeted for the project). In other words, there is an order to common sense after all. This is not to say that it can be computed, but given enough certainty about the activity, elements might exist that can be used in a computer or machine environment. This natural commonsense approach can yield more user sophistication.

Sherlock Holmes developed his own organizational scheme for cataloging tobacco ash. Other experts build collections of things, places, and people. A pattern or trend can emerge that can be organized with other collections as they overlap one another. Certainly, if there are any trends, they can be organized into even higher orders or societies. There might be enough data to delineate absolute laws, and to that extent, a basis for further reasoning can arise. Something always seems to violate the laws, and we are forced to reevaluate the entire matter and maybe even start all over again.

Evolution begins a process that proceeds step by step down an almost predictable path. Then, as if planned, evolution takes a leap in a new direction, though not necessarily forward. It can, as it has done many times, take a leap that will doom the next species to extinction. This leap can, in fact, occur due to natural, nonlogical processes. This uncertainty exists in nearly all events.

Rather than purely deductive, these methods are used in coping with chaos. This is the management and tolerance of ambiguity. In AI it is called **fuzzy logic,** and is described in terms such as coefficients of probability, inductive ranges, analogies, the impossible or unrealistic, and others. Fuzzy logic allows for a natural open-endedness to deferred logic. It is the ambiguity of logic that exists in any activity. Although fuzzy logic allows for ambiguity, it also sets a range of operation that can still be modeled, which can be the statistical limits rather than the norm, mean, or median.

Other methods of reasoning include charting, semantic networks, maps, chains, proof procedures, node-related search paths, and hundreds more. Some systems are either more logical or more ambiguous than others. Some work well if the factors are known (variables are found), and others only work in illogical, fuzzy environments where little, if anything, is known.

Obviously, many types of computational reasoning systems exist in many forms. They are generally created to solve specific tasks. At the same time, new forms are emerging that tolerate greater amounts of ambiguity and are suited to solving management problems which are complex and not easily understood or defined, and which require a considerable amount of common sense to solve.

Reasoning Horizons

Much about the nature of commonsense reasoning is related to a historical approach to problem-solving. This bias works well when the problems to be solved have been encountered previously, and are merely variations of a theme. In nearly all game situations where the outcome is already known and the players are just reenacting an activity, the issue of the future has no relevance. This approach has been taken in the design of most AI systems to date. Such systems use conventional processing to predict known outcomes. This process is useful for the following:

- To increase the validity of both the machine's capabilities and the data
- To test the ability of the machine to process data in a consistent manner (this is different from the previous point, which is a software issue)
- To allow for the machine, if possible, to develop its own processes or outcomes as a side benefit
- To eliminate or discourage the element of surprise from processing

Selection is necessary in order to eliminate the boring, useless, and inconsequential pieces of information that bombard us every day. Language can be a tool that reduces large quantities of sensory data into more workable units that are then capable of being efficiently utilized. Thus, each area of a language can be defined in smaller parts. As Asomov noted, "With each model of a letter or word there is a record of its address and the penetrability of the various connections."[6]

It is this sense of connection that makes language so exciting and so practical. In many cases, words are irrelevant as singular units, gaining relevance only in relation to other words. Asomov uses the term "connection" when discussing this aspect of language, and the relationships between words take on an almost machinelike perspective.

This type of research suggests that words have an energy level. In this sense, words have a physical value aside from their value as perceived by the listener. As connections are made, the volume and value of the words increase. The value is possibly computable when combined with other word values.

Asomov is speaking in terms of human mental processes, rather than machine-based systems. However, semantic networks, as well as thought-processing systems, offer similar models for consideration. The concept of even larger groupings of words gives rise to consideration of associative behavior processing. These behavior patterns bridge the gap between purely procedural mental processes and those which would be considered machine intelligence.

Language and the machine

Associations, feedback, and independent action are some of the many functions that can be designed into a machine. The ability to test the environment before acting, common to humans, is an important criterion in evaluating machine intelligence. The machine initially acts on simple activities and then proceeds to increasingly complex levels of programs. Language and machines evolve from simple processes to complex ones within this evolutionary structure, and form is created, which supports understanding. In this way, the machine understands according to its experience of the environment.

Natural languages are similar in function. The complexity of a problem or situation increases upon exposure to greater numbers of humans. In other words, the number of words that are being interpreted by machine or human is directly related to the ability to interpret them correctly. Natural language systems are thus confronted with the dilemma of increasingly complex statements being used in an attempt to describe existing problems.

In this study of language, it appears that language reflects a natural order of the mind. Technology, through machines, allows us to study language closely and, thus, be able to record in an organized fashion what has been learned. Machines also allow the development of independent abstract models that can be tested against the real world without suffering real-world consequences.

Today's machines and software languages are quite primitive in attempting to provide an interface between the lay user and internal data. With the increased ability of computers, as well as the increased sophistication of software design, we will see advanced modeling of languages. This development will allow humans to increase their knowledge of languages and, in turn, lead to the development of more complex and useful languages. Natural languages are not merely complex processes; they are also a means of understanding things we often assume we already know a great deal about.

Reasoning, in essence, discourages openness, surprise, or ambiguity. It is a process, mental or mechanical, that works through a series of pieces of evidence to new data until the problem is solved. In certain circumstances, reasoning is a process set against time: All answers are known; it is just that time eludes them.

Reasoning is also a natural language issue because language is often the means on which the evidence is built. In the field of learning languages, the building process is often a history of ideas gathered together into stories. These stories are told in order to pass on information or reasoning processes. In stories, as in reasoning processes, clues are included or omitted to frustrate the process.

Reasoning through language is generally a more difficult process than through heuristics. In *Computational Models of Reasoning,* Eugene Chouragin notes:

> In all these situations the conclusions at which one arrives are only probable. It follows that these kinds of reasoning do not allow us to draw conclusions with certainty, as in the case of deductive reasoning. Moreover, it is very difficult to gauge the probability of conclusions. The latter depends not merely upon the propositions used in the reasoning, but also upon the nature of the logical links which connect them, these links being stronger or weaker, and perhaps establishing only a probabilistic connection.[7]

Many reasoning possibilities exist that lead to new horizons in the development of natural language systems. Reasoning suggests that processes which lead to behavior can be modeled. These models can then be used to establish patterns of behavior or languages. Languages can then create other model types leading to the solution of the problem.

Natural languages are both exciting and perplexing to the study of AI. As in human communication, which fails as much or more than it succeeds, communication with a machine poses perplexing questions; herein the attempt to design a system that "knows" what was said to it.

Capturing and processing is not the issue. Any word processor can perform these functions along with others. Natural language systems can now reason, given generally accepted deductive processes. Natural language systems pose the ultimate possibility of machine consciousness in that the machine could possess the ability to act independently of both humans and itself. It could attain the ability to look beyond itself and establish its own view of the world.

AT *Fantasies*

Maybe reality is a dream and what we live is a fantasy—or is it the other way around? As the complexity of machine languages for information processing increases, much of computer programming will not be simple payroll programs. It will be programming that exists in a world of images, symbols, and fantasies.

In AI this world is called by many names, but it generally falls into a symbolic environment. This symbolic approach to reasoning becomes difficult to define. For example, one, two, and three dimensions are all important, as well as size (8V2 by 11, A4, and so on), movement (how fast a symbol can be), and other issues. These factors alone would be enough for most computer programmers to consider changing careers.

The issues of recognition and manipulation are important, too. For example, the machine recognizes the desired symbol, such as a car, and lets you know that it is a Ford. However, the information desired is the type of key lock for the car, and the system might not know what that is.

Many AI theorists focus on the application of symbolic environments as extensions or, at the very least, oppositions to numeric processing. This juxtaposition of the concepts follows traditional left-brain or logical-subjective thinking. Neither people nor machines should act in a purely one-sided manner. Moreover, the types of machine instruction or programming needed to cope with symbolic environments should also be mixed. Certainly, in machine environments, it can be helpful to disable one side or the other and receive either a totally logical or a completely fanciful answer. This is not to say that only two opposite forms of machine instruction are possible or even desirable. This multidimensional approach is being considered as the boundary at which intermediate approaches can emerge.

At the center stage of symbolic environments is the issue of reasoning and the necessary pattern recognition. As the earlier key lock example typifies, what the user wants is rarely, if ever, what he or she asks for. The development of the machine as a friend of the user is important to this process. This friend learns intimate details of its user to the point of understanding or, at best, having a good idea of what the user is really asking for. This may be considered an inference about the user. Thus the machine becomes an expert on the user. For the most part, programs today consider only the probability or the statistical closeness of the machine that is understanding the actual user request. At this point, the issue of reasoning is still untapped.

Scientific Methods

In previous discussions on inductive, deductive, and intuitive processes, the issue of increasing levels of intelligence was raised. Over the past few years, many AI systems have emerged that attempt to provide tools that possess machine-based intelligence. However, many processes, interactions, steps, and stages or levels must be addressed before this would be possible.

In the grooming of a new corporate president, years might go by before this person possesses a comprehensive understanding of the intricacies of the company. Often, if this person is placed in charge before being ready, ill consequences result. It is this careful monitoring of a person's readiness for the complex challenges of upper management that can be difficult, if not impossible, to integrate into machines.

The purpose of this section is to review and explore scientific method as a means of developing processes or approaches to machine-based intelligence systems.

Among other things, the scientific method is based on extensive and intensive gathering of data against which a hypothesis is judged. As enough data are gathered, the hypothesis is proven right or wrong, or modified to suit a new hypothesis. This process facilitates the structuring of uncertain data and the application of a definitive procedure that can be automated.

For example, assume that the president of ABC Company needs to make a decision about whether to expand the company's product line from its existing market in Golden, Colorado, to California. The president can test the market by giving free samples, comparing the demographics of the existing customers, doing nothing, or proceeding unchecked with no additional thought on the matter. Each of these activities has been tried by all of us at one time or another with mixed results.

The goal is to develop a machine that can process all these alternatives and many more, maybe hundreds or thousands, and come up with a winning recommendation. Who could argue with that? The difficulty with this scenario is that the real-world model changes. What we know today probably will not work tomorrow, at least in the business world. At best, we can develop an estimate of the real world and design models that approach it and, when wrong, be prepared to modify our position as rapidly as possible.

This is a business equivalent to Goedel's proposition that even in the elementary parts of business there exist propositions which cannot be proved or disproved. These propositions might be directed by Goedel to certain elements of mathematics, but there is no question about their applicability to business. Business will always be a crap shoot. The goal is to move the odds a few percentage points toward us and away from the house.

To conclude this point in a technical way, Stanley L. Jaki, in *Brain, Mind and Computers,* supported the applicability of Goedel's theorem, which states that

> no strong enough arithmetic theorem can have in itself its proof of consistency to the mind-machine relationship, can easily be seen if one postulates that since minds can do arithmetic, any artificial mind should be able to do the same.[8]

Jaki goes a little further in the endeavor to absolutely address the winning models, and allows the machine to consider that "a conscious man is a unity in which the potentially infinite sequences of acts of self-reflection do not signify distinct parts of a thinking apparatus."[9]

The consequences of logical thinking in a scientific method might not always allow the best decision to surface among all the options. It is as though the opposite approach is also desired, which is not opposite the scientific method, merely juxtaposed. In *Artificial Intelligence through Simulated Evolution,* Fogel states that "evolutionary processes allow the interactive convergence upon a goal."[10] Models, in this sense, can move to higher levels of instruction to be tested against more complex issues; that is, it works in this instance and the next, but not in the third. This movement to higher levels establishes models that are proven and against which future data can be tested.

This process is closely akin to nature. Fogel noted, "The correspondence between natural evolution and the scientific method is obvious. Individual organisms in nature serve as hypotheses of their environment."[11] Behavior, in this case, is an extension of the deductive process. Deduction with the comparison of both logical and illogical elements is an important issue in designing thinking machines. It allows for a procedural "scientific method" to provide a framework for the gathering of data and the growth in the testing of higher levels of abstraction. It concludes with a system that can evolve absolutely as the issues or data change, like the "real world." The only fallacy is that any such system's process is only one of many that are available.

Heuristics as Hypothesis

Heuristics can also be thought of as hypotheses. In fact, some AI researchers, F. H. George for example, use heuristics and hypotheses interchangeably. However, in this book, I try to separate them, if only subtly, to allow for hypotheses to be adjusted by experience or to use heuristics as a testing mechanism for hypotheses. Here, hypothesis and heuristics can play an integrated role. This process allows different perspectives, rules, and worlds to coexist. In real life, we make these "jumps" every day and are either proven right or wrong, which then becomes an additional level (heuristic) or model (hypothesis) from which to operate.

In this context, building complex AI systems becomes relatively elementary because the environment is not assumed to consist of either all heuristics or all hypotheses. Various components can be operating at the same time. As F. H. George noted in *Models Thinking,*

> It is in these terms that we see problem-solving as a synthetic undertaking. Problem-solving is the ability to construct or reconstruct subroutines to solve problems and learn new subroutines by experience as circumstances demand.[12]

George suggests that components do make up a system and that problem-solving can be dealt with by using such means. There is a subtle but key distinction about who is making the actual decision. This process clearly would be helpful in the case of the machine being an assistant to the decision maker rather than actually making the decision itself. According to George,

> Hypotheses are generated in terms of the language used and problems dealt with. . . . These can be used in dealing with problems and finding their solution (e.g., theorem and proof or a game and its algorithm) or dealing with associated features of the environment.[13]

Here, we begin to address the specifics of the problem-solving process. Although science might operate under the scientific method, business does not. However, in the design and implementation of computer models under which business can operate, business itself is changed. As machine intelligence increases and those in decision-making positions within business begin to understand that scientific methods can improve the decision-making or problem-solving process, these methods will be adapted for business use.

For upper management, the corporation is a set of hypotheses for which effective heuristics must be developed in order to create effective operation. Upper management sets the stage for the rest of the corporation to develop its own heuristics. In addition, the theoretical models being developed must be fed real data. As upper management develops its own heuristics against which the rules of the corporate game can be played, there is a parallel need to gather information from the real world where hypotheses are emerging. These hypotheses can be used to modify the heuristics, creating a self-balancing environment.

This self-balancing environment is also self-perpetuating, which is quite an evolutionary approach. Crisis comes with revolutionary occurrences that take place unexpectedly; for example, the oil crisis, a technological breakthrough, or a competitive market entry. This is where the system falls apart. Machine-based models often fail due to the lack of ability to anticipate; therefore, they are not generally considered appropriate in this application. It might not be logical to develop illogical approaches, yet this is what is required. Considering the impossible, is the hypothesis or the heuristic necessary?

In business, the most difficult situation to simulate is that of competitive entry. What if IBM or Japan, Inc. enters the market in which your company has a dominant or lesser share? Certainly, this is the issue in the computer industry today. If one looks at the size of the personal computer market, conventional wisdom suggests that the market is large enough for another manufacturer. However, PC manufacturers declare bankruptcy almost every week.

Again, there is a need for wild cards to be developed in any AI system, just as there is in life. These cards force the participants to guard against conventional wisdom and evolution and to consider all logical and illogical possibilities.

Metaphors

Part of an intelligent system is to provide a means of heading the user in different directions. As discussed in the section on guessing in Chapter 2, *Issues in*

Knowledge Engineering, the machine can direct the user as a result of internal predeveloped programming, a historical interaction with the user. This kind of interaction takes many forms and is sometimes called **conditional branching,** where the user selects a course at various turns in the road. Other directors take the form of **dependency-directed branching,** or backtracking, where biases are introduced to drive the interaction in certain directions. Even more directors consist of **goal-oriented branching,** which seeks to bring the user to the decision or goal in the shortest amount of time. See Figure 3.6 for an example.

Goal-directed branching is certainly useful in time-sensitive solution-seeking. A historical or chronological perspective provides a means of viewing a process over a period of time. From starting a car in fear of being late for work to preventing a nuclear power plant from reaching a meltdown, one's view of time pressure can differ according to user requirements in varying situations.

The machine should also provide the user with road markers for decision-making after receiving only small amounts of information. This essentially allows the machine to step aside at a given point. It also suggests that users might only require the assistance of the machine as a helper rather than as a controller.

Much of the effort of machine-based systems is to understand the context or picture of the problem at hand. As through a looking glass, interaction most likely appears in the form of multiple images of the problem. As each problem is presented, the machine is faced with the task of understanding how the picture fits together.

People, however, understand problems in many contexts or dimensions simultaneously. Some people escape the logical dimension so quickly that they do not understand the simple solution. Others focus only on the immediate solution, to the point of ignoring the long-term effects. In other words, multidimensional approaches are needed simultaneously in order to provide any human assistance at all.

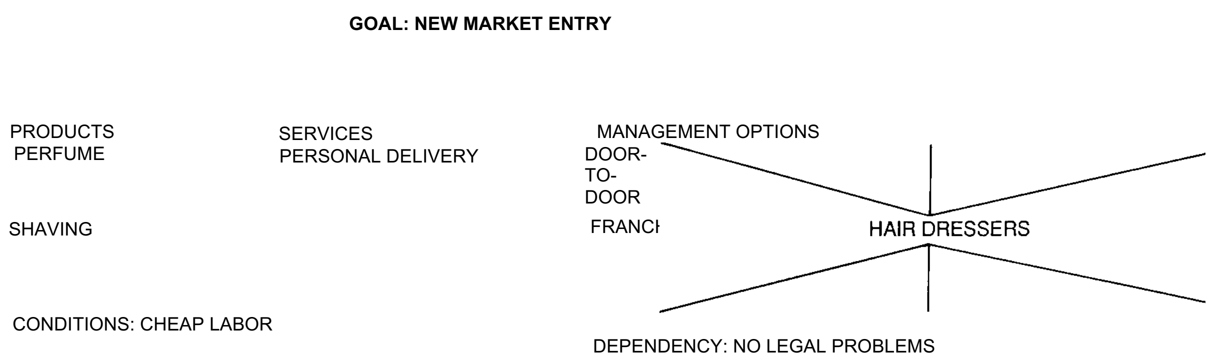

Figure 3.6 Branching network with selected conditions, dependencies, or priorities.

Metaphors or, in practical terms, story boards, allow the machine to parse the situation into a number of subcomponents, dissecting each problem into smaller and smaller pieces until it understands what is taking place. Metaphors provide branching opportunities to be inserted at various stages of the analysis, allowing for immediate decision-making. Thus, an infinitely variable branching system can exist. Metaphors offer the user variable symbolic presentation; the user can act out any desired situation in any conceivable context. User interaction can change moment to moment, frame to frame, story to story in any dimension (time, space, goal, game, guess) that can be conceived by the user or suggested or directed by the machine. Depending on the context described by the designer-user (the user can be both at various times), the application can call for only certain metaphors to be used.

A new field of designers might emerge, taking the form of metaphor makers. Metaphors reflect the ability of the machine to be intelligent or dynamic in changing conditions, therefore incorporating the ability to alter the context at any moment. Software currently exists that provides the rudimentary forms of this future holographic metaphor technology. The creation of multidimensional imaging and machines that provide symbolic imaging will create a new environment for human interaction.

Metaphoric machines are practical extensions of branching systems. If the car doesn't start, check the battery; if that doesn't work, check the fuses; and so on. As cars become intelligent, they will know what went wrong before you do, substitute or replace defective systems (if possible), suggest maintenance, and so on. However, much of problem-solving has to do with the unknown. Metaphors and fantasy environments allow people to create situations that might or might not exist in the real world. It depends completely on your imagination.

Natural Languages

Communication and content form the basis for most languages. Languages must have a purpose beyond the mere pavement of the highway. They must lead somewhere, and it is inherent that they are two-way. Programming languages have evolved from the movement of electrical switches to program computers to free-form languages. Languages have evolved from pure machine languages that consist of l's (ones) and O's (zeros) to rudimentary languages in the form of assembly words to various types of low-level languages such as FORTRAN, BASIC, and COBOL. Currently, much of computer programming is done in Pascal, C, and hyperlanguages such as LISP and Prolog, which are most suited for developing AI systems.

The next generation of languages emerging is unlike any other existing group of computer programming languages. They are free-form, nonprocedural, and most like English or any other human language system (for example, French or German).

The computer or machine interprets the request of the user and performs the activity, if possible. Certainly, a computer response to "check for a flight reservation" is more likely than "give me a report on your mountain-climbing adventure."

These free-form language programs have emerged because of the need for machines to reach a wider audience of employees within an organization. In addition, machines have evolved to the point where they are more like humans than machines. In addition, language designers or programmers are learning more about machine interfaces with humans. Certainly, there is a long way to go in getting a machine to understand body language or a double entendre, which form a large part of human interaction.

At this point, natural language systems are most effective in practical business and factory applications. Some of the most suitable applications are:

- Decision support systems
- Program testing
- Report writers and generators
- Inquiry gathering
- Simulations
- Games
- Computer-aided instruction

As the ability of these natural language systems to solve everyday problems increases, the level of expertise necessary to use these programs will also likely decrease. In a parallel to automobiles, early automobile drivers were also skilled or semiskilled mechanics. Today, people with no knowledge of the internal combustion engine can buy an automobile and not be expected to look under the hood.

Natural language systems offer the same promise to computer users who care about their tasks, not about the machinery that performs them. In addition, the variety and scope of the languages that will be available should rapidly increase. This will be largely due to a number of factors, some of which include:

- Generic or standardized word lists
- Compatible programs
- Translators (data and language)
- Industry standards
- Marketplace pressures
- Integration with expert and AI systems

Natural languages offer, or will offer, a more suitable climate for applications development. In the privacy of their home or office, users will be able to create programs that solve personal management problems. They will be able to test situations by simulating real events, and apply these situations in real-world settings with a higher probability of success than before. The user will be able to develop a historical approach to problem-solving that leads to a possible integration with other real experts or machine-based expert systems. This will also allow for increased testing of problems with other machine systems without concern for real-life consequences.

This is only one scenario that offers a look at the future evolution of natural language systems. Other scenarios include systems for training, sales, accounting, and other management functions. Correspondingly, the role of users and programmers might dramatically change as well.

Advanced systems and languages place additional emphasis on language-understanding and interface technologies for programmers. In this environment, users design their own programs, solve their own problems, and, as a result, are not reliant upon technicians or mechanics to drive down the highway. As you might have already guessed, this is no panacea, either. As the ability of users to design their own programs increases, using words, phrases, or other English language communication, expectations about the ability of the machine to solve the problems at hand will also increase.

Natural languages are, therefore, dynamic new tools allowing the system and the user to interface. However, if the data are not in the data base or if the task is out of range (such as issuing the command "walk that mountain" to a fixed factory robot), the problem remains unsolved.

Natural languages are currently caught in a computer quagmire, neither fish nor fowl; they are an optimistic means for users to solve their own problems, yet they are limited by the information available to do it.

Natural Languages and Understanding

Natural language systems seem to suggest that computers understand the world in the same way humans do. The associated controversy around this concept goes to the heart of computing machinery.

If one says the word "green," what does it mean to you, me, or the machine? These concepts have to do with a pictorial view of the world, and words such as "freedom," "anarchy," or "terrorism" invoke powerful emotions that go beyond the scope of machine intelligence. Juxtaposed against this pictorial world view is the mechanical perspective which suggests that beneath art exists science capable of explaining the world around us in concrete terms.

Natural languages pose one of the most complex problems in computing and intelligence. How do you explain to a computer the experience of the sky being red or what a water buffalo is? Certainly, you can give the machine the context, the key factors, and even the mental state of a human, but will it be able to understand and experience the aforementioned concepts? Will the machine then create an environment that leads to a better-educated system? Or will the machine, in time, degenerate due to the lack of cohesive structure in which to organize the information—in other words, become confused? Can a machine ever truly pass the Turing Test? The answer lies not so much in machine or artificial intelligence but in whether humans can accept machines as having the potential for learning and the ability to perform tasks independently. There are parallels in certain races viewing other humans as not having the ability to have knowledge.

Natural language systems are also faced with the dilemma of developing their own view of the world. Viewpoint is often more critical to the solution of a problem than the actual problem itself. Even if the machine is able to converse as a human would, can the system be designed to take the antagonist's view, for example? The ability to solve problems can depend on being able to see as many different sides of the problem as possible before attempting to solve it. A natural language system presupposes that at least one view is perceived: the condition of the problem.

Internal translations

Natural language systems are made even more complex by internal translations into programming and machine languages. Many authors have suggested that a similar internal language exists within the human mind, often referred to as languages of thought, mentalese, private code, or mindware. There are many interpretations of mindware, strong arguments concerning the number of mental language types that exist. Some common categories include input-output systems and processing language.

Input-output systems include the senses and historical memory as well as the lesser-understood areas of the subconscious, astrology, lunar tides, intergalactic particles (neutrinos), and so on. The outputs can lack the quality of the inputs but can be more dramatic in the sense of movement, speech dynamics, and the entire range of emotion.

Processing language is something like a software of the mind. In a truer sense, it is probably related more to biology and chemistry than to mechanical systems. This might sound as if the mind is computerlike. It has been suggested that mental compilers exist which act to translate one language to another as well as possess intelligence to interpret the issues being passed back and forth. For example, trying to solve a family crisis involves similar emotions and thought processes, whether one is thinking in English, Chinese, or Swahili.

Certainly there could be a great deal of discussion on the mental "no man's land." For example, consider the correlation between the physical burning of skin when a hand is placed on a burning candle and the mental state of pain. In simple terms, fire violates the law of pain; therefore, humans should avoid pain. It could easily be argued that an expert system could be developed to simulate this occurrence. A natural language would be particularly useful in determining the appropriate action to be taken: Remove hand from fire now. The natural language might have an internal mindware language that instructs the arm and hand to move plus a timing condition that tells the arm and hand to do this now rather than tomorrow. Natural languages certainly have other advantages as well as extensions to grow on.

Diverse interpretations

Natural languages are vast, with a limitless ability to interpret. This diversity of interpretation creates an opportunity for mental languages to form. A sentence is a metalanguage in the sense of formed bundles of programming and input-output information.

The word "act" offers a large range of interpretations (a theater performance, a deed, an ordinance, the main division of a play). However, the statement "I am going to the Flagstaff House restaurant to eat a buffalo steak with mushrooms" is either a statement of action or a program language that possibly is computable in a machine-processing sense. In addition, to the extent that anything is understandable, the sentence is understood and quite possibly not subject to interpretation or argument.

In the future, conveying this sentence to a machine might cause some electronic responses: (1) here is a list of call forwards to the Flagstaff House; (2) take buffalo meat off the week's menu; (3) get the credit line open for the restaurant; (4) how many meals need to be bought? These responses suggest that within a generally accepted realm of possibilities, natural language systems offer convenient forms for processing information. Instructing such a system to determine generally accepted ideas or concepts (What day is it? How many sales must I achieve before getting a bonus?) can be achieved without complex modeling systems or true intelligence.

In fact, the processing of vast amounts of words, sentences, paragraphs, chapters, and books will allow designers of natural language systems to develop intelligent compilers that can come up with generally accepted interpretations. These compilers might also develop those interpretations that are not often considered by humans because of the physical limitations of the mind. These concepts can be computed either in input-output terms or through mental processing.

At this future point, the machine might be able to understand more than a human could, although the machine could still be fooled or confused, or could even respond or act irresponsibly. These responses would be quite humanlike. Or should the computer be programmed to be strictly nonhuman, that is, always logical, in its activity? For instance, guessing often involves a leap over logic. This conflict revolves around the ability of the designer to eliminate undesirable behavior, and at the same time retain desirable actions and responses within the programming of the machine. Natural languages can create some problems because of the ability of machines to capture, process, and manipulate vast quantities of information. The machine might read a novel but could not make any distinction between fact and fiction.

The issue of this discussion is that natural languages have limitations due to ambiguity, but at the same time also have limitless possibilities as extensions of human behavior. Therefore, the question to pose is: Does a machine have certain key advantages when possessing the ability to be humanlike in its processing?

Language Development

Language must be viewed as a subset of the overall communication phenomenon. Just as nouns and verbs are parts of sentences, language can only be viewed as information that has been packaged to describe human activity. What portion of language can be attributed to overall information or to communication processing is certainly debatable. To the extent that language refers to some aspect of thought processing, it can be regarded as a tool and hardly more than that.

Language can be more a tool for human interaction than for mental processing. You might be thinking the words "If I take a long lunch, I might be late for the meeting." Your processing probably includes images of the restaurant and emotions of taste satisfaction conflicting with images of your arriving late to the meeting and the client's face and emotions of self-defense. In this case, the process of human interaction actually develops the images and emotional bursts much more than language. The results are simply communicated using language. "I'll just grab a quick bite." Certainly, this aspect of language is a battlefield for computer scientists and cognitive psychologists. Much of the discussion and research involves analyzing words at this base level through meaning and purpose to behavior and modification to mental mapping and beyond. Few scientists have suggested that we ignore language and deal only with conceptual display or an overall approach to thought processing.

The mind must cope with an environment where few rules exist, such as situations that require that nouns become verbs and that slang becomes language. People process information efficiently without knowledge of infinitives, prepositions, and interjections. Moreover, language serves only to limit information processing rather than to expand it.

Language, as we know it, is reaching a crisis point. To increase its life, it must be redefined in terms of utility and application. The crisis is taking place because machine technology is capable of assimilating far greater amounts of so-called language than humans can.

Language, in this context, is a linear array of known characters, arranged in a compatible format for a given organization. Humans consume vast amounts of language in this way. However, they are now reaching the upper bounds of sensory capacity. In other words, the velocity of language in traditional terms is being surpassed by the needs of the user.

For example, it is commonly known that a human can read twice as fast as he or she can hear, which, in turn, is twice as fast as he or she can speak. Simply put, there is a vast amount of processing going to waste. From a technical perspective, the information-processing capacity is significantly greater than the amount of information being presented at any one time. It is hard to tell how much information any one human could process. There are a great many factors that influence this capacity, including biological (awake, tired), mental (interest, no interest), presentational (black and white, color, graphics), and content (mathematics, mystery story), to mention only a few.

As machine technology increases to a point where processing capacity is no longer an issue, new approaches must be found to allow human and machine to reach new levels of processing. Current systems cannot address the capacity issue, except to be road markers for the next generation of emerging languages.

The development of new systems might also move away from language. Language itself might need to be eliminated if only until these new processing systems find a place to settle. Moreover, the concept of new processing systems might come from the development of new machine technology as engineers create supercomputers that process billions and trillions of bits of data. Linear processing and even parallel processing are too slow as yet to cope with the problems under consideration.

Languages and natural languages used by humans or machines to process information are a first generation means of data management. The next generation of languages might be as different as modern cars are from the Model-T. It is not a question of if or when, but simply of how soon we can create these new tools of the mind.

One of the candidates for new language development, or very high speed processing (VHSP), is music. Music offers a multiprocessing approach and, at the same time, allows for simultaneous foreground-background processing. In addition, music provides a unique approach to modularity by allowing growth, both in types of instruments as well as in numbers. Music can also provide a range of data in terms of absolute definition as well as syntax, semantic networks, and phonetic representation.

The portability and presentation capabilities of music can be more natural as a language than character-based communications systems. In terms of compatibility, music is a far more universal language than spoken language. Thus, when considering the long-term impact of machine-based system designs that offer versatile elements such as data networking, security, storage, operating systems, and the like, engineers must consider music as a viable alternative to spoken language.

Nodes and Languages

A difficulty in machine language development lies in creating a language that is natural enough to follow its own rules. Elaborate semantic networks are colorful visualizations of language interactions, yet are ineffective representations of real-life situations and experiences. In other words, they try to create order where it cannot be found. Artificial systems or machines are just that, representations of human interpretations of the world. Human interpretations probably would not describe the same world as that viewed by a machine.

Machine languages and corresponding languages used to interact with machine technology are more complex than the communications technology used by humans. This complexity should raise a red flag of caution when considering natural languages as part of intelligent systems. Although the AI community will scream heresy, it appears that the conventional wisdom taken by natural language systems is inappropriate. New approaches are needed to cope with existing communication language systems as well as those which are on the horizon.

Languages are complex properties of human origin. Languages emerged when a higher order of communication was needed to move ideas from one place or person to another. Languages as we know them originated in an era prior to the concept of machine intelligence. Thus, from a historical perspective, they might be less effective if we had to start all over again.

With the advent of machines, new languages were created, such as assembly, BASIC, FORTRAN, COBOL, LISP, ALGOL, Pascal, and C, to name only a few of the common ones used in the computers of western civilization. The pursuit of advanced, higher-level computer machine languages gives rise to the certain possibility of even more complex machine languages as well as accelerated versions of existing ones.

Natural languages suffer from other problems as well. Which one do you choose from? Machine technologies are becoming increasingly diverse. Certainly, it would be nice if the world would adopt only one language for use in computer programming. However, it is extremely unlikely that this will happen. This diversity is also true of natural language systems. For example, finite-state transition networks are similar to, yet have subtle differences from, recursive transition networks, which are different from augmented transition networks.

Semantic networks and corresponding nodes are the key to any information processing. Links from one idea to another are critical to any kind of data base system. In addition, they are important in chemistry, project management, recipes, and almost everything else that has to do with human activity. The issue here is whether this has anything to do with the way in which the brain or machines process information.

From the research that is currently being conducted throughout the world, there are more and more ways to process information by different people, and fewer and fewer ways for these same people to understand it.

Infinite Structures

As the evolution of machines progresses, the complexity of these devices is projected to increase on an exponential basis. Presently, on an evolutionary level, machines are hardly more than single-celled organisms and, according to most standards, are substantially less than that. In comparing machines with living organisms, it could be argued that even the most basic level of life—an insect, for example—possesses considerably more intelligence than the average personal computer.

The issue, then, is one of complexity and structure. It can be argued that complexity is one of the underlying factors that influences the behavior of an entity. Structure is the fundamental building block from which the entity is composed. One item to discuss in this regard is language and infinite structures. Chomsky, in his famous work *Language and Mind,* stated,

> The generative grammar of a language specifies an infinite set of structural descriptions, each of which contains a deep structure, a surface structure, a phonetic representation, a semantic representative, and then formal structures.[14]

In this sense, language offers a level of complexity that might not be suited for machine transformation. Machines need a level of the concrete that is not possible in language in its broadest sense. Machine-based language seeks to create infinite options, less structure, and greater complexity, which rests on the language designer's ability to create even more complex relationships among its components. By its very nature, language is allowed to inhibit the transfer of communication, and is often considered more in the realm of the arts than the sciences. The complexity of language increases to the point that it takes on new meanings and more abstract conditions, which means less opportunity for computability, and forces the development of a new science of language; this is not unlike what electronics has done for art and graphics.

The development of a science of language opens up new possibilities for its use. The basis of the English language is 26 characters plus numbers, which can create an infinite number of structures. The rules, or grammar of the language, might disappear because of the language's vast complexity and its inherent inability to be coded into rules. Grammar and its related components, which have limited the use and application of language in the past, can be removed, and language can then be expanded for use in multiple instances, such as in business or personal communication.

Therefore, the abstraction of language might allow its use in conveying matters of intent, meaning, and representation. In addition, the expansion of language might allow for its consistent and successful use in oral communication. For example, "tomb" and "bomb" are spelled similarly yet are pronounced quite differently. By allowing the structure to expand to another level or two, these types of language faults might be rectified. Maybe "tomb" could be "tumb," or "bomb" could become "bombe." This approach is almost certainly too simplistic because it merely extends the current structure in order to correct defects. Another approach would be to develop matrix words that are something like those shown in Figure 3.7:

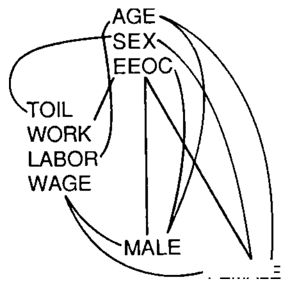

Figure 3.7 How words and thoughts are connected by other concepts.

These symbols might mean nothing to us, not unlike the Egyptian hieroglyphics, which also had hidden meaning until the discovery of the Rosetta Stone (a stone that gave translation clues). After translation, these Egyptian pictograms flow in understanding, meaning, and purpose.

Machines might greatly influence the development of new language technology. Because existing devices are little more than simple organisms, to return to the evolutionary example, infinite developmental possibilities arise for designing machines that can speak within a complex structure. To the extent that programming languages are themselves new languages, the stage is set for the creation of multidimensional languages within machines. Fellow languages offer not merely expansions in structure by using more of the same components; they offer new approaches to the elements as well. This might entail the use of musical notes, environmental modification, or some form of codification of the gray areas of human interface.

The use of human-machine technologies to create new communications opportunities is a growing concern among machine designers. More and more attention is being given to the design of this human-machine interface. This activity, with related research, also offers new language issues. For example, how does the machine interface affect the language being transmitted across the visual display to the retina? Considerably more discussion is required at this point in order to facilitate the creation of new languages that are more compatible with the increasing levels of human complexity.

Summary

The key to an expert system is the power that it derives from the knowledge it possesses. What constitutes knowledge in a given field? Knowledge consists of descriptions, relationships, and procedures in a domain of interest. Each consists of elements that work together in helping people. An expert system is only one of many different systems that, with properly trained users, can be powerful and versatile. Chapters to follow discuss technologies that bring all the elements together into a "systems" approach to knowledge engineering.

Endnotes

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Chapter 4

Visualization Systems

Introduction

In any situation, there exists the need for more-detailed explanations than can be reasonably conveyed by words. Words, in this sense, slow the process to an utter and complete standstill until (1) the words communicated from point A to point B are known to be appropriate and technically correct; (2) they are received and acknowledged as those sent; and (3) an understanding of both parties exists about the message. This understanding, or lack thereof, creates the environment for a visualization system (VS). VSs generally consist of:

- Text or data
- Graphics or images
- Sound or music
- Other (smell, intuition, and so on)

The first two systems are presently in use in many conventional computer programming environments. Sound and music are increasingly being used in videodisc computer training systems. Sound and music are clearly required enhancements for effective communications to facilitate the efficient transfer of information.

The last category is futuristic, to the extent that pheromone generators and receptors will be required in order to allow a machine to smell or think intuitively. However, because many job occupations require an accurate and perceptive sense of smell, either in restaurant applications or hazardous environments, this technology will emerge over time.

VS development is presently limited to advanced computer-aided design (CAD) systems that automate the drafting process. However, CAD systems have quickly evolved to the point where the simulation aspect of design is as important as the design itself. In order to provide a viable design, many simulations are required, which can yield a better design as well as a greater understanding of the options available during the design process.

This conceptual or visual approach to design is a creative breakthrough, enabling the designer to maximize or minimize any possibility. For example, the ability to simulate and predict test bridge loading-factor stress points for component, group, or system failure has led to new designs in the areas of architecture and automotive technologies, and will continue to do so. The trend toward automating many simulation systems will also create new design options.

VSs are being used in weather analysis. Weather, although certainly a mathematical concept, is also one of the most dramatic visual entities of the earth. It is the unpredictable nature of weather that requires intense research and study, and creates the need for computer or VS usage in order to be understood. Due to the enormous daily impact of weather, its predictability and the potential for its modification are vital on an economic and survival level. Therefore, as the capability of VSs to simulate alternative weather situations increases, so does that of the weather researcher.

VS approaches to many management functions are often limited to models of the physical world, such as cars, rainstorms, and buildings. It is, however, the evolving ability of VSs to model and simulate nonphysical situations that is exciting.

Decision-making is considered by many management experts to be a process incapable of automation. For the sake of argument, we will assume this is true. Decision-making and problem-solving are very personal activities, according to my research findings. In a random study of executives, the question was asked, "How do you make decisions?" Unequivocally, the answer was similar to the following response: "I gather all the facts and listen to all sides, issues, points of view, and perspectives. Then I might sleep on it. And I usually make a decision about what to do based on my gut feelings." This is how the world runs—on intuitive feelings about what to do or how to act.

VSs have great potential for simulating visual, decision-making, or problem-solving environments. The issue is not one of VSs being used to make decisions, but rather of learning how decisions are made. It is then a subtle and simple extension from simulation to reality.

VSs are also quite capable of coping with intuitive processing. Artificial intelligence and expert systems exist to solve problems beyond the scope of conventional computer programming, such as medical diagnostics. There is the need to develop systems which cope with the fuzzy or wild-card problems that exist. There is an interesting trend emerging which suggests that as new problems arise, their impact must be understood by an increasing number of people. These problems might only exist for a moment, as in the case of Delta Airlines Flight 191, which crashed in Dallas due to momentary wind shear. Other problems, such as toxic waste, are so complex that society has, as yet, been unable to develop effective solutions for them. VSs might not be able to solve these kinds of problems, but they might provide insight. The information is fed into a VS and translated into images for use in studying such events.

In this sense, VSs offer the greatest potential for automating situations that require enormous amounts of information and the ability to learn as one goes along. This is a rather human-like and conscious effort; these systems interface with their environment much as humans do.

Conceptual Information Processing

VSs offer not only *a* wide variation in image collection, simulation, and complexity, but also a wide range of ergonomics. In communicating thought, text or language-based systems can offer concreteness in reducing the level of ambiguity in the communication. Graphic technology can offer simple yet ambiguous interpretations. AI and expert systems can arrange or configure the environment to reduce the ambiguity in terms of options. VSs can only offer ambiguous environments. The problem is to address the goals for the various machine-based technologies and to develop operating environments for which they are best suited. Although a foot and a hand have certain distinct similarities, they are best suited for dramatically different functions. Can you imagine running a four-minute mile on your hands? No doubt hands could evolve to run, but what would you do with your feet?

VSs are better suited to specialized applications, including interface technologies. As mentioned earlier, interface technologies understand and enhance the human sensory organs for better communication. VS concepts will evolve beyond basic terminal screens to holographic immersion environments. However, the challenge is getting from here to there. At present, millions of people sit daily in front of computer terminals that are mostly black and white (green or orange). Like the early Model-T cars, they are only available in two colors.

We have only begun to explore the possibility of other interface systems. What do we need to know now in order to develop advanced systems that address how technology can be used to enhance rather than replace human thought processing in decision-making and other human pursuits? In designing these systems, it is often the approach rather than the activity that is the challenge. Menus, commands, and mice are all effective interface tools if one knows the process or the sequence of operation. See Figure 4.1 for an example of a window presentation system. Few people are intimidated by a light switch if they know the outcome of the activity. However, most current state-of-the-art software systems assist the user in understanding the concept behind the activity through on-line help and user manuals, but few give the user strategies for understanding the fundamentals. People make toast every day without knowing how electricity works or giving a thought to how it gets from here to there. As new expert or AI system technology is developed, it should be directed toward getting the user into the working environment of the system.

These VS software concepts are driving the process but are also altering the approach to work as well. As Bill Spencer put it, "Software is changing the way people work, not enhancing it."[1] This reflects a dramatic shift from a fundamentalist's view that the tool only enhances the speed of the work, to the dynamic perspective that the tool alters both the process and the outcome. As mentioned elsewhere, the technology is moving from the inductive stage (light switch) to the deductive stage (what if?) in its evolution. As VSs emerge, the process will evolve to a third, intuitive stage. As this intuitive stage emerges, the intuitive process of the machine will rapidly increase. This prediction is based on the assumption that as interface technologies improve, whether through visualization systems, AI development, or new behavioral approaches to computing, the difference between the human and the machine will blur or fuse. This fusing is necessary if the machine is to be of increasing assistance to people in their jobs. The machine will have to be closer to understanding (knowing) its user. Our approach to this process is coming

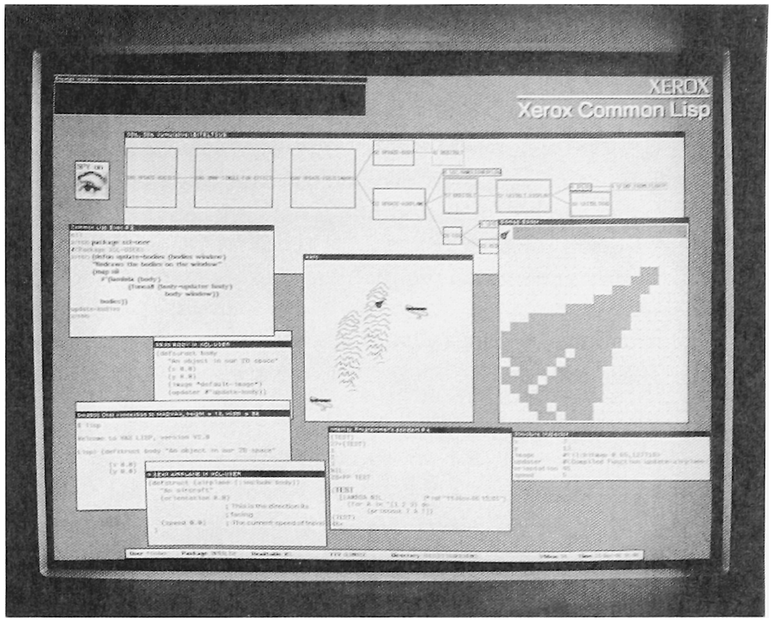


Figure 4.1 An example of a window presentation system. Photograph courtesy of the Xerox Corporation.

from the development of the videodisc. A videodisc currently has the capacity to store 10^{10} bits of information. Given the current bit rate for video transmission, which would be the mechanical equivalent of the eye and the current life expectancy of 70 years, it is estimated that to store every second in a human life would require approximately io$^{1315 +}$ bits of storage, which at the current pace of technology could be stored on one videodisc within ten years. That is to say, the pace of technology is such that within a short period of time, systems will be available to track every activity that we might want to save or, rather, process in a knowledge engineering system, which can then be modeled, communicated, organized, and processed any way we might choose. The ability of a system or systems to process this information into patterns, hierarchies, data bases, networks, charts, and the like might well go a long way toward machines' understanding of human behavior and human understanding of themselves.

Spatial Reasoning

Developing methodologies for VSs is a vital step in constructing thinking models. It requires that the developer think or design the thinking process in visual rather than textual formats. Some scientists use the **cognitive map approach** with X-Y coordinates. Decisions lie either to the right, left, up, or down on a cross axis. While such a map places ideas and decisions in one discrete location, CROSS/POINT uses a relational approach. These two methodologies attempt to address both definitive thinking and nonlinear "fuzzy" thinking. The use of pathways or routes through the network is a typical process for the user-designer. Figure 4.2 shows how various elements can be connected into a network. As mentioned earlier, the recreation of the decison-making process in visual terms is complex and requires that the developer understand the problem from as many different perspectives as possible. Charts or maps of these pathways represent conceptual rather than factual information. Within a chart, down to a crosspoint, the user can explore various knowledge bases like books in a library. The disadvantages of this kind of thinking are:

- Charting is not an exact science. It is a nonheuristic approach. Thus, for certain absolute conditions, this system is not recommended.
- Close relationships are not always connected or recognized by the designer. Moreover, very large charts can be too time consuming or complex for simple user interaction and access. Additional learning strategies to know how to chart processes are therefore required.
- In simple charting systems, the pathways cannot be tracked, so tracing systems or features are necessary for the next user to know how to get from here to there. These trace features also become design strategies that can further complicate the design process. Moreover, the ability to examine the chart from a number of different perspectives does not necessarily mean a better decision; it just means more options to choose from.
- The concept of error is not eliminated or even reduced. Charting systems allow for complex multidimensional, visual, and cognitive, nonheuristic knowledge processing. This does not mean that greater reliability is achieved because, as with the brain, more pathways lead to greater ambiguity and fault-tolerant thinking.

Communication Theory Versus Information Theory

Much of the interest about theories has to do with believers. They either support the basic theory or argue that it has no merits. Information-theory followers argue that "general information theory is concerned with the problem of measuring changes in knowledge."[2] In its simplest form, communication theory is concerned with the movement of information from one place to another or, simply, the

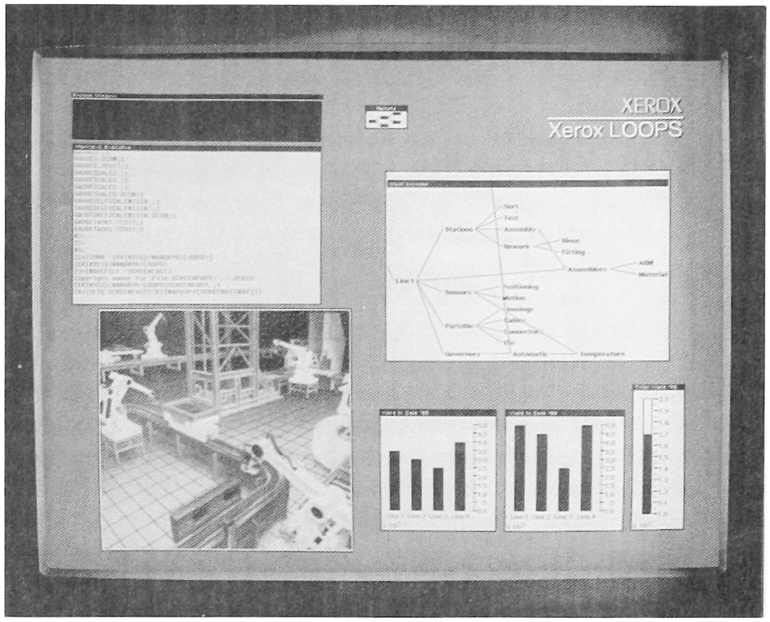


Figure 4.2 Various elements can be connected into a network. Photograph courtesy of the Xerox Corporation.

duplication of it. At this point in our discussion, we are not concerned with the content of the message, only that it exists.

The Theory Bake-Off

In communication theory, the critical issue is the transmission of information in the most economical and pure form; that is, get the information to its destination fast without damaging or distorting its content. Merely by reading a letter out loud, the meaning can change. In the same way, sending information across a communication channel does not ensure that the meaning is transmitted as well. Communication engineering technology has to do with the ability to take increasing amounts of information and condense or code it and still be able to unpackage and understand it. Information theory, however, is concerned with measuring changes in knowledge. Change is a complex term. The degree and velocity with which change takes place can affect the impact of that change to a greater or lesser degree than might be necessary or desired. At some point, we have all been bombarded with too much information too quickly, leading to indigestion of the brain.

Communication theory is not concerned with the content, only with the carrying of the message. The situation can become complex, though, if additional information is needed to make sense of the message. The message is properly understood only after communication of the desired activity or decision occurs. But this part is easy. Try designing a machine that accomplishes the same activity within the same constraints.

One argument is that the machine equivalent theory remains the same as the human counterpart, thus:

Machine Equivalent Theory =
Communication Theory X Information Theory

if the desired action remains the same. In real situations, whether the amount of information itself or the communication channel needed to supply that information are equally important is disputable. We can begin to look at measuring the changes in knowledge, and develop a machine information theory.

Entropy

In *Consciousness: A Philosophic Study of Minds and Machines,* Kenneth M. Sayre defines information as "a mathematical characteristic of an event selected out of a possible set of events, each of which may be assigned a specific probability of selections."[3] This quotation suggests that information is a free force in the universe and that its use or capture is only a matter of proper selection; little is assumed about the specific nature of the information.

Other AI theorists argue that information is only important as a function of its entropy, not of its value, entropy defined as the opposite of information or the relative decline of the usefulness of information into noise.

In addition, there can be a mathematical relationship between various pieces of information, if not an actual formula. This is the "i before e, except after c" theory, which in language and information shows that probability plays a significant role in the selection of each successive term. This theory yields a series of values associated with each set of circumstances. Simply put, grammar rules yield language, which can be powerful (e.g., We, the people . . .), trivial (e.g., groovy), or incomprehensible (e.g., vgoce).

Entropy is always at work over time as well, to wit, yesterday's news. As with the bottom-up approach, information is defined only in terms of its relative entropy, not its potential value.

This way of thinking leads to the information channel approach, which suggests that information by itself is worthless and meaningless and can hardly be defined. This goes back to our "weather theory" of information, which suggests that knowing what exists now is only important in relation to what it is going to become. For Sayre,

> An information channel consists of two sets of possible events, each member of which is related to every member of the other by a specific conditional probability of occurrence. The expression information channel suggests a medium for the communication of information.[4]

Thus, "good" can only be important in that it is not "evil"; "on" has value only as it relates to "off." Measuring the value of information as it moves from one point to another is a key issue. If it is true that for information to exist and have value it must cross from point A to point B, the communication channel adds value aside from the intrinsic value of the information itself. However, if the communication channel adds only some amount of entropy, it can cause the information to lose its value.

If it is true that information alone has value, communication either adds to or reduces that value in the communication process. In communicating information, a loss of value is only possible under other circumstances, such as in the case of entropy. However, information is always in communication; it cannot exist without communication. The mere acknowledgment of information assumes that it has been communicated.

In any study of communication there exists noise, which can be valueless communication. Sometimes the absence of an activity can have significant information value if what is being measured is the time between certain events. Any amount of information can be important in achieving the desired activity. Also, it is the elimination of information, or forced entropy, that is often needed.

Most systems are designed to eliminate unnecessary information in order to reach the desired activity or decision. Most bodily functions require only a certain amount of information in order to perform appropriately. Too much muscle stimulation, light in the eyes, or words spoken at a high rate of speed yields entropy. Information overload (glaze) is often mentioned in reflecting on the vast amount of information available today. This can, in fact, be more of a physical limitation of the body than is currently understood. Human evaluation might need to occur before humans are able to adjust to higher thresholds of information flow (inflo). The human, in this instance, is an entropy device shifting, filtering, or otherwise significantly reducing the amount of information in order to survive.

Machine Intelligence Technology

In robotics, a great deal of research has to do with the recognition of objects, or seeing. The process of the robot seeing is generally performed by a video camera. At present, these devices do not see in the same way as humans. The point is not that robots cannot see or recognize, but that machines perceive objects differently from humans, a reality which should be compensated for. Perhaps machines should be developed in machine terms, not human terms. They will need to react differently to changes in their environment, and how they perceive the resultant changes in their knowledge bank will affect their own activities.

Operating in a machine environment allows humans to design additional theories and applications that suit their models of the world. As MacKay notes, "Events of perception are what we know primarily, and what is organized as we receive information is our conditional readiness to match the pattern of events of perception by the pattern of our own internal or external reaction." In simple terms, activity is more or less a matching of patterns, which then leads to appropriate behavior. Artificial intelligence can be represented in many different patterns such as in Figure 4.3. In addition, as these activities and corresponding patterns are repeated, a history is established, and generalized conclusions can be applied to similar situations.

The problem is that humans are designed for a wide range of ambiguity and deviation from existing patterns. Machines, however, are not designed for tolerance, ambiguity, or possible deviation from the norm. Thus, either humans need to become better organized, which seems unlikely, or machines must be designed with more options. Without taking a scientific poll or making a Delphi study, the evidence suggests that it would be easier and more desirable to make machines more like humans than the other way around. From a biological perspective, it might be genetically possible to engineer a "better" human, but the hotly debated

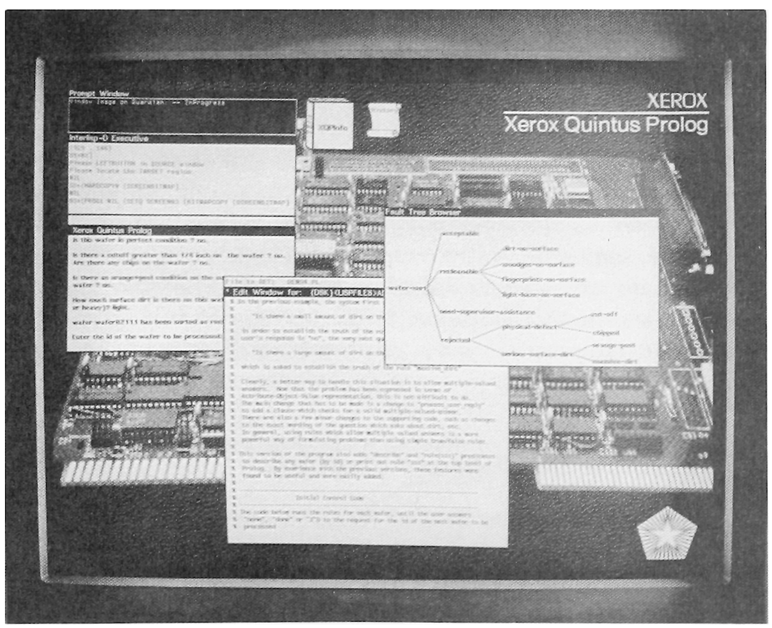


Figure 4.3 Artificial intelligence can be represented in many different patterns. Photograph courtesy of the Xerox Corporation.

social and moral issues concerning this process are not yet considered a part of the machine engineering discipline.

Summary

In a machine intelligence technology environment, meaning can be many things. Most machines have the advantage over humans of not needing sleep, getting tired or bored, or having built-in biases. These advantages make machines desirable for certain activities. In looking at the concept of meaning in machine environments, machine communication theory has to do with the technical and physical realities of machine readiness and the ability to receive the information transmitted. Whether the communication contains the appropriate content is immaterial at this point.

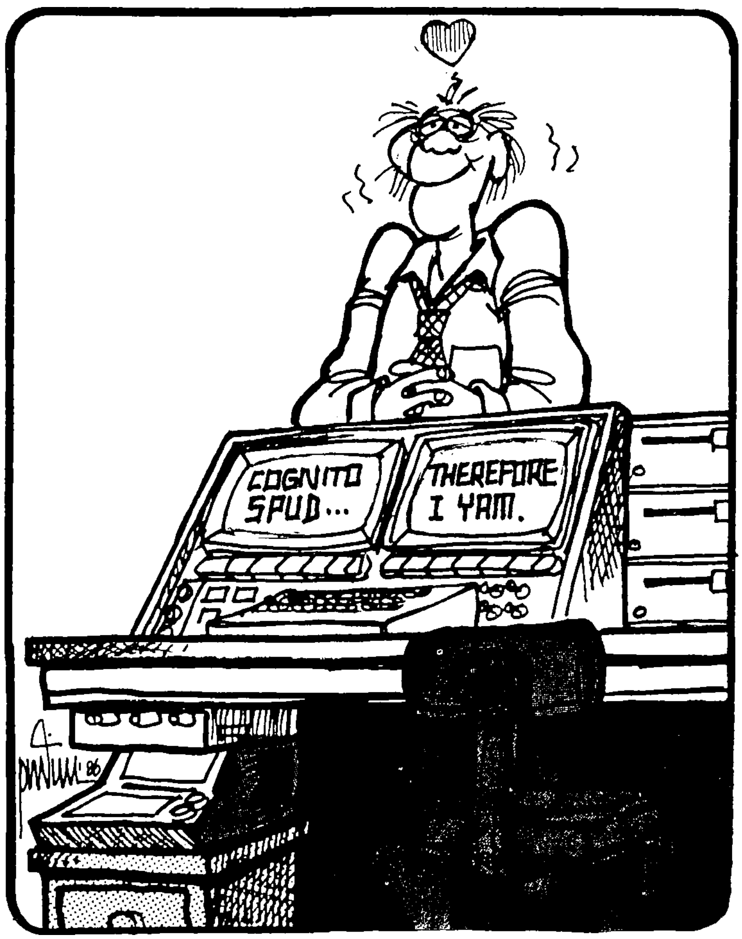
Machine intelligence technology must also cope with the process of desired, it not required, information entropy. This process, like basic information theory, is one of comparison. Some call it pattern recognition, whereby all new information is compared against existing sets of information or mental patterns. Thus, information is only as good as the information already known. The process of knowledge is entrepreneurial in that useless information is continuously and persistently eliminated until only the desired information or pattern remains. At this point, the process of recognition is rather simple. This is a somewhat negative approach to the world, in that it assumes no beauty until all the waste is gone, rather than encompasses all the beauty and ultimately the waste.

Endnotes

1. Bill Spencer. Personal interview. 1986.
2. Donald M. MacKay. *Information, Mechanism and Meaning.* Cambridge MA: MIT Press, 1970, p. 42.
3. Kenneth M. Sayre. *Consciousness: A Philosophic Study of Minds and Machines.* New York: Random House, 1969, p. 152.
4. Ibid, p. 153.
5. MacKay, op. cit., p. 61.

Chapter 5

Artificial Intelligence



Introduction

Each stage of development takes a different path. The mind, however, seeks to build interlinking paths over which ideas can flow. New paths link together to form different and more complex ones. As the fundamental level of learning is increased, increasingly complex pathways are formed, yielding profound change in thought patterns. Change and velocity of thought are key factors in complexity. Change can go as unnoticed as the withering away of roads, or be as profound as a beach eroding under relentless waves. Similarly, velocity is often imperceptible. Combining these factors can bring about catastrophic disturbances in the mind.

In *Modeling of Thinking and the Mind,* Asomov states that this kind of pathway yields increasingly complex networks.[1] In turn, these networks join with comparatively simple factors to yield more complex systems.

Artificial intelligence, or the intelligent machine, is a complex subject, which evokes as much passion as a religious sect. According to the AI research community, if you ask the average man or woman what **artificial intelligence** is, you would probably get little insight as to what it *really* is. This discussion on AI represents my view, concluding five years of research in this still-to-be-understood industry.

In his preeminent work, Asomov builds a case for artificial man:

> The possibility of creation of an "artificial man" is theoretically possible, a man who possesses all the entire programs of the prototype, but this would have to be built of technological and biological elements. In man, insofar as his structure is rigid, the principle of self-organization is not expressed, and only in the cerebral cortex are new functional structures formed, owing to the selection of many redundant connections.[2]

Asomov then raises the issue to a higher level and suggests:

> The upper level of modeling must be contemplated in a similar manner. In reality, any given system, no matter how independent it may appear, is a part, or element, of other higher-level systems. Its life programs depend not only on its particular structure but also on the high level and neighboring systems.[3]

Concerning futuristic models, Asomov projects that "it is necessary to know both its structure at each given moment and all influences which await it in the future, and which of these will alter this structure and thus its subsequent programs."[4]

In an earlier discussion on fundamental systems, I introduced inductive, deductive, and intuitive systems. Old mechanical systems had few control mechanisms built in to ensure they would not go out of control. Control meant that a device could manage some or all of the other variables, such as valves, over time to maintain normal conditions. Control also meant that the system was aware of inherent weaknesses and could either act or react to correct them. As Stafford Beer in *Management Sciences: The Business of Operations Research* points out,

> The steam governor . . . does not rely on separate inspections, nor does it initiate a series of events any one of which may go wrong, nor does it include several time lags of which escaping variables may take advantage. It is an implicit controller: variables are brought back into control in the act and by the act of going out of control.[5]

This concept of continuous analysis and skepticism about the environment is critical in designing new artificial intelligence (AI) systems. Much of the research, as pointed out, has to do with designing systems that mimic or act intelligently. In this vein, systems are expected to act within a range of accepted behavior. Systems that require intelligence also require some form of governor to which behavior can be compared. As Beer notes,

> Governors, or implicit controllers, depend for their success on two vital tricks. The first is continuous and automatic comparison of some behavioral characteristics of the system against a standard. The second is continuous and automatic feedback of corrective action.[6]

AI Systems and Variables

Any system, from management to shop floor control, requires behavior comparison and feedback methods to function appropriately. As the variable numbers and types increase, the nature of the behavior increases, too, making control nearly impossible. Thus, the challenge is to design systems that opt for the widest number of variables, rather than just a few. Beer provides an example of the complexity of communications networking. Suppose you have six people in a group. One of the members is the leader, who asks that each person respond to a new policy. In addition, each person is asked to provide a copy of their response to each other. How many messages do you have? One answer is 30. Beer supplies another answer in the form of a diagram which shows the in path of four orders among six machines, or processing steps (the communications network), in a jobbing plant. The route of each order is determined by the particular requirements of that order; there are 720 possible orders in which all six machines could be used.

This represents a simple situation that by machine standards would be an extremely complex problem to solve. In order to design new AI systems for use in a real-life environment, a view of existing systems is appropriate. The point is to understand the vast complexity of simple problems that might not be resolved by machine technology. Certainly, statistics and model simulations bring us closer to the problem. However, even two- or three-step processes can have a sufficient number of variables to result in a task not being cost-effective. In machine technology, designing for ambiguity is beyond the capacity of the machine, not to mention the designer. Conversely, the speed and accuracy (if possible) of machine technology allows for sufficient comparison and feedback to the point where machines can replace human monitors.

Machines can cope extremely well with large numbers of variables, as well as their exceptions, up to a defined limit set by the human governor. The machine can quickly narrow the number of variables to a point where a human can decide the choice of action or outcome. Certainly, this is the function of steam governors or their close relative, the escape valve. This approach to AI is not always economically or technically desirable, and such systems might be better used for continuous comparison environments where intelligence provides the feedback and analysis concerning the task. They could also be used to closely define future actions and the manner in which new or existing variables should be dealt with.

A friend once suggested that one certain way to get rich would be to go to the U.S. Patent Office and look through all the old mechanical patents to see which ones could best be applied to computer technology. By understanding old systems and determining from a mechanical point of view how problems were solved, one might gain valuable insight into the development of new computer systems. The computer started simply and became quite complex in a very short time, and will be ever more complex in the future. It seems an expectation exists for AI to solve very complex problems immediately, but today a back-to-basics approach might be more important than ever.

The Effective Procedure Model

Effectiveness is concerned with the success with which the meaning conveyed to the receiver leads to the desired conduct. At first glance it might seem undesirably narrow to imply that the purpose of all commmunication is to influence the conduct of the receiver. With any reasonably broad definition of conduct, however, it is clear that communication either affects conduct or is without any discernible or probable effect at all. The problem of effectiveness involves aesthetic considerations in the case of fine arts. With speech, written or oral, it involves considerations that range all the way from the psychological and emotional aspects of propaganda theory to the value judgments that are necessary to give useful meaning to words such as "success" and "desired." The effectiveness problem is closely interrelated with the semantic problem, and overlays it in a rather vague way.

The theory of effectiveness is useful not only to prove things about complex systems but also to prove things about proof itself, as shown by Turing's thesis: Any process that could naturally be called an effective procedure can be realized by a Turing machine.

In discussing computers, we must also examine the process by which Turing established his theory. Many contemporaries and followers provide insight into the impact of Turing's work. Marvin L. Minsky, a renowned professor of electrical engineering, talks about Turing and his theory in his book, *Computation: Finite and Infinite Machines:*

> Perhaps the strongest argument in favor of Turing's thesis is the fact that, over the years, all other noteworthy attempts to give precise yet intuitively satisfactory definitions of "effective procedure" have turned out to be equivalent—to define essentially the same classes of processes. In a 1936 paper, Turing proves that his "computability" is equivalent to the "effective calculability" of A. Church.[8]

Minsky, who is now one of the leading experts in AI, considers thinking to be within the scope of effective computation, and wishes to warn against subtly defective arguments that suggest that the difference between minds and machines can solve the unsolvable. There is no evidence for this. Minsky points out, however, that one cannot expect to prove Turing's thesis because the term "naturally" relates more to human disposition than to any precisely defined quality of a process. The issue before us is not one of human disposition, however, but one of language analyzed in terms of compatibility, where one recognizes that there are many things taking place at the same time. Other researchers in AI have approached the problem from other perspectives such as psychology, linguistics, and learning theory.

Solving well-defined problems

Learning is a form of problem-solving, where the objective is to find the form of behavior that is most effective in approaching a particular goal. We are mainly concerned at this point with what Minsky calls a "well-defined" problem, for which there is at least one precise solution and a way to determine whether that solution is acceptable. The problems tackled by learning systems can be ill-defined because the system cannot usually determine whether the current mode of behavior is the best possible one.

Methods for the solution of well-defined problems depend on heuristic rules. Because there is a way to test any proposed solution, problems could, in principle, be solved by searching through all possible forms of solution. The number of forms is so vast for any worthwhile problem that such a search is not possible unless some rules can be applied to select search areas that are likely to be fruitful. Heuristic rules are, in fact, systematic ways of forming "hunches" whose correctness can be rigorously tested.

Support must come from intuitive argument, and we can hardly do better than to discuss the impact of this premise on words and communication. It is in this gray area of communication that we can use computers to provide heuristics.

Turing did begin to think of computers as having mind-like characteristics. In this vein, it seems appropriate to quantify communication in terms of symbols transmitted over, and received from, a communications medium, which is Shannon's thesis. Yet, it might be that the understanding, or the computation, of these symbols is the essence of the process.

This process is similar to oil refining, in that the system is sifted and resifted into smaller and smaller particles until each of the elements can be examined by itself. Then the system can be reconstructed and, thus, organized into another system. Communication can be rigorously pursued in this way as well. The problem usually comes in capturing the communication; at present, the human mind is the only tool available that can do this.

The universal computing machine

To characterize the effective procedures, however, we have a remarkable tool: the universal computing machine. It turns out that a Turing machine exists that can imitate the behavior of any other Turing machine, given an adequate description of the structure of that machine. As Minsky notes:

> We may be able to decide, for one reason or another, that certain machines will work, and that certain others will not, but we will never be able to put this on a systematic basis which will work for all machines. I regard this, and similar other "undecidability" results, to be among the most significant intellectual discoveries of modern times. One can reject its implications by rejecting Turing's thesis, but there is no apparent prospect of any satisfactory replacement.[9]

Turing gave the world a means by which computability could be understood and accomplished. Much of his work lies in the area of effective procedures, a set of rules that tells us from one moment to another precisely how to operate. Thus, as Turing so aptly theorized, any process that can naturally be called an effective procedure can be realized by a Turing machine. Turing asserted this a decade before the first electronic computer was invented. He was describing the computer as a human, which we now know can be imitated by an inanimate device. Minsky treats this man-machine issue quite nicely: "We find that certain of the questions we naturally ask about machines cannot be answered, at least by any effective procedure for answering questions. It could be argued that there might exist definite processes whose communication requires the transmission of a mental attitude, or disposition, that cannot be captured in any finite number of words—which must remain intuitive.[10]

These questions are associated with the ideas of an algorithm, an effective procedure for calculating the value of some quantity or for finding the solution to some mathematical problem.

The idea of an algorithm arises whenever we are presented with a set of instructions about how to behave; for example, in the course of working on a problem, we discover that a certain procedure, if carried out, will result in our finding the solution. The task of problem-solving is reduced from a matter of intellectual discovery to a mere matter of effort: carrying out the discovered procedure, obeying specified instructions.

How does one know, given what appears to be a set of instructions, that these instructions are correct? How can we be sure that, henceforth, we can effectively act in accord with the rules? The answer is easy if the process is supposed to terminate in a predetermined, finite time period; we just try it and see. In some cases, we can simulate the problem, or have another source attempt it.

Effective procedures

In precisely defining effective procedures, one encounters various difficulties. Minsky suggests we can avoid the pitfalls of interpreting and understanding the problem in the effective procedure if we specify, along with the statement of the rules, the details of the mechanism that is to interpret them. This would leave no ambiguity. He suggests that the most convenient formulation would be one in which we set up (1) a language in which sets of behavioral rules are to be expressed, and (2) a single machine that can interpret statements in the language and carry out the steps of each specified process.

We might develop schemata that examine the unique properties of words applying Turingesque considerations. These schemata would include set analyses, simulation predicates, encoding sequences, flow charting, recursive functions, matrices, and others. It is interesting to note that both Roger Schank and Neil D. Jones, in *Computing Theory,* appear to take the chartist path of word analysis. Their paths are not exact, but both appear to analyze the issues in the same fundamental way.

What these people (and many others) are trying to comprehend goes beyond the mere cognizance of words. Machines can consume words by the billions, but no computer is able to grasp the meaning as well as a small child would. Now, this discussion is not about intelligence, but, to a certain extent, when we convey information or ideas, or communicate, we are in fact transmitting intelligence. Certainly, in designing software, we are faced with this dilemma.

In *Grammatical Man: Information, Entropy, Language* & *Life,* Jeremy Campbell clearly takes an approach that is in the spirit of this discussion:

> It is generally agreed that there must exist a "syntax" of memory. Information is easier to remember when it is in an orderly state, rich in pattern and structure, highly interconnected, and containing a good deal of redundancy. Disorderly information that lacks structure is easy to forget.[11]

Campbell suggests that relationship and pattern are the key to the device of remembering.

Using the patterns at hand, Mark Twain, when giving a speech in a strange town, would walk through a park beforehand, imagining the ideas for his speech seated on a park bench, hung from this tree or that, or attached to a fountain or a bandstand. Twain was then able to talk for two hours at a time, without using notes, by strolling through the park in his imagination, "seeing" his ideas in their correct sequence.

In remembering, the brain does not like disarray. Clearly, as suggested earlier, the brain does not simply store sequences or words as it hears or reads them. Even though all the sentences in a list might contain the same number of words, they are not remembered equally well because their conceptual structures vary in complexity. As it has been shown many times, people rarely remember written or spoken material word for word. When asked to reproduce it, they rephrase, which suggests that they are able to store the meaning of the information, rather than a copy of it, in the mind. Information is stored according to the way in which it will be used, consciously and unconsciously.

Thinking about information adds depth to the experience; we can, at will, increase the impact of the event. Shannon might agree to this premise, suggesting that nothing is conveyed until something is changed in the receiver's knowledge. This goes beyond the transmitter-receiver issue for which he is most famous. Shannon and Weaver devised a theory that information must not be confused with meaning. Two messages, one which is heavily loaded with meaning, and the other which is pure nonsense, can contain roughly equivalent information content. This work in communication theory relates not so much to what you say as to what you could say. Weaver points out, in examining effective procedures, that information is defined as the logarithm of the number of choices. In unfolding the theory, though, it becomes obvious that logarithmic measures are in fact found throughout nature.

Simple Becomes Complex

As with any subject, the more study that is completed, the more complex the questions become. In developing a new theory of computable words, we must consider a natural order of words that fall into patterns that can be computed without exacting punishment for failed comprehension of all the possible derivatives. A natural structure is one in which the information source makes choices from a set of elementary symbols. The resulting sequence then forms the message. At least there is an effective procedure, or algorithm, that can be used to organize our thoughts into a stream of consciousness by which we can then act. Shannon might fully expect a defined, if not proper, action on the part of the sequence. Processes have been organized according to certain previous probabilities; these are called **Markoff chains. In** certain roles, heavily structured through these Markoff chains, situations can exist where there is only one course of action. The probability of that action must have been determined to be nearly 100 percent. From a business perspective, AI will be a long and involved process that will become one of the greatest business opportunities yet invented.

Shannon notes that the redundancy of the English language is about 50 percent, which accounts only for the statistical structure out to about eight letters; therefore, the ultimate value is presumably higher. About half the letters or words we choose in writing or speaking are under free choice, and about half (although we are not ordinarily aware of it) are really controlled by the statistical structure of the language. If you add any environmental structures, ranging from management situations to lunch at the coffee shop, you probably add another 30 percent or more, leading to many situations where there is one effective procedure possible.

Without a long discussion of entropy and channel capacity, we can find even more computable situations that can easily accommodate most responses required by the receiver-transmitter (talk-listen) environment. Conversely, there is a low probability of predictability in the areas where aesthetics abound, such as art.

In Campbell's discussion of William R. Bennett and Gatlin, a context of probability is applied to randomness. In certain cases, there are two different kinds of redundancy. Both kinds lower the entropy, but not in the same way, and the distinction is critical. The first kind of redundancy, which can be called Dl, is the statistical rule that some letters, on the average, are likely to appear more often than others in a passage of text. Dl, according to Gatlin, which is context-free, measures the extent to which a sequence of symbols generated by a message departs from the completely random state where each symbol is just as likely to appear as any other symbol.

The second kind of redundancy, D2, which is context-sensitive, measures the extent to which individual symbols have departed from a state of perfect independence from one another. D2 also makes the sequence of symbols predictable because it sets up a relationship between letters. As a result, it is often possible to guess what the next letters in a sequence are. Campbell suggests that context-sensitive redundancy is not as restrictive as context-free redundancy. Context-sensitive redundancy does not restrict the message to only a few letters, as does context-free redundancy. English is higher in context-sensitive words (words that mean different things in different contexts) than in context-free words (words that have only one meaning in any context), which accounts for the rich variety in the language, and its excellent readability, even when distorted by misprints and mistakes.

To be truly effective, AI must be able to process information in a language environment that is internally consistent, capable of human processes (logical and emotional), and able to translate results into a language humans can understand.

Gaming

Within any organization or environment, games are played in nearly every interaction or transaction. For example, in making a purchase of goods or services, people will buy if the price is low enough. Yet, regardless of the quality, if the price is too low, many people will not buy because they feel that if a product is inexpensive it cannot be worth much.

All societies have physical games of strength, endurance, or maneuver. In the agrarian period, nearly all games were of a physical nature. However, as people came to have free time and the mind was often bored, new games were invented. Some of these games still exist today.

These games simulate different events. Chess can simulate fighting a battle, whereas Monopoly can simulate running a business. The relative value of a game depends on the situation. Government defense agencies use games to anticipate potential outcomes of military, diplomatic, or terrorist activities. Corporations use games to better understand business and to develop successful business practices; for example, financial spreadsheet programs allow managers to change assumptions and understand where profit points are. These tools can steer the directions of corporations, giving companies a strategic advantage in a competitive marketplace.

The movement of games from the purely clinical world to the social and business worlds has been aided by the popularity of computer games. Computer games, beginning with the famous computer pingpong, allowed society to form a basic knowledge and experience of games in a technological sense. The pace of these first computer games was certainly different from pinball and board games, with the manner of interaction also quite different. Apart from the visual graphics, these games are generally one-to-one, person-versus-machine, which might account for their being short-lived. Although they offer powerful and limitless graphics displays, the challenge of interpersonal relations is lacking.

This lack suggests that a different kind of game is necessary to simulate corporate environments. Corporate success is often simply a matter of gamesmanship, with many executives continuing to believe this a function of physical sports rather than games of strategy. Some corporate strategies are thought of as business versions of football, Softball, basketball, or another group sport. Certainly, the metaphors are there for the choosing.

Whether a corporation is actually run like a sport is immaterial, but the successful corporation, in reality, operates best as a team under rules set forth by ethics, the marketplace, or leadership. Corporations will need to continue this practice in order to grow. Companies that fail to incorporate such methods into their operations might fall by the wayside.

Utilizing games upon which to model organizations might be one of the most powerful resource management tools available. Resource management entails all the assets of the corporation, both human and raw goods. Vertical integration of raw goods to finished products, and horizontal integration of markets and plant operations are only two of the areas that must be managed in order for the organization to be effective and efficient. Games, models, and simulations are tools that can be utilized to look at resources, combine them into products or product markets, organize enterprises in order to build and service those products, and examine outcomes: profit, loss, position.

With organizational modeling, all of this is possible without having to risk a nickel of the corporation's resources. Certainly, it costs to perform this function; however, in comparison to the millions or billions at stake in reality, as well as the time involved, the game costs virtually nothing.

The greatest benefit might be a better understanding of corporate opportunity. Most corporations have had products or services fail because of an early or late entrance into the marketplace. In such a case, time is the neutral or mitigating factor. It is fair to all and to none. Large companies entering a market too late often lose to new companies who entered "right on the money." Time cannot be managed, controlled, or predicted (in terms of market ebbs and flows that change in uncertain or independent ways), but it can be better understood.

Many believe that games are an essential part of a total technological approach to corporate management. It is within this experimental, simulated environment that innovation can best be allowed to take place. Innovation resulting from this approach can only mean greater success, profit, and position for the company.

Gaming Models

One of the most exciting developments in management is the use of game theory. Game theory (as opposed to gaming, which is a method used in experimentation, operations, or instruction) provides the language that describes conscious, goal-oriented, decision-making processes involving more than one individual. It provides the tools for the analysis of certain subtle concepts, such as the state of information, and the definition of certain planning terms, such as choice, move, strategy, and payoff. Game theory is simply mathematical modeling. It is also multiperson decision-making. In general, game reasoning and analysis are of considerable use in constructing, discussing, and analyzing business situations and training exercises.

In designing decision-making systems, there is typically a forced trade-off between absolute solutions and approximate solutions. Economists and mathematicians use mathematical models to explain reality. In *Mathematical Theory of Expanding and Contracting Economies,* Morgenstern address this conflict:

> The idea that there is an efficient point and allegedly a unique one is unwarranted. There is, on the other hand, a welcome similarity to the solution concept in game theory, where for an essential n-person game, there are, in a solution, several, possibly infinitely many, imputations (or in some cases an n-person game and a corresponding economy may have no solution of a specified kind).[12]

In other words, game theory often poses multiple outcomes even in simple games such as chess, as opposed to reality, where methodologies and unwarranted points are sought for absolute decisions. Unlike game theory, business decisions can have billion-dollar impacts, as, for example, during an oil crisis which can lead to a disturbance of the total world economy. Game theories can offer solutions to problems that might not exist, or the solution can be outside the realm of reality. The problem can be so complex that simple elemental solutions fail to grasp the situation. In the past 300 years, the corporate world has emerged as the primary environment for human endeavor. Corporate planning and management strategies have become the new Monopoly game. The corporation allows a set of structures similar to those found in any operational model or game. It is increasingly clear that "what if computer simulations are helping business organizations focus on winning strategies. Once a simulation model has been constructed, whether it be a gaming model or a computing model, it constitutes a systematic source for scenarios providing a host of strategic alternatives and contingencies.

Computer technology and the small business

In 1950 computer technology came into existence. However, it wasn't until 1977, when two dropouts in a garage invented the Apple Computer, that computers became tools for small businesses. Since that time, personal and business micro-computers have become a ubiquitous part of society, much like the automobile. In fact, microcomputer sales are beginning to approach annual automobile sales. However, most small business computers lack the capability for doing more than a few tasks, and are primarily used for games. According to the *Washington Post,* "People use their computers only 20 percent for task activities but 80 percent for games and other personal business pursuits."

H.G. Wells, in one of his megalomaniacal visions of the future, proposed a "world brain" that, like a vast computer, would bring together all organized scientific knowledge in one place and make it available to the "new samurai," the coming scientific elite of the world, through communications networks. The computer has been critical to current management and corporate strategies, and probably will be so for strategies in the next century.

Machine-based gaming has a definite advantage over human growth: language. Computers have a standard language in a quasi-mathematical notation that is used for describing a dynamic activity. It is a language that is clearer and more precise than spoken languages such as English or French. Computer programming is a simple language. Its advantage lies in the clarity of meaning and the simplicity of the syntax. Once explained, the language of the computer model can be understood by almost anyone, and provides a means of communication that crosses traditional foreign language barriers. Furthermore, any concept and relationship that can be stated clearly in ordinary language can be translated into computer language. The essence of effective gaming is in the creation of a suitable model structure much like a computer program.

Assumptions can then be checked against all available information and can be improved rapidly. The great uncertainty with mental models is our inability to anticipate the consequences of the interactions between the players and the components of the game. This uncertainty is being eliminated through computer modeling, simulations, and computer games. Changing technology requires new attitudes and skills. Because computers are changing business and even the work that is being performed, we need to understand corporations from a new perspective. Management restructuring games and simulations is now only beginning to be recognized as one of the critical success factors in profitable organizations. Overall, management gaming will be one of the applications of knowledge engineering systems in simulating existing or future settings.

Business and home computers, communications technology, and time-sharing systems offer a solution to the problems of personnel, time, and costs. Corporations and workers connected by computer communications will be able to participate in global business game environments, enabling them to deeply understand from many angles in a long-range perspective both the nature and the implications of any problem or issue. Even advanced technologies such as AI will allow the development of advanced decision-making systems based on gaming theories.

Renewed interest in AI

In the past decade, there has been a considerable surge in the study of AI, or the study and construction of computer programs that perform tasks requiring intelligence. Generally, however, no distinction has yet been made between the intelligence required to solve difficult problems such as playing chess, and that required to resolve interpersonal problems such as bargaining.

A computer program that can play chess well requires efficient searching and calculating abilities. The nature of a computer chess game does not have any personality. Such a game has to be intelligent, but not pleasant or nice. It is possible to build an artificial player for a business game that plays in a manner comparable to a human player. The rules or heuristics needed to construct such a player call for an emphasis on interpersonal relationships rather than on the player. A nice, moderately cooperative, and not particularly aggressive artificial player in a business game can elicit cooperation from the competition and, in this case, be successful.

The literature on designing AI games contains very little on the subject of social intelligence. Currently, there is a division of opinion on the nature of problem-solving, leaving aside the subject of human social interaction. Along with the growth of interest in AI has come a considerable interest in the design of protocols and ways to describe decision-making or learning processes. Analogies are consistently drawn between how one teaches a machine and how one teaches a child.

Robots and artificial players, such as HAL 9000 in the movie classic *2001: A Space Odyssey,* allow the modeling of sociopsychological processing. This will be especially true in the distant future when the players will be machines pitted against one another and not against people.

Robotics

The essence of the state of living is better defined each day. The states of nonliving for machines and death for humans separate humans from machines. Machines do not die. In *2001,* the HAL 9000 computer displayed all the feelings of a human dying, yet few would say that this computer was ever alive. In this sense, the psychology of the robot was that of its maker. HAL was programmed to display certain characteristics and to perform certain actions when it encountered the particular circumstances indicating its end.

Do we program robots or machines to act similarly to humans so that they, too appear lifelike? Or do we relegate them to be strictly inanimate devices that perform functions so that we can remain detached?

It is probably true that some time in the future all machines will be capable of displaying an enormous range of emotions, depending on the job or function desired. A drill instructor robot might have only cold, rapid-fire commands to issue, whereas a social worker robot might need to express words of sympathy and compassion.

In *The Feelings of Robots,* Paul Ziff raised various questions concerning robots and their ability to be bored, expressive, tired, and alive. In summary, Mr. Ziff concluded that a robot would always behave like a robot.

Behavior in the true sense is the result of programming. The knowledge which you and I possess that tells us to remove our hand from a fire or not stand in the path of an oncoming train is the result of human programming by our parents, peers, and society. The issue is how a robot, like a child, can be programmed to suit its master.

Robotics might require a new approach to morality. Robots are now being tested in battlefield environments to detect and kill enemy soldiers. Are the robots responsible for the deaths? Currently, vehicular homicide is treated as a minor offense in comparison to premeditated murder, yet the outcome of the action, the death of a person, remains the same. If I send my machine out to kill you and it completes the task, is the crime diminished? Am I the murderer?

Robotics, as it applies to AI, is a new science. Westinghouse demonstrated a walking, talking robot at the 1939 New York World's Fair. Does the ability for independent movement make this type of robot better than a fixed manufacturing robot? Robots that move and perform functions might need humanlike programming tied to the need for interaction with humans. In designing these robots, we might well learn how to be more compassionate in our own behavior.

Robots will assume additional human activities as robotic technology advances. Currently, a surprisingly large number of bodily functions are being replaced with machines. In most cases, however, these machines are not necessarily intelligent; they do not recognize and interact with their surroundings. Robots will eventually become humanlike structures capable of performing operations without human limitations, such as the need for sleep, air, food, proper climate, and so on.

This discussion is not meant to be an instruction guide for building robots, or a lesson in the care and feeding of your pet robot. However, it is meant to provide an overview of some of the issues surrounding machine intelligence. Robots can be thought of as machines that have the ability to move about or to move objects about. Machine intelligence, however, resides as software or programming in a machine, and access is only achieved using devices connected by communications lines.

Given current trends in machine technology, there will be little discussion, other than for the sake of argument, about whether a device is a robot or not. Certainly, many might not think of a wristwatch system as a robot, but it might be similar to the control mechanism of a distant mining machine. Robots can then extend the power of the human in many directions and ways. Robots might be able to perform certain functions for humans that will allow humans to learn faster. They will accelerate the ability to test situations in the physical world just as other machines test in the imaginary world of games.

Architecture for Intelligence

The possibility of any one piece of information being understood on a minimal level by a diverse group of individuals is becoming rare. As has been said, communication will usually fail except by chance. Given this kind of environment, coupled with rapidly changing technological conditions, increasingly complex kinds of information, and diverse societal interpretations of information, informational architecture needs to be constructed that can cope with these issues.

Needless to say, standards are often society's worst example of accomplishing anything more than mediocrity. There exist many "camels" in the machine world: COBOL, most of IBM's operating systems, and the propensity of writers to describe AI as HAL 9000. On a serious note, however, the natural world evolved through diverse standards yielding many mistakes (dinosaurs) and many successes (dolphins).

Similarly, a number of dominant strategies have emerged through experiments in the programming world. As Donald Michie points out in *On Machine Intelligence,*

> When the program grows a search "tree" it is using an internal model to construct a plan, but when it is restricted to growing a "bamboo," correspondingly to what I have elsewhere called a "continental choice strategy," it is operating in reflex mode (a bamboo stem has nodes but no branches).[13]

Thus, many questions arise regarding the evolution of machine life: Where are we going? Which branches are dead ends? Will we know when we get there? Machines are probably in the dinosaur stage, and some cataclysmic event could result in their extinction. At the same time, new machine developments demand that some commonality exist in order for them to have practical use in the real world.

To cope with the changes that will no doubt take place, although when and with what impact is unknown, industrywide standards would be beneficial. Proposing standards initiates a long list of arguments about what elements should exist where, but it is understood that as the result of an evolutionary process, these standards might be rearranged many times before agreement is reached, if ever.

To keep this process relatively simple, I propose seven levels of interaction:

Levels of Interaction

1. Physical: the actual physical recognition of an experience
2. Interpretive: putting such experience into recognizable patterns
3. Ambiguous: adjusting those patterns for focus or open-ended manipulation
4. Thinking: associating information with other experience
5. Cognitive: active manipulation and integration of symbols
6. Contextual: prioritization of symbols, issues, action items
7. Philosophical: none of the above

In creating meanings for each of these levels, it is understood that knowledge can move from one level to another without any intervention from the other levels. Also, it is a given that each of these levels has a positive and negative element (for example, +10, 0, -10).

It is possible that humans might deal with ambiguity by cheating their way through an uncertain or unknown activity. Within each level, such elements as repetition and similarity exist that allow humans to create mental "replays" of past events without physically experiencing the event in the present, leading to confusion and ambiguity about "real" versus "imagined." The human machine has the ability to vary the elements of a particular event, thus allowing additional and more diverse experiences to have occurred in the mind than in reality.

The interpretive level focuses on the first level of understanding beyond simple recognition of what the experience or object is. For example, the physical recognition that the object ahead of us is a grizzly bear can be more important to our personal survival than a philosophical discussion of a bear's eating habits. At the same time, interpreting hundreds of details that occur in any one hour while working at one's desk requires a deeper understanding of input-output issues than is required while eating dinner. At any one time it could be argued that any of the above is true, depending on the interpretation.

Ambiguity is similar to interpretation, but it is a narrowing or widening process. Sometimes interpretation needs to be rapidly narrowed in order to make a quick decision. Visit any hamburger stand. You are faced with entering the building, interpreting and narrowing the choices, and making a decision. As mentioned earlier, ambiguity also relates to cheating, wild cards, tricks, and other skills that make the interpretive process faster or more enjoyable.

There are other mental power tools that can be compared to a vast array of computer programs. Each of these programs contains a test that the activity can be accomplished successfully. This prepackaging of skills allows us to perform many activities without ever thinking about them. Even complex tasks such as driving home from work are relatively automatic once they have occurred with some frequency. Remember that, to a point, activities can skip to higher levels. In some cases, events can be considered philosophically before any physical action takes place.

The thinking level

At the thinking level, one seeks to associate information with other experiences and events, much like the often deliberate expansion of information into realms of activity. I regard this association as the first stage of conscious thinking.

Instead of merely reacting to events, the human or machine must consider other possibilities in a contemplative process. Daydreaming or group brainstorming requires the participants to actively engage in mental exploration. The thinking level differs from the ambiguity level in such a way that at the latter level activity or reactions result from tested programs, whereas at the former level, testing of various structures is modeled. Thinking recognizes that ambiguity is desired, if not required. Also, the system is not actively engaged in activities that require immediate attention.

For example, delivering a speech, answering the telephone, and making love offer little opportunity for a discussion on the existence of life on other planets. This is not to say that thinking cannot take place simultaneously with these activities; it is suggested, however, that there are different activities for different concepts and environments. At the thinking level, the system explores how different known alternatives can work together. Thinking demands the creation of new programs for consideration or implementation. This level also copes with the queuing of information, particularly new information.

How do the terms "cat" and "dog" relate to one another? Is the light from the stars the same as that from a light bulb? These concepts are ambiguous until they are thought about and considered and become new information that has been validated in the mental framework or data base. One can react to a new situation without having thought of all the consequences. However, with experience, the nature of how one reacts also changes. The nature of thinking is an evolving issue for the human or machine. It is, however, a means of interfacing with higher and lower orders, from simple to complex problem-solving.

Within the upper realm of thinking there are a number of considerations. In order to keep the architectural scheme relatively simple, three major categories were developed: cognitive, contextual, and philosophical. Cognitive issues are similar to the physical level; they relate to the integration of complex symbols, language, visuals, and other fuzzy factors. The integration of historical influences with genetic characteristics also takes place on the cognitive level. In machine terms, the influences are not only historical but also futuristic, and include the ability to imagine future situations, not only as an extension of known facts but also as a projection of the unknown.

At this junction, the possibilities for experience are both wider and narrower. The human or machine is less able to react to any real situation. Issues become more complex, purposes more strategic, time horizons increase, and so forth.

In the contextual category, environments are created that balance the issues of philosophy and cognition. The architecture for this kind of information processing can have more to do with cataloging major and minor elements than any other particular activity. Information elements rise through the various levels to points of usefulness or action. Contextual processing assigns relative values to higher issues, and directs them toward action.

The philosophical level is the catchall for everything else. If some experience or element cannot be processed, resolved, or whatever, it can be relegated to the philosophical level. In order to escape any immediate activity, humans often respond to these conditions by saying, "I don't know." This level also copes with totally inexplicable issues: Why are we here? Where are we going? How long will I live? Machine-based systems should not be expected to resolve issues that humans are unable to answer. The philosophical level is the area where the machine can deposit these issues as well. This level might be the equivalent of a machine-based black hole. Over time, humans have the opportunity to examine the architecture or design of philosophical statements. As humans resolve these issues, they can be integrated with machine-based architectures.

Architectural standards exist in nature as they do in human-made systems. The size of a tree's root system must be in proportion to the height and mass of the tree, or the tree will fall down. The IQ test is a traditional but antiquated system for measuring intelligence with standards. Machine-based systems currently exist as dumb, inanimate objects that would not work without electricity. Yet much confidence is placed in their ability to provide expert opinions on an increasing number of issues, even life and death issues found in the medical and nuclear power areas. Nevertheless, few commonly accepted determinants are found in the computer world. There are more standards in carpentry nails than in procedures for writing computer programs.

The word "architecture" provides an opportunity to express oneself in both artistic and definitive terms. How machine-based architectures will emerge remains an unanswered question. This discussion has hopefully shed some light on the ability to distinguish major areas of knowledge engineering (KE). If the information-processing industry can just begin to look at the possibility of commonly accepted architectures or standards, the development and design of intelligent machine-based systems will be eased dramatically.

Virtual Processing

A discussion of computational linguistics leads toward, but does not complete, a theory of information processing. Computing the analysis of information through parsing directs the development of an artificial reality based on prescribed notions of the environment. This analysis suggests that the machine is rather passive in its quest for knowledge. In other words, the machine obeys the rules of the road, but does not seek to leave the road in assimilating the new experiences before it.

The next question, obviously, is how to train the machine to "fetch as well as go hunting." Currently, thinking in this regard ranges from "the dog looking for the bird and skipping the fox" to mapping the landscaping and enjoying the view. Certainly, there are few concrete and proven theorems for the processing of information, although there are some fundamental notions such as "I'll know it when I see it." This theory suggests that the brain sees and does not process information. Humans can formulate scenes from abstract images, such as found in psychological ink blot, or Rorschach, tests.

This mental mapping is a relationship of images, historical reference, contextual setting, emotional states, and a considerable number of other factors that we are only now learning about. In fact, the current study of mental mapping could fall under computer science, engineering, mathematics, philosophy, or psychology at any one university. Information processing must, in terms of humans, consider not only the obvious factors but the senses such as sight, also. Machine intelligence of the 1980s fails to process anything that is not in the program code.

The concept of **virtual processing (VP)** encompasses many different issues, ranging from real-time processing to global networking. Virtual processing is not an expert system, AI, or any other attempt at modeling the brain. Rather, VP seeks ways to allow humans to interact with machines and amplify the results, just like heavy machinery equipment facilitates the building of large skyscrapers. VP is a mental gaming process allowing the player to maneuver through a mental network of thoughts, images, patterns, abstract ideas, shapes, forms, or anything that can now be consumed by a computer. This does not represent a majority of human activity, when you eliminate food, sex, smell, touch, and a lot more. However, it is a model, like an artistic representation, such as photography, oil painting, or writing.

Virtual processing is a concept that devises ways to probe and enhance the abilities of both the brain and the machine. If the single cell of an organism can avoid destruction by moving away from impending disaster, an intelligent machine should have at least as much common sense. Moreover, VP seeks to understand the machine not in terms of how it computes information but how the information is linked or networked, and to understand the machine not so much for its intrinsic value but for how the information is used; it is as though much of the information is different rather than similar. VP incorporates ways to look at oneself through the eyes of a machine, rather than through the created image of a human.

Virtual processing attempts to cope with the issue that humankind is becoming quite complex, advancing more rapidly than time or physical evolution, not to mention mental development, has previously allowed. Humans, it seems, strive for more complexity, not less. Our thermostats are now controlled by computers, therefore freeing us from homes that are either too hot or too cold at the wrong time. Humans create complexity out of chaos. Machines reduce the chaos into explicit, containable systems functioning to reduce errors, stabilize environments, and improve the quality of life. The processing of chaos is an insurmountable task. However, capturing some part of it for any amount of time can give us a glimpse of the greater whole. Much of AI thinking involves more how to consume and process vast amounts of data. By overlaying considerable and expensive software systems, the entire experience attempts to reduce the error in the problem at hand by some statistical amount. By creating, in this logical sense, a language, we have formed the basis for a communications system. VP is thus a communications environment and not an information-processing one.

The concept of VP

The concept of VP is based on a large number of issues, including charting, developing a system of learning and understanding, as well as memorizing. In simple systems, such as the early telephone exchanges, communication was based on one-to-one connections; as the network grew, the potential number of connections also grew enormously. In fact, there are over 500 million teletypes in the world today, with the possibility of future connections reaching an infinite number. On a global scale, this arrangement is similar to that of the brain. Each of these synapses is a node in a much larger network. Connection is made by a number of different arrangements, including one-to-one, as in the process of getting goose pimples. It is unclear how much of the software of the brain has to do with issues and actions coming from primeval times and before. For example, goose pimples may be a response developed when humans were cave dwellers; today, body hair still tries to thicken in times of danger or fear.

In terms of learning and information processing, a number of other connection possibilities exist, including many-to-one, one-to-many, and many to many. In *Grammatical Man* it is noted that

> some connections between neurons are "many-to-one," as if several different words in a language had the same meaning, improving reliability. Other connections, however, are "one-to-many," as if one word had several different meanings, leading to ambiguity.[14]

In the situation where a many-to-many connection exists, it is our belief that a complete thought is either saved, as in receiving and possibly memorizing; retrieved, as in remembering; processed, as in modifying or altering the information for communication; or handled in a myriad of other possible ways, including dreaming. In this many-to-many environment, the brain is connecting a number of nodes together and drawing upon them as needed. Certain medical studies using brain scanners have shown dramatic differences in the brain when resting, thinking, eating, talking, and so on.

Charting is, in machine terms, the ability of an electronic device to conceive of possibilities, although not necessarily as a brain would; machine models copy with explicit rules and the need for tolerating vast amounts of ambiguity. Charting allows the machine to process information in an infinite environment, rather than in a linear or even a parallel processing environment; these forms of information management still only consider that many things are processed sequentially rather than in a matrix or charting environment. Charting also allows the brain to be more thorough in considering and evaluating or in pondering thought, idea, or action. Charting allows one to consider the relationship among things as well as the things themselves. For example, a marketing plan takes into consideration such things as product, competition, budget, market, ads, promotions, timing, and the economy. Charting lets one study each item alone, as well as juggle relationships. How are timing, competition, and the economy related? Can this relationship be restructured to advantage?

VP considers that the brain, unlike computers and even those involved in real-time processing, unceasingly continues to ponder thoughts long after they have been removed from immediate brain processing. VP continues to connect and build complex charts consuming vast numbers of synapses. Because there has been no proven research to date that suggests humans are running out of memory, it might be assumed that the brain is free to use these synapses, whenever and however many are needed, at will.

Thus, charts can be simple notes on a particular project or even libraries of experiences consuming millions of synapses. VP charts in machine terms probably will never be as complex as brain charts. However, because one of the most complex challenges facing society involves education and training, new tools are needed to reduce learning time and increase communication. In addition, tools are needed to teach, without regard to time and space, to better accommodate the flexibility and personality of the learner.

Parallel Connections—Liveware

The issue for discussion is the ability to connect, disconnect and reconnect thought, images, motion, and imagination, often all at once. Simultaneous conceptual processing would be a nice word for the mind's approach to what generally has been called **parallel processing** in the machine world. It is really more than parallel, which implies two events taking place at the same time. Conceptual processing suggests that a broader range of activities can occur. Processing here is chosen only because it helps define a beginning and a possible end to an event.

Fundamentally, the human body recognizes only two events: birth and death. Everything in between is merely an extension of one or the other, leading away from or toward. However, what takes place in the middle is a series of microevents separated by time. If each event were broken down into smaller and smaller pieces, one could see life as a series of flash cards with each card representing a particular moment in time. However small, these events can be considered concepts, images, thoughts—whatever you like.

Examine one of these flash cards like a page in a book, and explore what it would take to understand it from all sides. Look at each word, phrase, sentence, paragraph, and border. At this point, there is only an understanding of the physical nature of the page. Now look at the images the words try to present. Are the words depicting a story of foreign intrigue, domestic violence, or _______________? You fill in the blank, which most of you automatically did without even thinking about it. Or did you think about it? Was it an automatic decision or a conscious decision on your part to answer the question? Now you understand the problem of designing a machine that even approaches the intelligence of a human brain.

Let's continue to examine the page and develop a model of what it might represent. In this way, we can look at constructing models that might be able to conceptualize a word, then a few words, even a sentence. Language, as discussed earlier, has its own limitations.

The purpose of this discussion is to focus on the ability of a machine to present its own impressions or images of what it thinks the event means. The machine might draw upon its own internal inference references (engine) as well as use the network, drawing on other machines for help, guidance, and analysis of the event(s). Certainly, a decision has to be made at some point about what we think something is or is not. We all share a certain sense of common reality; for example, the sun rises in the east, and we breathe air. Yet perspectives vary greatly. It is surprising to realize how differently we each view meetings, events, or art.

Preferences and knowledge in a machine can contain images and concepts far more varied and detailed than our own. Consider having the Smithsonian Institution, *National Geographic* magazine, or Bell Laboratories within the electronic reach of the machine. The ability of the machine to conceptualize events in this framework offers the user the ability to conceive of ideas beyond his or her normal scope. The machine and the user working together can offer each other new dimensions in thinking and exploring. In this sense, the machine is not so much a processor in the number-crunching sense; it is more a system of elements connected together like the telephone network.

The former Bell System offered a single integrated network of hundreds of millions of telephones worldwide. The telephone network, although highly computerized, provides little intelligence to the message being processed. The evolution of the telephone network will add intelligence to the message as well as the medium. This concept, as applied to parallel processing, is the ability of a large-scale network to perform functions that individual elements might not be able to perform.

In other words, concepts and processing can be performed in parallel or complex parallel, allowing for numerous concepts to be discussed continuously over long periods of time. With the computer, this complex network can work and interact worldwide, allowing users to tap into a source at any point. This global brain works more like a human than a supercomputer in drawing resources and providing input. It functions like large-scale superprocessing systems that work sequentially, processing each data element in a linear (1, 2, 3) fashion.

Network processing can also accomplish limited, single-point processing; however, each node in the network can only process many small elements, not large programs. Some researchers consider this approach a **connectionist approach** to processing, which allows for essentially infinite tree branching or outlining as needed to resolve the problem (for example, determining a market strategy for our product) or establish understanding (for example, Do you know that I need your help?). To accomplish this, various design architectures are possible. In fact, these designs become more like art than mechanical switching connections or neurons.

Summary

Asomov noted that the next stage is the generation of planner systems, several long linear chains with feedback processes. Other systems become more or less stable, depending on the number of connection or feedback lapses. Some are even called superstructures, which give rise to spatial or multilevel systems.

The AI architecture has moved into the realm of the network or superstructure, if you will. How information is processed within such a network depends largely on how designers view the effectiveness of existing networks.

Endnotes

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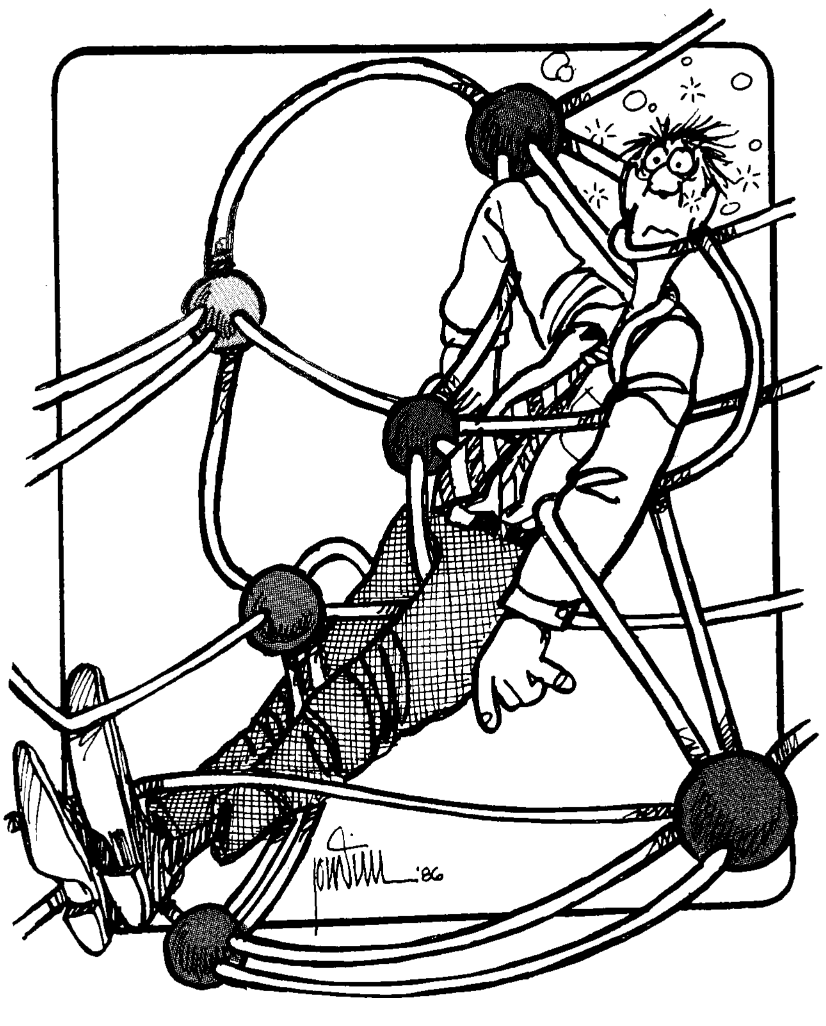
Chapter 6

Knowledge Networking Systems



Introduction

A knowledge engineering system has emerged, providing a dynamic new approach to strategic planning. This technology is called knowledge networking (KN). KN is a powerful tool for person-to-person and group-to-group communications using computer terminals assisted by powerful, though friendly, computer software. The applications of thought processing are vast, and it is important for us to understand how it can be used for strategic and corporate planning.

A number of major developments are forcing management into planning five, ten, or even twenty years ahead. These developments include the increasing rate of technological change, the growing complexity of business, and intense worldwide competition.

Technological change shortens product life cycles to the point where a company must continually plan for new products or services to maintain its market position. There was a time when a company producing a fairly stable product or service could count on a market for decades. Today, however, a product can begin to lose sales within two to five years because it is being replaced by competing products or by different products altogether. This shortened life cycle requires quicker management decision-making and careful planning. It is less and less possible to watch what others do and then imitate them. The day will come when the company that introduces a product will be the only one able to make money on it because by the time the imitators get into the field, the product will be approaching the end of its life cycle.

With constant technological change and the increased globalization of the economy, the scope and complexity of business demands sophisticated planning. There is greater need for considering those governmental regulations and policies regarding international trade and investment. The question now is, How can KN help?

According to Mr. Daniel C. Thomann, formerly of Burroughs (now UNISYS) Corporation,

> Knowledge networking is the ability to conduct an ongoing meeting with personnel in different geographic locations. An electronic message system is used to record communications among meeting participants. Each person involved in the meeting can access, read, and respond to these commmunications, regardless of whether other participants are communicating simultaneously or not. The system thus provides a verbatim log of the meeting, and the asynchronous method of participation offers *extraordinary flexibility,* especially if meeting members travel frequently or are in different time zones. The technique has proven to be *highly effective* for managing ongoing project activities.'

Thought processing can be considered an online meeting concerned with a wide range of subjects, and lasting from several hours to several months. Members come and go at their leisure. A bulletin board is usually available for public notices, and members have "memo" areas for creating, editing, and sending text to discussions and conferences.

Thought processing can be subdivided into specific areas of interest. These secondary divisions are referred to as discussions. These divisions are comprised of actual information, but serve as pointers and organizational structures for the actual textual information maintained by the system and stored in comment files. Each file, therefore, points or belongs to a specific discussion topic, which, in turn, belongs to a specific conference area.

Life in the Electronic Fast Lane

KN (also known as computer-aided communications [CAC], computer-aided networking [CAN] or computer conferencing), as used in this book, is a tool that in all likelihood will dramatically alter corporate communications as well as the corporate organization. KN focuses on one of the most complex and troublesome areas of management communications. In a KN system, much of the activity, as with face-to-face meetings, has to do with protocol. That is, communication of any sort must be evaluated and considered by the conference group.

In *Computer Message Systems,* Dr. Jacques Valle notes that

> this approach involves three assumptions: first, a generalization and basic principle is that everything communicated is meaningful; that is, all aspects of the transcript are to be considered. Second, meaning and pattern in communication are culturally based and then mediated by the individual person, the communication situation (e.g. the medium, the task), and others in the situation. Third, communications may be about the topic, but it is also about the communicators themselves, about the situation, and about an immediate concern.[2]

In this way, the experience becomes more important than the message. The role of the message or the media is not diminished, but the "driving experience" must exceed the emotional impact for the value of the information to be effectively communicated to the participants. Indeed, the relative role of the conference manager is far more important than a live-meeting moderator. The moderator must be aware of every notation that the conference members bring forward, as well as suppress irrelevant or inappropriate statements. KN conferences convey much more than what takes place in conventional meetings. Every thought, comment, and response is "cast in concrete" in written words as opposed to verbal statements that are filtered when assimilated by the brain. To understand the dramatic impact of KN, a discussion of the structural characteristics of a KN conference is appropriate.

In KN conferences, there is far more flexibility than in any other form of communication. By allowing virtually unlimited branching with ease through conference manager control, participants can meet in any combination desired. Unfortunately, this concept has never been fully explained in the trade press or in books on the subject. Essentially, a conference starts out with a group of invited participants who agree on an overall conference issue topic. However, like conventional conferences, there are always subtopics, orders of discussion, and a number of other issues and diversions.

In an electronic computer conference, the conference manager can create what are called discussion areas for these other topics. There can be many more subtopics than major discussions. An example is client satisfaction on nuclear issues; subtopics include sales analysis, production scheduling, quality assurance, and department coordination. Moreover, various major discussions can be linked together, such as a conference on shipping bottlenecks, with subtopics that include packaging, absenteeism, and automation. In this case, the two conferences would be linked together by a subtopic discussion on product delivery systems. This kind of linking has been called charting, which describes how conferences, depicted as grids, can be linked together, just as ideas that are often related under different topics can be utilized by participants as references.

The concept of the conference grid can also be used to describe different conference discussions within the same conference, and show how different subtopics relate both to the major conference discussion topic and to other subtopics. This kind of communications linking is truly unique because of the ability to track any number of text files and easily link them, as well as to change these patterns (links) at the option of conference participants. In this way, participants can create their own charts, link topics, and display this chart on the computer. The chart can be moved in any direction, allowing for different perspectives. These charts can also be sent electronically to other conference members for their feedback or modification; changing the links in the chart is similar to words being edited on a word processor. This kind of visualization system can be used by conference participants to examine any problem from numerous different perspectives.

Charting is the next generation of KN systems. Currently, most systems only allow for unlimited subtopics, much like a traditional outline format. However, the inflexibility of outlines and the need to link far more ideas than are traditionally possible will give rise to graphically oriented communication or visualization systems.

Figure 6.1 describes the linking concept integrated, using the form of a traditional bookshelf. This figure shows how a computer can link electronic "books" in any manner desired by the user or participant. It also suggests a means of information networking that can be integrated with a data base management system (DBMS). DBMSs are primarily used for the management of vast amounts of pure data (facts, figures, bibliographies, names, places, and so on). The design of a DBMS enhances the ability for rapid retrieval and interlinking of data into information modules. In a KN system, much of the data is in the form of words, but graphs, charts, and video frames are also used. A KN system can be organized by arranging KN conference materials into a DBMS. Thus, the convergence of a KN system and a DBMS can yield an exceptionally powerful management communications system. In the following section, the experience of participating in a KN conference is closely examined.

Organizational Communications

In an electronic communications environment, the patterns of communication change the nature and type of organizational structure. The key issues at stake here are:

- Changes in communication channels
- Perceived and real changes in human interaction
- Nature and type of messaging
- Organizational relationships

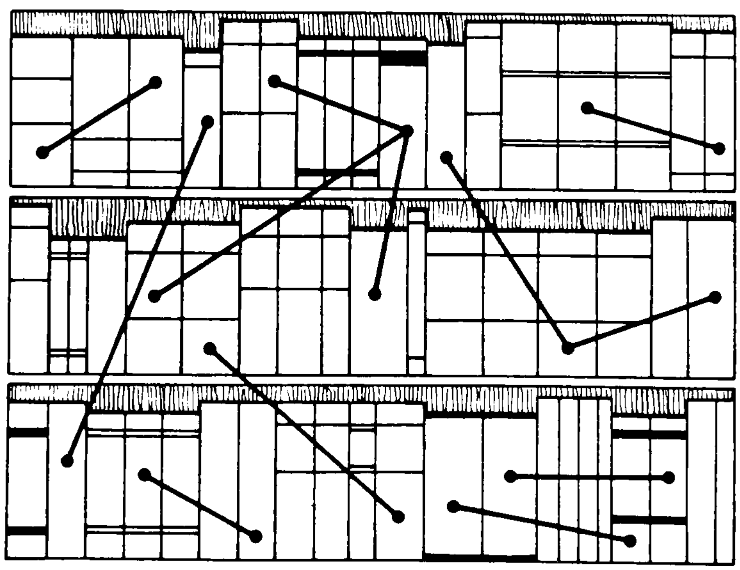


Figure 6.1 This view of books on a shelf depicts how on-line information systems can connect books and their respective words and contents with other books in any fashion desired by the reader. Photograph courtesy of Cross Information Company.

Communication Channels

In viewing future changes in traditional communication channels, people assume there will be a direct substitute for face-to-face meetings or hallway conversations. In conventional environments, management is interrupt-driven; that is, work takes place until there is a random event which disturbs the worker, for example, telephone calls, unexpected visitors, and trips to the bathroom. Due to the random nature of these events, it has been difficult to quantify, much less redirect, these kinds of interruptions. In an electronic environment, these interruptions can be packaged as electronic mail, allowing an individual to send as many messages as needed without being disruptive, and allowing the receiver time to review and adequately respond to these often numerous questions. Rather than running into someone's office every time a question occurs, electronic media makes electrons do the running. From years of direct experience, I have found this form of communication to be quite successful. Moreover, the packaging of these interruptions affords the receiver the opportunity to forward the question to the appropriate person, for example, "Sorry, that's a question for Fred; he is the project manager."

Another advantage lies in the ability to quantify, primarily in terms of numbers of messages, the amount of interruptions one actually receives in any one hour, day, or time period. Thus, the manager is less interrupt-driven, available to work on projects needing additional or immediate attention, and is better able to manage time.

Another key advantage is that by changing time you can also change space. By altering the point in time of an interruption with the use of an electronic communications system (ECS), you also change the necessary proximity of the resource. By eliminating the need to be physically present, a greater, though not necessarily absolute, ability to manage from a distance is allowed. Is it more important to the disruptive person that I be there now, or that a quality response be given in a reasonable amount of time? People with telephone-answering machines, for the most part, understand the ability to receive long messages, obtain the answer, and respond without having to speak to the caller in real time. Management from a distance is not a new concept. Field offices across the country, or around the world, experience management from afar every day. ECSs offer a closeness not previously available, as well as the potential for a greater understanding of, and involvement in, corporate activities at the home office.

Human Interactions

One of the limitations of electronic communications is the inability to convey emotion, feelings, humor, or any form of body language. In audio and video teleconferencing, certain types of emotion, such as anger, can be communicated by voice or visual body inflection. Humor or laughter can also easily be conveyed to other participants. Such human emotion is generally lost unless the session is videotaped and the audio recorded, a method not common to the corporate manager. Few managers have an audiotape system, much less a videotape player-recorder, on their desk; so, although audio and video are user-friendly communications technologies, they are not readily available.

Text communication forms the basis for nearly all corporate communications. An interdepartmental memo is the basic communication tool. Electronic text communication is the new management power tool for corporate communications. As with its paper-based equivalent, there are people who know how to use it effectively, and there are those who don't, just like there are those who know when to stand up in a meeting and sabotage a dumb idea. The questions associated with human interaction using electronic media should be of concern in the training process.

For example, one of the simplest notions about computer terminals that is missed by many trainers is "computer terminals don't speak words." This might seem obvious to most, but not many truly realize this. Discussion of the human interaction process is critical in the training process to long-term effective use of these systems. Another electronic text communications issue is the proper conveyance of emotions and needs, such as frustration, urgency, or applause. One of the interesting problems with electronic communications that emerged was called "flaming"—the negative overreaction of recipients to otherwise noninflammatory statements. Emotion increases the understanding of communication. These actions are simple to portray in a face-to-face situation, but in written communication, adverbs, underscores, and special punctuation are used to convey these forms of emotion. Where one once understood the urgency of a request by the position of a manager's eyebrows, one must now equate urgency with the underlined phrase "by morning at the latest!"

The Onset of Electronic Communications

Needless to say, changes in human interaction are brought about by electronic communications. However, most people don't realize that these changes take place in their communications channels, patterns, and flow. This electronic wonder curtails disruptions; improves time management and information productivity by reducing typing, copying, and handling costs; and reduces telephone tag, in some cases eliminating it altogether.

Communication interaction by electronic means is also far more intense than spontaneous verbal interaction because of its explicit nature. Electronic communications yields greater understanding of the task or problem. At the same time, deliberation is dramatically increased by reducing "off-the-top-of-the-head" or "shooting-from-the-hip" thinking. By giving someone the time to think through a problem, that person can effectively evaluate the situation, arrive at a better solution, or consider additional alternatives. The issue of crisis decision-making has been researched, with the conclusion that electronic communications allows issues and problems to be thoroughly evaluated prior to a crisis, providing for better in-crisis decisions.

A two-year course in advanced management concepts can sound like an expensive luxury to an executive who cannot justify that much time away from the job. However, the course can entail a minimum of the manager's work time when it is conducted as a computer conference. Computer conferencing is a unique and exciting concept that increases the "time value" of communications.

WBSI and knowledge networking

One of the most exciting examples of KN currently in place is at the Western Behavioral Sciences Institute (WBSI) in La Jolla, California. WBSI is a 30-year-old independent nonprofit research and educational institution that is using computer conferencing to network knowledge experts on a wide range of issues. In January, 1982, WBSI inaugurated the School of Management and Strategic Studies to present to key executives strategic issues that might affect their company's competitive posture. Its purpose was to discuss a broader range of topics than are traditionally found in the advanced management programs of major universities. Beyond just the significance of the topics, the use of advanced computer communications formed the basis for a situation previously not possible.

The WBSI approach considers the broadest limits of strategic thinking in an awareness of the total environment. Dr. Richard J. Farson, the President of WBSI, notes,

> It entails a broad understanding of national and international issues, of the problems and possibilities of new technologies, of environmental concerns and social movements, a sensitivity to changing values, and a perception of how all these

The underlying theme is to enhance the value of today's executive by providing a larger context for personal, as well as corporate strategic position. WBSI is creating an environment of "intelligent foresight."

In knowledge networking there must be a firm objective, whether it be planning, brainstorming, or strategic thinking. The following are only a few of the elements important to KN as a strategic resource:

- Past as a prologue for the future
- Contextual framework
- Values and ethics
- Systems and networking
- Wild-card thinking

The concept of nonlinear complex thinking is a mental tool for anticipating both unpredictable and in-depth problems. The WBSI curriculum focuses on this approach.

The course begins with an eight-day training session in La Jolla, and focuses on interpretive management processes. Once the executives are trained in the use of Electronic Information Exchange System (EIES), a university-based research and development (R&D) laboratory for computer conferencing, and armed with a simplified version of the EIES documentation, they return to their offices and begin their computer conferencing course participation.

Equipped with terminals and accounts on the EIES conferencing system, participants carry out coursework at their own convenience, as well as take part in group discussions with both the faculty and each other. There is no need to take notes because the material is always available on-line. Participants, "hunt-and-peck typists" for the most part, spend an average of 13 hours a month on-line. "The beauty of this program is that it allows executives to use their available time," notes Farson. The course is heavily moderated by WBSI faculty, a factor critical to its success.

Participants respond favorably when the moderator indexes and summarizes conference items, and usually make their own summaries of group discussions and offer them for evaluation by others. This continuous record in machine-readable form allows a kind of "weaving" of the members' ideas, adding a new dimension to what otherwise would have been a simple exchange of texts. Given the success of the computer conferencing management course, WBSI is editing the content of its management course into a textbook for wider distribution.

The directors of the program note that they have encountered none of the attitudinal problems which are presumed typical of executives toward computer conferencing in general, and a keyboard in particular.

There is "a kind of inner drive to play," McAndrews notes, and "their response to the keyboard and other equipment is as to a toy. A maximum of ten hours suffice for the user to forget the machine is there, to arrive at the point where the machine is 'transparent.' "[4]

The assumption that computers are intrinsically biased in a technocratic direction can also adversely affect attitudes toward computer conferencing. Such thinking might lead to the conclusion that computer conferencing is more appropriate for business meetings than for knowledge dissemination. After utilizing computer conferencing as the communications medium for his course, Dr. Andrew Feenberg, a professor at WBSI, concluded that "those who fear computers may have drawn premature conclusions concerning their social implications from a rather narrow range of applications."

Feenberg suggests that the focus should not be on the artificial intelligence (AI) aspects of the computer, such as its capacity for data analysis and storage, because these very aspects "shape the image of the technology." Rather, he believes, an appropriate metaphor is one that considers computer conferencing an "artificial" model of normal human communication:

> The interesting feature of AI is not the use of computer hardware, but the conscious construction of new programs and conventions by which to simulate familiar communications systems, and to make possible new systems not previously

Farson adds:

> Through computer teleconferencing our program allows the participating executives to maintain continuous communication with a faculty composed of top authorities in their fields and with a group of high-level people like themselves—without having to spend an appreciable amount of time away from the office.[7]

According to Feenberg, the advantages of using computer conferencing are as follows:

> Writing is the more personal form of communication, the one which permits the most natural expression of feeling. The message, once detached, can cross time and space, acquiring objectivity, permanence, and mobility.[8]

> Darrell Icenogle, director of educational resources at WBSI notes:

> We are confident that profound learning is taking place. Computer teleconferencing supplies an element that has always been missing in other attempts to educate people at a distance—the ability to interface regularly with faculty and students. Obviously, this capacity is most important when clear-cut "right" and "wrong" answers to questions do not exist, or when subtle or complex issues are being discussed. It is time to change our conception of training. Training can now take place at any time and just about anywhere in the world. In the rapidly changing field of electronic teleconferencing, the telephone conference already seems outdated. Also, it is extremely difficult for busy executives to find regular times for audio or video teleconference calls.[9]

The use of video has now been developed and refined for face-to-face meetings, so that executives and managers can be brought together no matter where they are located. According to Icenogle,

> Only about 40 percent of all business telephone calls are completed, and the percentage of completions for the kind of high-level executives we have in this [WBSI] program is of course much lower. With computer teleconferencing, on the other hand, one has the confidence that a message sent is a message received. Also, communication of this kind tends to be less redundant, more precise, and less pressured. People communicate at their best because they have the time to say exactly what they mean to say.[10]

How does a computer conference actually take place at WBSI? Typically, a manager circulates the proposed agenda of major discussion topics among the conferees for their input. Once the topics are set, the conference manager can ask all or some participants to prepare statements on the different topics to be discussed. Once all contributions have been entered, participants can comment on anything that is on file.

Participants can also ask questions, raise objections, filibuster, debate, vote on issues, request references, and add new material. This can be done in any sequence, at each person's pace and convenience, and without having to leave the office or "electronic cottage." Icenogle says:

> Any part of the discussion can be retrieved at will, enabling an individual to reconstruct the meeting at a convenient time and direct comments to the specific part of the discussion that is of interest or import at the moment. A person can check in at a convenient time, retrieve any communication that has occurred to date, and compose a response. One never has the feeling of imposing on another's time because communications are sent and received at times of per-

One of the most important advantages of computer conferencing as a training vehicle is that it takes only a few hours to learn the basics. It can be, according to Icenogle,

> . . . achieved in a few hours. At its conclusion, all [the students] are competent conferees, even if they have had no previous computer experience at all. We find that typing ability is unnecessary for success; hunt-and-peck works fine, and people have fun mastering the keyboard and getting the message through. In fact, we find that the two-finger typists tend to send longer comments than do the virtuosos.[12]

One of the most famous WBSI instructors is Dr. Walter O. Roberts, the founder of the National Center for Atmospheric Research. According to Dr. Roberts,[13] some of the most important concerns include the following:

- Encouraging people to practice, like drivers' education
- Developing a "buddy" system to share ideas and give support
- Developing a system to overcome the fear of typing
- Establishing communications protocols—who speaks and when
- Eliminating grammar and typographical issues
- Encouraging participation of all, rather than only from those who are "English professors"

- Establishing separate discussions pertaining to desired communications formats:
  - News flashes: very short, one sentence
  - Editorials: one-page, forceful opinions
  - Essays: structured, in-depth reports

WBSI has proven computer conferencing can be a viable methodology for executive training and education when combined with a strong sense of human factors. Moreover, with an instruction manual of the communications protocols required with this new technology, WBSI can utilize faculty unfamiliar with computer equipment.

Nature and Types of Messages

In any communications medium or language, certain protocols assist in accelerating the pace of communication. Electronic communication often allows the use of shorthand, such as "u" for you and "ur" for your, and the elimination of extraneous vowels or letters. People tend to eliminate any unnecessary typing, reducing the verbiage to the minimum number of words that still yield an acceptable and understandable message. In some cases, this shorthand tends to degenerate messages into codelike phrases that are often incomprehensible to others. At other times, participants use scholarly writing, much to the boredom of the rest of the group. Simply put, the group manager sets the tone and the level of writing. This can be difficult and uncomfortable for many of the participants at first, but the boss usually has the final say.

Certainly, there has been a significant amount of research into group communications, but research into electronic language analysis is sorely needed. The messages in an ECS, aside from the grammar and spelling, tend to be short and to the point. As explained earlier, messages are focused on the issue at hand and tend not to wander, as in face-to-face meetings. In computer conferences, there is usually an electronic mail facility used for normal one-to-one communication. A separate discussion area of electronic mail should be used for personal and "getting-to-know-you" aspects of the group. This discussion area is critical when people are unfamiliar with one another, or when a new member joins the conference. It also encourages side communication to take place, as it does in a face-to-face meeting. This becomes the electronic "coffee break," and allows participants to test the waters by lobbying with individual participants before raising the issue to the whole group.

Messages and discussions need to be managed. The conference or discussion leader sets the stage for the type of message to be included. The manager should monitor and track the participation of the members (unlike face-to-face meetings). If one person has not been heard from, the manager should send a private note to determine that person's opinions on the discussion. Much like newspapers and face-to-face meetings, there are always more readers and listeners than writers and talkers, which does not mean that people are not interested. Quite the contrary, they would rather just sit on the stands than play in the field.

With electronic communications, there is far greater opportunity to participate, should one desire, than with any other known medium. Face-to-face communications, audio, and video teleconferencing provide a linear communications pattern; that is, when one person is talking, no one else can. Thus, to get a turn at the podium, so to speak, can involve quite a lengthy process. In ECS, however, each participant can read the comments, prepare a response, and dispatch the message instantaneously without having to wait their turn. The computer places this new message in front of the group for immediate consideration. The instantaneous response also impacts the nature and type of messages communicated: Not only is participation immediately available, but a broader style of communication is possible. There is virtually no limit to the number of message files. When the message files are organized into an outline or book chapter format, as with most computer conferencing systems, new avenues are opened for the type of message as well.

This medium offers new potential for increasing participation by members. This participation can take the form of flashes, headlines of current events, examples, applications of the issue, tutorials, detailed explanations of the issue, monographs, lectures, or papers by conference participants. It is up to the conference manager to determine the most appropriate form for the group. However, because this medium tends to bring out shy people, it is suggested that some sort of separate "open-forum" file be established for potpourri, jokes, and other forms of banter.

Organizational Relationships

There is more of an egalitarian level of power in ECSs than in traditional systems. When the computer systems allow for immediate access to the discussion floor, the face-to-face meeting bullies are somewhat mitigated. Certainly, there are related problems, such as the emergence of treatise or novel writers. Opening the flood gates to the people can be risky and might not even be possible for industrial-age corporations to attempt because of the time-honored, ingrained communication processes that have existed for years. As with structural changes brought on by technology, regulation, or competition, many companies have been unable to alter the corporate culture in even minor ways, much less to accommodate ECSs.

However, established companies continue to initiate projects, research new products or services, form task forces, or create subsidiaries or independent entrepreneurial business units. The most appropriate time to implant KNs to augment new management styles can be when other "accepted" changes are occurring within the company. Typically, at this time, organizational communications patterns have not been fully adopted or implemented; openness is encouraged and management relationships are just forming; innovation is encouraged; and, generally, there is too little staff to handle the known problems, much less the unexpected ones.

Even in established environments, the impact of KN might not be known for some time because the new communication patterns often require a lengthy gestation period before significant results can be seen. In some instances, this can take years. In such cases, where the impact is not felt for a long period of time, the changes might also yield marginal results in analysis studies.

Organizational Intelligence System

In discussing strategies for corporate planning, I have noted various techniques for gathering information. In many cases, these techniques are organized around a corporate planning or intelligence department. Organizational intelligence (01) refers to external competitive and environmental company data that have been evaluated and found useful in a specific project or class of situations. However, the term is not restricted to external data, because a great deal can be discovered about competition and environment from internal sources.

No person or organization effectively operates in a volatile environment without a basic understanding of that environment or without up-to-date information on occurrences in the environment. The information about competitors is generally considered part of the library, and includes market pricing, discounts, terms, specifications, total market volume for a given product, historical trends, estimates of the competitor's share, the competitor's trends, evaluations of competitive product quality and performance, estimates of marketing policies and plans of each competitor, and new competitive systems or trends.

KN provides an information vehicle for organizing, storing, retrieving, and managing this information. Ongoing KN can be carried out in each of the previously mentioned areas. This allows input from all points of a company, and is an ongoing rather than a static process. Using a KN system, OI can be managed effectively to provide a forum for long-range planning.

An OI system should be action-oriented in order to inform managers when actions should be taken, and should provide some indication of the best action to take. KN is a powerful tool for integrating numbers, raw information, opinions, and executive thought into a decision information system. Some of the key aspects and advantages of KN for strategic planning are as follows:

- KN allows individualized time management.
- Working at one's own pace improves one's ability to organize work for the most logical presentation. The discipline of putting thoughts into writing before communicating them improves the quality of this communication.

KN eliminates unnecessary confusion, making both the strategic planner's job, such as evaluating, and the manager's task, such as writing a report, clearer, easier, and more efficient.

Planners can "discuss" topics with other planners and even with those outside the planning department. Thus, all points of view are exposed for comparative and critical analysis, resulting in richer feedback to the planner. Workers can move on quickly to solving difficult and unknown problems.

Teamwork takes place among planners involved in, for example, a research project on the same topic.

Improved project-tracking is possible for strategic planners. Everyone involved in a project is informed from beginning to end. People can enter the process at any point and get full documentation for evaluating the process to date.

Far from discouraging dialogue, a KN system encourages users to put down ideas as they occur, and gives time for reflection that might not be possible in a transitional planning situation. With KN, everyone has "equal time" and "equal access" for speaking before the group. Moreover, shy or inhibited persons feel better about communicating before the audience.

One of the most exciting aspects of this technology is the ability for thorough and fully contemplated thought. In most real-time group activities, individuals must respond with an answer immediately. In KN environments, each person has time to review materials and requirements and, thus, time to develop a clearly thought-out answer.

Corporate Management

Networking has received more and more attention in organizational contexts of late. Management has long been concerned with "getting its message across" to workers, that is, networking throughout the organization. Frequently, management is concerned with a lack of effectiveness in the communication process, and is not entirely familiar with semantic problems of the networking "medium" involved. Administrators are often concerned with upward and downward communications, soliciting attitudes and feelings of lower echelons and encouraging their networking upward through the hierarchical structure. When only 20 percent of those messages sent by top management are understood at the bottom, innumerable problems arise. KN is a computer communications system that not only provides a written log, but also a means whereby ideas can be exchanged, clarified, debated, and resolved. Organizational structure is definitely tied to networking systems. This relationship is apparent when formal structures, channels, and media are involved. For informal alignments and irregular information flow, the relationship is less evident. Networking does not necessarily follow stated organizational arrangements, or vice versa. Numerous overlaps and gaps are apparent in most organizations, causing further problems. The very act of setting up a KN can point out these organizational shortcomings.

Networking and control are decisive processes. Networking makes organizations work and cohere; controls regulate behavior. If we map pathways by which ideas are communicated between different parts of an organization and the ideas are applied to behaviors of that organization in relationship to the outside world, we have gone far toward understanding the organization. Networking offers the road toward this understanding.

Organizational Networking

Generally speaking, networking provides a means for study and management. Instead of concentrating solely on an organization's strategic purpose, I focus on two questions: (1) How are an organization's formal and informal networking channels connected? and (2) How are these channels managed and maintained? For our interests here, how can KN facilitate networking?

The most important concept in organizational development is that personal organizational structure follows the development of networking systems, rather than vice versa. For many organizations, networking systems have been designed to follow organizational lines without recognizing that this system might not follow the optimal flow of information for decision-making.

Problems in networking systems for decision-making have resulted from the recent changes in organizational relationships. Companies have been faced with dynamic world conditions, rapidly changing technology, intense competition, and changing markets. In some instances, reorganization resulting from these changes has caused further reductions in networking activities. These phenomena point out the need for new networking methods. Unfortunately, management often loses sight of the seemingly obvious and simple relationship between organizational structure and networking needs. Having obtained more responsibility and decision-making authority, management might not be receiving all the information required. Also, too many companies do not follow reorganization with penetrating reappraisals of their information system needs.

Granted that organizational structure and networking systems are inextricably intertwined, the problem remains: Which comes first? Realizing that networking precedes organizational structure in company design is of significant importance to anyone creating or managing an organization.

Decision-Making

The relationship between decision-making and the networking system is extremely important. Decision-making and networking processes are so interdependent that they become, in many cases, inseparable. In managing a corporation, we see many approaches toward organizational decision-making: (1) the traditional view, emphasizing some logical arrangement for dividing work, hierarchical structure, and specialization; (2) the human relations view, developing cooperative relationships, participation, and informal organization; (3) the professional view, stressing the roles of knowledge, creativity, and innovation; (4) the decision-making view, focusing on the study of an organization as a decision-making unit; and (5) the systems view, integrating subsystems into an operational whole.

The decision-making view includes information, objectives, strategies, alternatives, probabilities, and consequences. The function of the organization is to facilitate the flow of ideas for the making of appropriate decisions. In this view, the networking system appears paramount; the organization structured around it is a frame of reference. In turn, the networking system is primarily considered a supplier of ideas for decisions, but how does information go from pure data to useful information on which a decision can be based?

Data 4 Information

A manager can require or desire any data from an organization to help in making a decision or dealing with a situation. It follows that when a decision is to be made concerning the development of a new product or the location of a new plant, a manager will require data on land and labor costs for each of the locations or products under consideration.

So, too, when a manager is faced with a simple situation, such as welcoming a visiting guest, data concerning the guest's background and interests are necessary to facilitate a productive visit. The essence of information, as opposed to data, is that information has been evaluated by people for use in a particular situation or class of situations. It has been "humanized."

Numbers representing records of a product's past monthly sales in various markets are data. If it is determined that these numbers are to be used for forecasting future sales and to serve as the basis for production scheduling, then the data becomes information; the data have been evaluated in terms of utility for a management decision situation.

KN lends itself well to computer manipulation of data into reports and, thus, decisions. KN is the management power tool for coordinating, developing, and utilizing information in a strategic manner.

On-Line Idea Exchange

Because the knowledge network is organized around networking, and thought organizing is designed to fit within an organizational structure, the concept of the **idea exchange** emerges. Although final decisions are not always made within the idea exchange, supporting evidence for a decision is created there. Moreover, the exchange is managed by idea leaders to prevent information from piling up. Here, ideas can be revised, outlined (see Figure 6.2), charted (see Figure 6.3), and edited.

Figure 6.3 shows the following: First, a cross/point is composed of different types of information, including text, graphics, or data. Second, each grid of different types of information can be changed as necessary. Additions, deletions, and modifications can be easily incorporated into the cross/point grid. Third, each grid of information can be expanded "to the nth degree." The structure of the cross/point is n-dimensional. Its boundaries can be expanded. Fourth, a cross/point idea network allows for n-dimensional linking by connecting any number of nodes together at any point, top-bottom and/or side-to-side. Fifth, a cross/point can be represented in a simple expression.

Structurally, administration can be viewed as a configuration of thought patterns that relate individuals and collectives of varying sizes, shapes, and degrees of understanding, cohesion, and stability. Dynamically, administration appears as a patterned swirl and flow of ideas. Many of them channel through transactional circuits between persons and persons, persons and groups, and groups and other groups.

For our purposes, communication patterns and flows are particularly important. Patterns relate communication to organization, and flow relates communication to decision-making. Thus, the concepts networking, thought processing, and decision making are inexorably interwoven.

Forming business management teams

Bringing a group of business analysts together and designating them a business management team does not necessarily make them a cohesive, productive unit. KN

Figure 6.2 As the sentences are broken (parsed) into smaller and smaller elements, for purposes of analysis and structure, they may be arranged in an outline format.

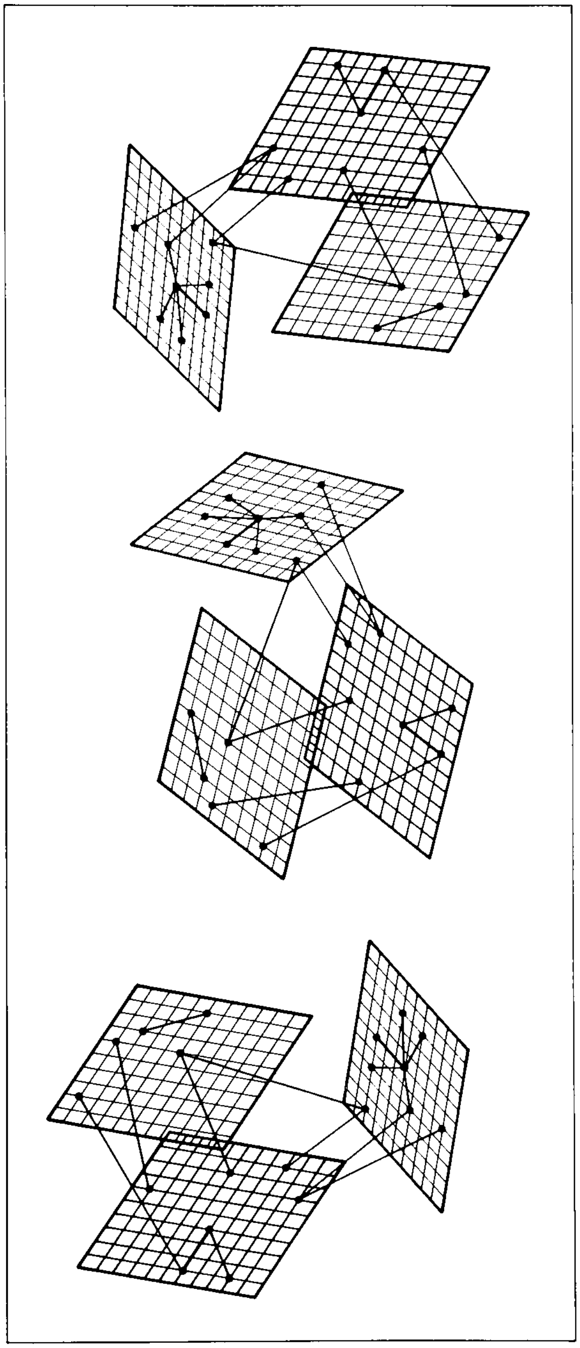


Figure 6.3 A cross/point is composed of different types of information, including text, graphics, or data.

can help in organizing this management staff. With KN, this team can participate more easily than with any other system. It allows each person to participate at once. Everyone from next door to the other side of the world "has the floor" at the same time because "you are there" on-line. KN systems allow many people to work on the same conference or discussion simultaneously. It also enables those on the road to access the system remotely.

Where it is difficult to measure the work output of "information workers," KN provides a record-filing, outlining, charting, and tracking system, as well as a personal notepad for private use. For the first time, we begin to really track the progress of a project from inception to completion, allowing management, new staff, or observers to participate at any point along the way. The name of each person who develops a position or an idea is added to the idea exchange.

In managing business, it is important to solicit input from others in the department or company; KN allows people who might not have direct responsibility, or job-related activities, to participate. Thought processing facilitates and encourages input by others. These "observers" can review the discussion and add their own comments. In this way, an executive who was previously a line manager can spot a problem being discussed that might have been solved years ago. Thus, more of the sum total of company knowledge is retained over time. Ideas can be networked from one person to another, increasing involvement and participation, without dominating or detracting from the forward movement of the idea exchange.

Neither rain, nor sleet, nor sickness, nor distance, nor time zones restrict participation in a meeting. Travel and other meetings are typical causes of scheduling delays. Such conflicts can disrupt the timely impact of a meeting's purpose for weeks, but the KN system ensures that everyone is "always on time." With networking, a meeting is not dependent on any one person's time schedule. Networking can be called non real-time communications.

The length of a meeting is controlled and facilitated by the conference manager, who can be located in any city; assignments can be given, and people can respond, argue, or discuss work without having to physically meet. In comparison with other forms of conferencing, KN is by far the cheapest.

Most groups exist to perform tasks. In meetings, the task involves gathering information, discussing, solving problems, implementing decisions, and evaluating the outcome of the group's work. Many of these functions require other support people, such as secretaries, researchers, and writers. In addition, much of the overhead is concentrated on "getting coffee," rather than working on the task at hand. KN systems provide an organized structure that facilitates major activities such as seeking information, giving information, giving opinions, elaborating, coordinating, evaluating, and energizing. The group gets down to business and does not waste expensive time on consummate overhead.

KN permits people to concentrate on an issue's substance rather than on an organization. How many times has the same problem been confronted over and over? Multiply this number by the efforts of close-working colleagues, by those of other people in other departments, other divisions, other corporations, ad infinitum. The wheel is continually reinvented, and the problem remains unsolved.

Documentation

An important aspect of business management is documenting work. How many times have you actually received minutes from a meeting or really known the status of a project? When you do get the minutes, how often do they actually convey what took place at the meeting? KN provides a verbatim transcript. Each person's comments are in their own words, and there is no body language to interpret. KN structures a meeting in such a way that purpose and content are not lost.

In a system such as CROSS/POINT, there is a meeting status indicator informing each person where the meeting is and what has occurred. At any point in the meeting, everything transpired can be reviewed. In addition, one can go back to the first meeting or to any meeting in between for reference.

KN allows a participant to read a speaker's remarks without having to respond immediately. Consequently, it is not easy for someone to undermine or sabotage a speaker. A friendly rather than confrontational atmosphere is thus created. Notes can be made, questions raised, and comments added without distractions. A speaker can respond to a question when prepared to do so.

If "the camel was a horse designed by a committee," then not much can be said for committees. A great deal of meeting time is spent clarifying confusion. The verbatim KN transcript and the use of electronic mail to clear up problems takes care of any possible confusion. KN allows private notes and discussions to occur during the conference to determine interests and positions of other people before an issue is brought before the group. Also consensus-building, a true "meeting of the minds," is far easier with KN. It allows members to work privately, without formality or scheduling requirements, or to pair off for work on various subissues of a problem. The result is vastly improved productivity.

KN facilitates candid discussion, which, in turn, means people pay more attention. A quality discussion and time for thorough thinking are the results. Communication and morale are improved because employees can talk with supervisors on an equal basis. When workers come up with an idea, it is attributed to that worker, not a superior who takes credit unduly. Therefore, the commitment to making it work is greater.

Throughout history, the transmission of ideas has been a key to progress. Efficient networking is important to all fields of human endeavor. However, as society becomes more complex, as technology increases at an accelerating rate, and in spite of improvements in networking media, it is becoming increasingly difficult to network effectively. The growth of organizations, together with increased specialization and functionalization, has led to barriers in networking.

Information decision systems can be developed to provide the proper flow of information among decision points in an organization. Both formal and informal communication must be recognized. Management might well analyze thought patterns in detail because the information decision system can follow "natural" patterns or systems, even though these are not recognized in a formal organizational structure.

KN enables a great many people to participate in networking and idea exchanges. It provides opportunities for managers to meet effectively, with time for thorough thought in their decision-making process. KN is the new management power tool for building idea networks that can help achieve goals.

The Importance of Time

A driving force behind computer communications is the rapidly changing value of time. Activities must be performed simultaneously with a look toward the future. In financial terms, the current value of a future event can dramatically affect the strategy of current operations. For example, most business plans, either venture-funded or corporate entrepreneurship, usually address the return to the investor three to seven years in the future. Investors need to know how to get money out of the project, that is, liquidity. They also want a substantial return on their investment. New projects often need to reach the $100-million figure by the fifth year. In an increasing number of cases, these corporate investments are required to repay the capital investment in less than three years, with product obsolescence not far behind. Product life cycles are so short that product strategy, not to mention profitability, is almost impossible.

Time is the only factor that humans cannot change, and it is a key factor in the success of any project. There are innumerable cases of products and services introduced either too early because they are too innovative, or too late because the competition already established market dominance. Timing means everything to winning.

Computer communications networks will have a dramatic impact on the present and future value of time. There are many multinational corporations with hundreds of locations on nearly all the continents (Antarctica has yet to be developed in any significant way). Managing these operations is no easy chore. In order to have a live, real-time telephone call between Los Angeles and London, one of the parties is required to arrive very early or to stay late, because of the eight- to nine-hour time difference. Therefore, management is time-zone limited in its use of live communications. Executives are increasingly using time-zone-different technologies that allow communication to take place at any time, at any location. These technologies also help to eliminate the game of "telephone tag."

Time management

Management activity reflects a change in emphasis toward **time management,** the effective utilization of time. Unimportant or irrelevant activities are eliminated, and as a result, action items replace agenda lists. Some companies find what I term **management velocity,** which reflects the subtle but increasing influence of time on activities in the corporation. The subtlety is that time might or might not impact any single component of a process. What time impacts more than anything else is the communication activity between processes.

As the trend toward an information economy progresses, information has fewer structural and geographic limitations. In contrast to the traditional geographic spatial need for transportation of goods and products, information requires no physical space per se. Information can be moved simultaneously and immediately to any and all points on this earth, a global village. As Yoneji Masuda notes in *The Information Society: As Post-Industrial Society,*

> It is space without regional boundaries. When this information space is expanded to global proportions, it will be global information space formed on the basis of a global information infrastructure of communication lines, communication satellites, and linked-up computers.[14]

Time has now changed. The informational cause-and-effect cycle has sped up. Strategy should, therefore, reflect this change and act accordingly.

Computer communications will become the tool for KN. These networks consist of various elements similar to, yet different from, geographical space. The similarity is in the physical links connecting the parties. The differences exist not only in the time factors, but also in the area of space; that is, the ability of the network or person to be anywhere as needed. Both players can be linked to many different locations, like the telephone network. The network can also be configured in any way the participants desire; in this instance, the applications software comes to the aid of the participants. This is a new and difficult approach, yet it is a critically important one. Consider that time, not space, is most important, and the structure of the network is time, which in turn determines the value of the process.

For any organization to be increasingly competitive and innovative and to facilitate increased performance, new tools to address business issues are critical. Much discussion centers around the issue of **managerial closeness.** Managerial closeness is a quantifiable concept measured from the bottom up in the amount of organizational communication or feedback. Managerial closeness is often the uncanny ability of managers to lead people to a level of utmost performance against all odds. As the now famous Grace Hopper, the "mother of computers," has often stated, "Lead people and manage things." This quotation illustrates one of the greatest dilemmas facing organizations today.

The MBAs in charge of businesses portray corporate management as management of corporate resources rather than corporate opportunities. Thus, corporate performance is judged by the ability to reduce or eliminate objects and other *innate* devices. Technology, a critical part of the corporate management team, is generally considered part of this realm. The simple fact that personnel are and will continue to be the most expensive and the least manageable corporate resource will drive corporations to automate every factory and every process within their control. The resolution and elimination of resources, including risk and innovation, is an agonizing means of resource management. Typically, this use of resources is also a process of downward communication: Reports written in upper-management terms describe floor room activity.

This resource approach to personnel management is clearly not a viable strategy, and because of executive failure to lead personnel in the present, there might not be a future.

Managerial performance is currently measured in terms suitable for reports, quarterly or annual reviews, or management retreats, measurements which reflect the least effective form of managerial leadership. The timing of managerial performance often lags behind the event by months, if not years. There is no "stopping the line" to correct a defective part: there are only dispassionate numbers and bar charts with trend analyses. The two key factors are synergism, the bringing together of forces, resulting in a greater effect than the actions of the individual parts, and a forward-looking perception. The typical management post is in front of the rearview mirror. As the need to lead the corporation in anticipation of events rather than in reaction to them increases, technology that expands leadership ability and meets the standards of synergy and feedback will become the competitive tool of success.

Executives are increasingly becoming communicators (see Table 1.1, Manager's Distribution of Time). They are meeting, talking, listening, presenting, educating, disciplining, and planning with others. Of the estimated one trillion dollars spent annually in the "office industry," it is not difficult to imagine that the majority of the costs are associated with communications. The traditional scenario of a communicator sending to a receiver with the potential for feedback is known. What is not known, to any large extent, is the action on the part of the receiver directed toward a desired goal or outcome. When a light bulb is turned on, the desired outcome is known (under the laws of physics), and the result is relatively immediate (the speed of light is only so fast). Given directives to staff by management, the outcome is never known in absolute terms because the timetable is always subject to delay. Several common problems that result in delay are:

- Misunderstood directions
- Sabotage and mistrust
- Ineffective resources
- Incompatible team personnel

Thus, the term **knowledge networks** reflects a system of ideas, thoughts, and concepts linked to other people or ideas. This network expands, contracts, and tailors itself to the needs of the knowledge players. (The term "players" conveys the subtle shift of roles from the present term "user.")

Neural Networks

The term network often implies a system of links that connect points, much like intersections connect highways. The term neural networks, as proliferated by AI researchers, explains how the networks of the brain work together to allow thinking to take place. Examinations of people with low intelligence versus those with high intelligence do not biologically demonstrate any clear neurological distinction. Perhaps at some point, intelligence in humans might effectively be understood, and the development of machine intelligence might be a requirement for this understanding. The development of machine-based neural networks might also give rise to a greater understanding of human thinking processes.

Networks shape thinking patterns. It might be in our own minds that there is no rigid networking system, only patterns which reflect a certain type of activity, such as walking, reading, or speaking. See Table 6.1 for an example of flow of mental problem-solving options.

In very simple graphics, cross/point charts where the user stands at the moment. Does the user want to move to another point? The system provides a chart of that point. This process is called linking, and the resultant chart would look like this:

TABLE 6.1 An Example of the Flow of Mental Problem-Solving Options

```
EXCHANGE EXCHANGE EXCHANGE
IDEAS IDEAS—LINKS—IDEAS
IDEAS IDEAS IDEAS
IDEAS—LINKS—IDEAS IDEAS
IDEAS IDEAS—LINKS—IDEAS
IDEAS       IDEAS       IDEAS
```

As we learn, these patterns become vastly complex; they are established and reinforced over time as a result of our environment. Certain personality traits emerge that, depending on the nature of the thinking required, give us the ability to process certain types of information more effectively or more efficiently than others. We all know people who can remember faces, telephone numbers, or dates better than we can. We all have certain thinking patterns that are distinctly different and allow us to see the world in our way, often to a fault.

Searching with these patterns or, rather, neural networks, is a process of thinking. Whether these networks are heuristic (that is, rule-based) or network-related (set up and broken down each time a call is made) is not well established. See Figure 6.4 for an example.

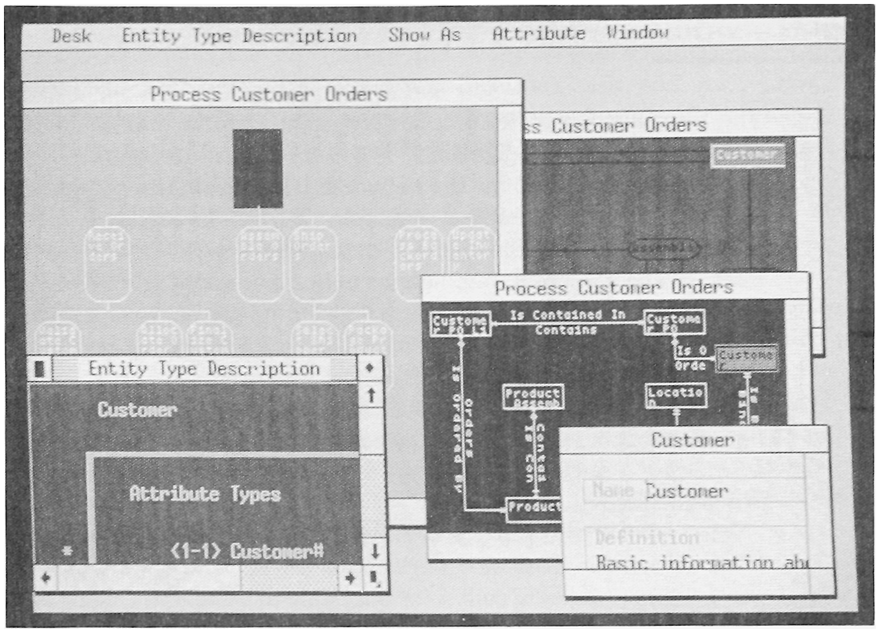


Figure 6.4 Sample data flows, entity-relationship, and decomposition algorithms with detail windows from KnowledgeWare, Inc.'s Information Engineering Workbench/Workstation. Photograph courtesy of KnowledgeWare, Inc., Ann Arbor, Michigan.

Let us examine the concept of searching that Margaret Boden raises in *Artificial Intelligence and Natural Man:*

> Basic to search theory is a distinction between two types of thinking, depth-first and breadth-first search. These methods respectively characterize the mind that follows its first ideas to their limits before turning to consider radically different alternatives; and the mind that skims all possibilities before lighting on a chosen few to be examined more fully.[15]

This search method is followed every day by most people who get out of bed and decide what morning television show to watch. There are the depth alternatives, such as getting out of bed or sleeping in, and the breadth alternatives, such as deciding which television channel to choose. The mind also has the ability to perform both depth-first and breadth-first simultaneously, or a hybrid-network. Neural networks, however, offer us a wide spectrum of such alternatives that are not necessarily mutually exclusive. At the same time, we can recognize both fear and joy, contentment and anger, and understanding and confusion. Needless to say, constructing machine-based neural networks is a relatively straightforward process, depending on the requirements for speed and complexity.

Designing a tree-based network requires no machine, merely a descending list of alternatives. Let us design a new neural network consisting of three dimensions: vertical, lateral, and angular. We should allow for planar to exist, which, like our holograms, allows for layers of information that can be connected by our other dimensions. In this environment, there are no rules about depth or breadth; these concepts coexist simultaneously in time and space. Consider that in this neural network any point has an infinite number of connecting links to other points.

If you have followed up to this point, we have created a universe, infinitely small or large depending on your perspective. Now comes the hard part. Is this network intelligent, or does it only have the ability to store intelligence? You decide. However, this kind of network exists today in multidimensional networking systems (CROSS/POINT) as well as in programming languages (LISP).

To understand how to functionally design these neural networks and how to use them is a complex problem. As Boden notes,

> There are two classes of heuristics applicable to tree search: generator functions, which influence the order in which the tree is grown (that is, the order in which nodes are visited); and evaluation functions (checker-playing games), which direct the choice at a given node by supplying information about the probable distance from the goal node.[16]

There might be other functions, including the mixture and composition of the interacting points, for example, single versus multiple links per node. This function is subtly different from generator functions, in that complexity can dictate the arrangement of options. Moreover, more processing might not result in knowing what the goal is, but rather that it might not exist at all. Neural networks bring about a reasonable and manageable approach to nonlinear thinking. As these networks emerge, they also can take on a dimension of time, thus giving a historical link of thinking processes over time.

Delphi—"On-Line" Decision-Making

Managing a knowledge network conference is an exciting and challenging task. It requires skills different from those of a face-to-face meeting because, in many cases, the participants never physically meet.

In most live, face-to-face meetings, interaction is fast and rapid fire, operating in many cases like a Western gunfight. Discussion is sometimes controlled by bullies or those with good communication skills, and shy people are often shut out or choose not to participate. Thus, the meeting is lopsided and the outcome probably does not reflect the best decision of the group.

Delphi is a concept developed for the Rand Corporation by Olef Helmen explicitly to remove the impact of a person's presence on the outcome of, among other things, a meeting or survey. If Dr. Henry Kissinger were a member of a discussion group, participant comments might be altered in some way by his involvement. Certainly we have all been swayed in meetings by the involvement of people we like, dislike, or do not know.

Delphi sessions usually take the form of blind surveys mailed to key people. The returned surveys are analyzed, and new questions are posed to the panel. In an electronic network, these comments and discussions can take place in real or nonreal time, affording the participants the opportunity to directly interact with one another. Even though the participants remain anonymous, using pen names or identifying numbers such as Foxtrot or 6321, some are always concerned about whom they are interacting with.

KN has a number of key advantages, including anonymity and privacy of communication. The Delphi process also introduces the concept of contemplation into the deliberative process. Face-to-face meetings offer the participants little time to think through all the issues at hand. In researching how corporate decisions are made, it was discovered that the Europeans and Japanese treat face-to-face meetings much differently than Americans. What is the purpose of face-to-face meetings and other forms of organizational communication? The Japanese and European models suggest that face-to-face meetings should be used primarily for team building, group motivation, or other communication directed primarily at the group, task force, or activity. The American theory is that face-to-face meetings are for letting the best idea boil to the top, popping the cork, and allowing the champion to emerge. One theory is group-oriented, the other is individual-oriented. The group-oriented process works behind the scenes, with communication used to iron out details, disagreements, and problems. The face-to-face meeting, however, is used for acknowledgment and group praise. There are strong inherent limitations in face-to-face meetings, as reflected in group dynamics. Groups work and function differently and at different times. Interaction must allow for the time and space to analyze a problem, whether through a Delphi process or through a knowledge network. Delphi is a key concept in improving deliberation and facilitating ongoing group communications.

Knowledge Acquisition

Learning is generally associated with training or education rather than observation. However, in a learning system, it is often the case that the learner is passively observing a sequence of events and doing little, if anything, about it. In truly simple terms, learning is hardly more than the recording of an event or sequence of events. To distinguish learning from reaction can require an intelligence that is more a form of analysis than it is active participation in changing the outcome of the events. Let us say that we have recorded an event and analyzed it, or at least attempted to understand it. At this point, we have yet to reach a level of understanding which is different from an interpretive level that suggests we know what has actually taken place.

Learning Systems

Learning systems have any number of levels that might not require any form of intelligence in order to function. In the case of a thermostat, for example, it might only be in the inductive stage that the environment changes (heats up) and the thermostat reacts (turns off heat); yet, according to some definitions, the thermostat has intelligence. Learning systems that have intelligence can differ dramatically from this simple example. The point is that the desired outcome of the learning process needs to be considered in the design process.

A learning system can only be required to recognize a pattern and react to it. Pattern recognition is in the early stages of development. Bar codes, optical character readers, and simple pattern-recognition systems provide the groundwork for the visualization and conceptual knowledge systems of the future. However, what is the desired goal of a learning system that utilizes the vast technology available for the accumulation and presentation of information? The intelligence associated with such systems will prevail.

Learning systems might also emerge as filtering systems that condense vast amounts of data—far more than any human could even technically process, for example, 5,000 words a minute—into desirable activities or outcomes. In some studies, this is called the **interrogator function:** a series of machine processes that have little or no intelligence, and save or delete predetermined occurrences or information.

In this way, the system can learn what is important and what is not. Moreover, the system can then be told why these certain occurrences are important; that is, to compare the occurrences with nonoccurrences and develop its own options for changing the filtering process. This is a simplification, but it demonstrates that learning systems might be able to act on their own behavior, thus learning about themselves.

Certainly, this activity is not accomplished without help from the instructor, who can facilitate or increase the pace of the learning process. This instructor-machine interface might well be the most integral part of the process, because learning can be most effective when the learner has some control over the process. Also, in designing these systems, the instructor or user might want to alter the learning process to accommodate changing situations.

Clearly, learning systems can be an important part of consuming and digesting increasingly vast amounts of information. The evolution of simple search systems into advanced technologies that provide commentary on the state of affairs is not the limit of development in this area. Further development of these systems will require in-depth initial consideration of the outcome. In this sense, learning systems can be accelerators of knowledge that was limited previously by human inability to process the data; it is in this environment that learning systems have the most to offer.

The potential exists for learning systems that possess visualization or other AI technologies. The systems might be application-oriented, with specialized functions devoted to knowledge processing and simulations. The technology has certainly evolved past the predictive stage; that is, each successive event is compared against the potential of a past event [(n-2), (n- 1), (n), (n+ 1), (n + 2)], where (n) signifies the present, (n-n) the past, and (n + n) the future.[17] In this situation, the learning system might be able to distinguish between different events in time or space (occurrence). Certainly, given this knowledge, the user will be able to develop even more complex levels of learning or problem-solving systems.

Knowledge Networking Features

The following features define KN:

Outlining

A computer is ideally suited for generating and organizing an outline of unlimited length. It has the ability to add, delete, modify, and reorganize. Most paper-based outlines do not allow for the easy addition of information. Text processing (TP) software offers the ability to "link" separate outlines at any point in a grid form, which can be displayed on the computer terminal. In this way, related ideas can have distinct primary relationships as well as tertiary connections to other outlines. The command to prioritize organizes a list of topics by importance or significance. The randomize command, for example, puts a list of topics in random order for possible associations. Grouping concepts by common attributes permits general observations. The categorize command creates an outline structure from grouped topics on a list, and certain commands provide additional links to organize, identify, flag, and retrieve information.

Charting

The problem with a white board is that you often want to save what has been written but need the space for something new. TP systems make it possible to save work as well as add new text. The networking capability allows text to be sent to other people for review, comment, and correction.

Networking

Building personal "idea networks" is an important approach to creating and managing projects or management activities. The network allows ideas to be coordinated, managed, organized, and presented for review. Networking permits easy filing, searching, and editing. Creating ideas, linking them through multidimensional outlines, and charting their relative positions is certainly a far more exciting and creative process than the traditional filing system.

Idea exchanges

An idea exchange point is an organized information outline for group networking. Each idea exchange can be divided into subcommittees, projects, chapters within a book, lectures within a course, or issues within a discussion, all of which are called idea points. Idea points let a group share information in a central idea exchange area or allow many-to-many or group networking. These areas are accessed much like normal meetings except there can be an unlimited number of idea exchanges (main topics) with a corresponding unlimited number of idea points (subtopics).

Status and tracking

This function provides the conference member with information about what new ideas have been sent to the conference, new mail, and information that concerns and organizes project activities.

Management reports and directories

This function tells network members how long an individual has been working at an activity. This information is useful for charge-back systems and management reports, and can aid managers of offsite personnel. The directory is a useful system for finding out what idea exchanges and what members are on the system or who might be interested in a specific issue.

Searching

Text searching of outlines, networks, members, discussions, and personal notepad areas can save large amounts of time as well as provide idea-exchange members with tools for better organization. In addition, after a search is completed, the results can be instantaneously sent throughout the system. For example, searching generally allows a person to find comments on Venus and Mars, but not Jupiter or Saturn. The system then retrieves the information requested and gives the conference member material that can be organized into a report or filed. Joining merges text by lines, words, or sections. Dividing reduces text into lines, words, or sections. Sorting performs a variety of functions, arranging text in ascending or descending order or by cross/points, charts, or other options.

Gathering

Once information has been amassed in separate idea folders, it can be reorganized into a summary report using the gathering function. This function collects personal memos, mail, and ideas and organizes them in any way desired. Inserting and deleting allows input of new text within existing or new areas. Most TP systems have commands for text manipulation, such as move, copy, put, get, mark, and undo (which reinstates a command previously performed). Editing functions offer a wide range of options, including interfacing word processing software and internal editing commands. Some of the commonly found editing commands include insert, overtype, block move, and annotate.

Real *time*

Most TP activities are actually performed in a nonreal-time environment, but this feature provides for an on-line conversation mode. The system "knows" who is presently "on" the system and can help organize a conversational idea session, which is very like a telephone conference or a face-to-face meeting except that the statements are made in text form. A verbatim transcript of the event is made automatically.

File handling

File handling is a demanding operation. Most systems can read ASCII files, but some have limitations on the amount of transferable text. Some systems allow for the uploading and downloading of ASCII files, but cannot read them in the same form in which they were written. Printing options include spacing, selected files, outlines, charts, mergings, headings, annotations, numbering, and status reports.

Other program options

Even TP systems have to be user-friendly, with multiple modes of operation, menus for instruction, on-line help and tutorials, direct commands, multilevel string commands, access to the operating system, user-defined macros, system programs or external time-sharing programs, windows, and other administrative management features. Other features include on-line applications and simulations that facilitate user interaction.

Communications Networks

As complex electronic networks emerge, there will be a need for packaging these modules into useful functions. Rather than universal modules, the modules will likely develop for specific applications, such as medical diagnostics, computer-aided decision-making, or home and factory control systems. These modules will probably be supplied with a great deal of baseline information. For example, a management case study might include all the information in the *Harvard Business Review*.

Communities of connections presently exist in elementary forms. Electronic mail networks form the basis for simple linear systems. Computer conferencing and its derivatives, such as thought processing, offer various combinations of multilevel systems.

Three-dimensional access allows complex, multiparallel processing or other possibilities. Even the dimension of time, as well as space, can be incorporated, in the sense that events are positioned or cataloged by a time or date in history. Space also applies because many events can only occur in a particular place (space, earth, water, Texas, and so on). These elements can offer additional means of connecting these networks, or designing multiplayer games or decision-making aids.

The range and scope of these networks offer an interesting mix of interactions. These communities can be developed into gaming societies that can play against one another.

In a game like Buckminster Fuller's World Game, for example, there are seven requirements for winning:

1. Make the world work (that is, satisfy human needs for food, energy, shelter, etc.)
2. for the most people
3. using the least amount of resources
4. with the least environmental impact
5. in the quickest amount of time
6. in an ecologically, socially, economically, and technologically sustainable, safe, and flexible way and
7. with the most degree of freedom or alternatives to humanity and the individual.[18]

Multilevel gaming is strongly pursued by some AI researchers as a means of balancing known reality with a grasp of the unknown. Multilevel complex networks can be developed in synergistic ways. As suggested by Buckminster Fuller, various elements can be combined to solve neighborhood, and even intergalactic, problems. Possibilities such as terrorist networks, organized crime syndicates, and ultra right- or left-wing political organizations can be included in these networks so that revolutionary tactics can be tested before being used in real situations.

Summary

The future of these complex network connections offers more than just an increase in the size and scope of such systems. The ability of these systems to take on their own living and intelligent activities is certainly within the realm of possibility. Drawing information and machine resources from various parts of the globe, the network could develop its own personality. It is also likely that this living network could offer security and protection from impostors (real or created by the network) by monitoring privacy

Complex systems will also need sophisticated technical support, which means vast network management to erect and sustain the dynamic needs of the network users. Additionally, network management requires the ability to implement new features and guard against privacy violations. Moreover, the network must allow for individual expression and diversity of thought organization.

As the network evolves, the need to catalog and archive older connections or combinations will arise. The network needs to have common sense as well as vision and imagination. As cars and computers have evolved from simple creations to intricate, highly developed devices, a network community needs the ability to grow and understand where it has been in order to design for the future.

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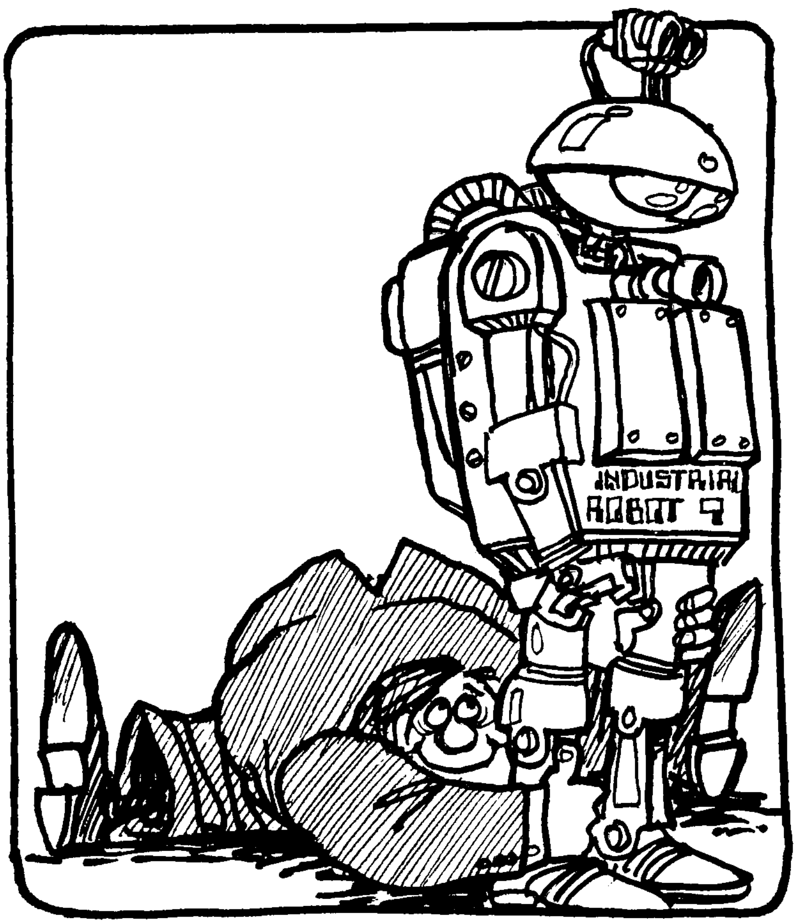
Chapter 7

"Real World" Applications—Metal Models



Introduction

This chapter will focus on some interesting applications of advanced knowledge engineering systems and provide a framework for developing these applications in your own organization. However, rather than presenting an automated system to streamline your operations or management processes, the chapter provides the necessary conditions to start all over again. The success of many of these systems may depend largely on the creation of the activity (sales, manufacturing, training) to be accomplished by using these systems from the start. In other words, some organizations might be vastly more successful using a knowledge system because they adapt their organization to the system rather than trying to get the automated system to adapt to an already bureaucratic organization, such as the IRS.

Advanced systems that either mimic or aid an expert in solving a problem have been in existence for over 20 years. The initial focus of many of these systems has been to provide expertise to novices and diagnosticians in examining all the possibilities or in speeding them along in their endeavors. Over the years many classical expert systems emerged. Other related KE systems may have certain levels of sophistication that would be associated with an expert, but that does not necessarily make them expert systems. Expert systems are also not just those that answer questions. Many derivations of expert systems or rather KE systems do much of the tedious, mundane work previously accomplished by their human counterparts.

Gathering information is often an incredibly time-consuming chore. These systems provide substantial benefit to information workers by searching data bases and organizing information, and by providing, in many cases, insights into how a decision or function is performed. With new KE systems the developers or knowledge engineers gain insights into medical diagnostics, sale and installation of computer systems, and the judicial process. Moreover, these knowledge engineers were able to pass this information along to the users as well as key principals and, in some cases, apply the knowledge gained from one system to another. For example, in the court system an expert system for drunk drivers was applied to the juvenile courts with dramatic new insights into the overall judicial process.

Classical Examples

Some of the most widely known knowledge expert systems include:

- Rl/XCON/ESEL—which helps sales personnel determine the configuration options for DEC computers
- XSITE—a computer site tool which interfaces XCON

MYCIN—a medical diagnostics tool

PROSPECTOR—a system for evaluating mineral options

DENDRAL—a system for evaluating chemical compounds

META-DENDRAL—a system for configuring DENDRAL

INTERNIST (now CADUCEUS)—a system for general medicine

MOLGEN—a tool for aiding biologists in molecular genetics

DIPMETER ADVISOR—an oil-well log interpreter

SPICE—an electronic circuit design system

PUFF—a system for certain lung ailments

CASNET—a system for dealing with certain diseases

FRUMP—an experimental language understanding system

Many of these systems offer specific information about a problem or issue. For example, XSITE, developed by the Digital Equipment Corporation, tells the customer how much air-conditioning, electricity, and other factors will be required for the new computer system. Other systems offer various levels of help or expertise in problem-solving.

Before designing any knowledge system, an examination of a number of issues is critical to the overall success of the project. Presently there are few "cookbooks" on designing an expert system. There are, according to some researchers, specific elements to an expert system, but the system specifics are often widely different depending on the programmer/designer. From my research, the fundamental elements of a computer-based knowledge representation system should follow the particular needs of the application. For example, most problem-solving exercises fall into the traditional business case approach:

- Define problem
- Explore alternatives
- Narrow and make recommendations
- Make decision

A knowledge system can be used in all of these areas, though not necessarily a single-purpose one. There are knowledge systems, like those mentioned above, that tackle a particular piece of the problem with the understanding that there are many other elements to the overall solution. In addition, there are subcomponents that might have to be solved first before approaching the main problem. Let's look at some of the issues behind these design processes.

Mechanization of Knowledge

In the machination of various human experiences or encounters, the question of initial observation arises. The choices are, for example, looking at the top view, side view, inside out view, composition view (what it's made of), impressionistic view (what it's supposed to be), or emotional view (how I feel about it or react to it). Take any group of people to see a movie, art show, or sunset, and each person will probably have a completely different view of these experiences.

The best case one could make about a model of the world is that it could form the basis for discussion or communication. In some cases, these models can fulfill the role of space juxtaposed against time. Spatial reality separates "here" from "there" as time separates "now" from "then."

Advanced computer graphics systems use high-level mathematics to display, tilt, and rotate graphic representations of precision tools, automobile engines, or computer components, but this computer technology is still in an early stage of development that can be compared to the first development of automobiles. Computing technology in modeling is nearly as primitive. (The term "metal models" is used figuratively here to distinguish it from "mental models." The terms metal, machine, and computer technology can be considered synonymous, but I use the term machine rather than computer because it is broad enough to cover robotics, holography, and biocomputers.)

Modeling in a machine sense is limited by its own imagination. Modeling and imagination are tied in a real sense as terms indicating an interface with the surrounding world. Close your eyes or block your ears. As you restrict one sense, the others take its place and enhance the remaining senses. A machine, limited in its imagination, can only operate at a reduced level of performance.

Metal models can only operate from a certain point of view, level of obstruction, or deductive approach, one that seems the most efficient at the time. Metal models are probably too logical in their approach to reality to effectively simulate human response. Humans often take specific ideas and generalize, making them larger and larger until they fit the arena of operation; humans also constantly narrow very complex situations and experiences in order to reach the point of making yes-no decisions. Humans drift between fact and reality at tremendous rates, depending on a large number of factors, including:

- Speed
- Emotion
- Obstruction
- Level of logic or organization
- Body chemistry
- Tolerance of ambiguity
- A variety of other factors

Metal models are more efficient and appropriate when the subject can be confined to a narrow knowledge base of information. Robots have proven to be quite successful in this area, for example in the specific, detailed task of assembly line production. Millions of applications overload humans with repetition to the point of boredom. Machines never get bored; so why not automate all boring activities? Millions of people could be employed in the production and research of equipment and programs to automate these mundane functions.

An area for resolution in the human-machine interface is the understanding of mental models. If humans develop mental models and build physical models to explain them, a machine would be a suitable example of mental modeling. However, what is the process when the model comes from the machine, giving rise to other or higher levels of mental models?

Currently, humans are learning as much from machines as machines are from humans. In the past, humans only possessed tools like muscles, feet, and hands that implemented body functions of walking, shaping, catching, etc. Now metal models, essentially portraits of the mind, offer humans a means of communicating with other humans, and in the future might offer an opportunity for machines to communicate with one another and to understand that communication as well.

Ergonomics

In designing software systems, programmers are faced with the arduous task of making the software user-friendly. Over the years, various methods have been used to bridge the gap between what the user says is needed and what is really used. This ergonomic or human-machine barrier generally yields programs that have extensive commands in "computerese," which force the user to know the dialect of that specific system. A menu-based, or tree-trunk process directs users down pathways to the specific feature or task desired. New systems include windows that pop up, pull down, put aside, or offer continuous explosion of deeper or larger elements. Neither the dialect process nor the menu-based process works efficiently for very long. System commands rarely work on other systems, and menus become a tedious user interface that requires too much time. However, there is an intermediate method that is called **mental mnemonics.** This concept is based on initially providing the user with the means to become familiar with the features, tasks, and functions of the program. The menus also contain the system commands.

The user learns the structure and scope of the system by moving through the menu hierarchies, analogous to learning that the living room is down the hall and to the left of bathroom, and one must leave the living room and walk down the hall, not through the wall, to get to the kitchen. Mental mnemonics build mental references like acronyms, such as GM for General Motors and IBM for International Business Machines, which allow the user to easily remember the features. As the user progresses, these mnemonics become commandlike and replace the menus. Advanced systems offer both menus and commands. In this way, the user can access seldom-used features through the menu without having to know the command structure.

These mental triggers are often the key to successful usage because users are easily turned off by software they cannot use right away. Level of difficulty is the ergonomic constraint to creating software systems that use English as the access media.

Modeling States of Mind

Until now, we have discussed modeling in the sense of acquiring and assimilating information within the machine. Now, the issue is the physical nature rather than the numeric. For thousands of years, people interfaced with paper rather than electric media. Now that people are interfacing with machines, a move is being made toward machines that have intelligence beyond the deductive and reactive stages—systems that are intuitive and, thus, might have a mind. A "state of mind" has always been associated with determining the presence of a human consciousness. Now we must apply this form of human consciousness to the machine.

Alan Turing spoke of computer states as on-off, yes-no, 1-2-3, and so on. In many cases, the order of the state of the machine was the determining factor in how the information was processed through the computer. Data base technology has allowed us to practically disregard the notion of order, unless we have a specific need for it. Network technology allows us to ignore the notion of the single value or state of mind that exists and assign a specific attribute or meaning to any one issue. Hilary Putnam in *Mind and Machines* states, "A physically realized Turing machine may have no way of ascertaining its own structural state, just as a human being may have no way of ascertaining the condition of his appendix at any given time."[1] However, we recognize that a machine can ascertain its state through such methods as on-board testing.

On-board machine diagnostics have been possible since the first computers. These early devices consisted of vacuum tubes that not only generated heat like a light bulb, but also failed at an amazing rate. Computers had thousands of these light bulb test tubes, and at any one moment the relative "states" of these devices could be failing or have failed, so self-examination was a technical necessity for keeping the computer alive. Today, it is evident that as devices increase in internal complexity (read capability), ongoing routing will increase the lifespan of the device, a cost-effective process when you consider labor cost in replacement often well exceeds the value of the device. Moreover, as computers continue to be reduced in size below the one-micron barrier, the need for redundancy will eventually overtake many of the capabilities of the device itself.

Yet the state of being presupposes any knowledge of the machine. As Putnam indicated, we know not the workings of our brain, much less anything else in our bodies, yet we are considered intelligent in our understanding of reality. In this isolated sense, the machine might know more about its own internal workings than humans and, therefore, might be far more capable of solving a problem than humans, in terms of alerting the repairperson, removing the faulty component for service, or instituting internal diagnostics to make a recommendation about a specific repair. If we could perform such services for ourselves, we might be considered intelligent.

The Machine's State of Mind

This argument again raises the question of the state of mind. In the foregoing example, it might be argued that the machine can be unplugged, but few people can live without air. Interpretation depends on one's definition of reality and the parameters that justify this reality. Like sea coral, which is stationary, a computer does not move. Does that, therefore, make sea coral a computer? We have not yet discussed the ability of the machine to have its own input devices that mimic sense organs. The research areas of machine vision, speech, and recognition are in their infancy, each with its separate approach to the problem. Machine observation can extend far beyond human reality and can reach places where humans are unable to go without considerable expense or support systems, such as the moon and the ocean floor.

In some ways a machine observes itself and makes independent "self decisions about its own reality. In a traditional view of a machine's state of mind, the condition of knowing is, like the diagnostic routine, relatively straightforward. In an advanced state, the machine can be posed with multiple states of mind as inputs; be asked to determine which reality is true; compare and contrast the differences; and act either in a logical or subjective state, depending on the predeveloped personal preferences of the machine.

Model Building and Ambiguity

The challenge of model building is learning to tolerate ambiguity. Models in mathematics, as well as physical construction, emphasize structural certainty. In mental modeling systems, the issue is tolerating even wider degrees of ambiguity. Ambiguity, in this case, is not noise, error, or irrelevancy, but differing perspectives or points of view. Ambiguity can also be defined as having a large number and types of connections to other data. In this sense, the more types of connections, the greater the ambiguity. The words "green," "blue," and "fast" have a vast array of possible connections as opposed to blue Chevrolet Corvette convertible car. Free-form association, a tool used in brainstorming, seeks a reasonable and, at times, illogical connection. By building structures that are based on high degrees of ambiguity, new structures are formed that are new models that can be used in other situations.

In human terms, these models are common; in activities such as walking or running, free-form association exists that connects unrelated bodily functions or movements into a pattern. In mental areas, these models have been difficult, if not impossible, to build and identify because there is rarely any definitive physical activity that results. Many would argue that art, writing, and other activities are reflections of organized mental action.

However, in executive decision-making there are hints of organized mental modeling. As is often the case, the challenge of subordinates is to anticipate senior decision-making and act in anticipation of projected events rather than be hit with a surprise attack. This approach suggests that it is possible to create models of models by examining and building upon underlying elements (words, emotions, images). From this vantage, these activities have associative connections with other base elements and higher proven situations, such as prescribed procedures for purchasing, fighting a legal battle, or having the machine repaired. In this sense, the network approach can be automated very effectively and established into a standard process of activity.

One of the higher challenges faced by senior decision makers is the modeling of complex decision-making when the outcome is considered nonlinear or the situation requires immediate crisis intervention, is futuristic, involves a myriad of elements beyond the participants' control, or involves some other activity beyond the scope of our comprehension. It is suggested that the computer be used in such situations, but not currently and certainly not always; however, as decision processes become instilled in machine models, an exciting possibility arises in the creation of games or simulations that the machine can interact with when not involved in other activities. Such games can overlay one another to form complex models and allow multithink gaming. This is not human playing against machine but machine playing against machine. This phenomenon has been commonplace for over two decades in computer chess.

The hierarchy of machine modeling is usually discussed in higher and lower levels. An example is a letter, which is composed of words that become sentences, then paragraphs, eventually leading to concept emergence. In this tree-structure environment, roots and lower-level junctions provide the foundation anchoring the tree. It is suggested that machine intelligence provides an infinite tree or network topology that might or might not be like any traditional hierarchy previously known. In a network system, there is no top, bottom, or side, only infinite connections in any direction or dimension. Moreover, it is not necessary to devise schematics or characteristics of the elements. Because each element can be part of any number or dimension of nodes, there is no need for definition.

AI researchers point out that words such as "war," "peace," "love," and "hate" mean fundamentally and dramatically different things to different people and that, as shown in psychology, these same words can mean different things to the same person almost simultaneously. Thus, flow of thought can be channeled by a network tolerating, if not encouraging, ambiguity. In the instance where ambiguity is encouraged, it might be considered imagination. When it is not encouraged, rules are provided for specific activities. Certainly, a network system conceived to be of use to people might be some time in coming; however, the necessary elements (brick and mortar) are available today.

Another difficulty in network topology is building and testing any particular thought process, starting with known situations and varying the consequences to meet the new situation. This is similar to using financial spreadsheets to alter or change the rules of a profit and loss statement. Networks can be "played with" by changing the assumptions and conditions of the known activity. Moreover, as the players become successful at developing outcomes, their ability to change the inputs also dramatically increases. In addition, the outcomes of the play can be used as inputs for even more complex network thought processes.

Business Applications

In designing knowledge representation systems, there are many approaches. As mentioned earlier, the classic business-case approach is one way to begin. Others include problem-solving from a communications perspective. For example, thought processing is a means of networking individuals together for problem-solving. The network is not merely a connection process but a series of overlayed software that allows participants to explore solutions from a number of different perspectives. Let us develop a framework for designing a knowledge system:

1. Gather knowledge or expertise. Gathering knowledge is a fact-finding mission to obtain the information needed to proceed. This information includes the expertise of individuals who interpret the aforementioned knowledge, or are already supplied with it.

2. Quantify the information into distinct units. Many of the most successful expert or knowledge systems break down the elements (sales figures, system components, production units, ailments, etc.), allowing each of the elements to be combined or recombined in any way possible. Thus, any element can be used to solve the problem or to gain knowledge in order to make the next step.

3. Observe connections. How do the elements work together to make something work or happen? By connecting the elements, like atoms, formations emerge which can then be used as parts (muscle groups, vertical sales markets, field engineering task forces, etc.) working toward a solution. By analyzing successful sales strategies, printed circuit board failures, and drunk driving prosecution statistics, certain inferences, trends, or knowledge structures emerge. In many cases, these patterns

become useful in designing new systems or providing expertise to those working on similar problems.

Not unlike statistical analysis, rising crime figures may point to the need for increased funds for law enforcement. At the same time, increased recidivism may not mean that crime is a worthwhile pursuit, but rather that inmates are not being trained in skills that can be used once they have been released. It is important to recognize the "wild cards" or the nonpattern-related factors as well as the known ones, in other words, to examine your outcomes from as many difference perspectives as possible.

4. Evaluate options. In expert systems the term "rules" is used to mean those attributes that are valid. Rules, however, range from "rules of thumb" to absolute, positive laws which bear no deviation. In the domain of present programming languages, the if-then statement provides the rule-making basis for most expert system development. If-then statements provide yes-no analyses of most issues at hand. If there is a shadow, then the sun is shining or there is sufficient light to cast the shadow. Most decisions or activities can be grouped into elements that suggest that if "A" is done, then "B" will occur. If-then (and usually else) statements can be added, deleted, or modified in the rule-making process as conditions change (model 45 tape drive replaces 40).

5. Test outcomes. Before spending lots of money and time to develop a knowledge system, test the system manually. Many of the most successful decision-making tools are manual and probably will remain so for some time to come. Test the system under various operating conditions and evaluate the results to determine what, if any, benefit, there would be to a computer-based system. In some circumstances, designers have found other uses besides the original one that can provide additional financial benefit. In other situations, the exercise provides significant financial return, where an automated system provides little functionality. Testing provides an opportunity to rethink the entire process, often giving insight as to how sales, education, and circuit-board design may be accomplished differently. As a result, an automated system may form the basis for performing the entire process.

6. Automate. After evaluating the test results (automating this process can provide added value, financial benefits, productivity improvements, or all three), the prototyping should begin. Before developing one's own expert system internally, a survey of the existing off-the-shelf systems should be completed. Packaged software may not meet your needs exactly, but it might further test the process in question and, if successful, work faster than internal program development.

This is a quick look at developing knowledge-based systems. By conducting your own research, you will probably find that there are few, if any, agreed-upon standards for these kinds of systems, as there are few standards for word processing systems, spreadsheets, etc. See Figure 7.1 for an example of a computer expert system. Yet, by getting your feet wet and developing manual models, you will quickly see how some of these automated systems can bring about substantial benefit to the organization. And, as mentioned before, it may provide the opportunity to rethink or recreate the organization in toto.

One approach to gathering information about the workings of an organization is through a concept called thought processing (TP). In simple terms, TP is an advanced management networking system allowing for many-to-many interaction. By bringing together managers (experts) and reviewing or analyzing the information they communicate, insights (inferences) can be gained that can have broader application than those gleaned from a single expert. Moreover, as the information grows, its utility increases dramatically. Thus, statis, one of the primary limitations of an expert system, is reduced. One of the most exciting possibilities includes the development of an expert semantic network (SN). SNs, for the most part, are those systems which allow for interlinkage or interconnection of thoughts or ideas. The semantic network is a multidimensional sentence in which any one issue or word can be connected to another, thus showing how sales strategy relates to production output. It is in this concept of **relation to** that TP, SNs, and other advanced forms of artificial intelligence become useful to the average business person.

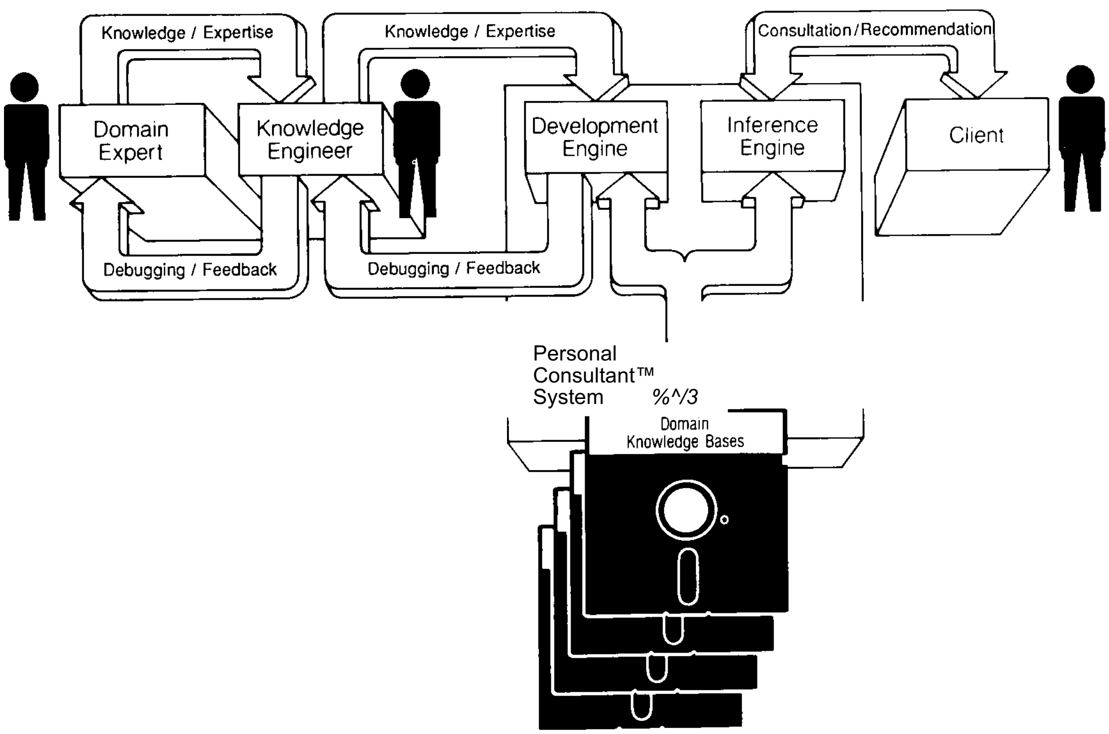


Figure 7.1 How information is gathered, organized, and developed into an expert system. Photograph courtesy of Texas Instruments.

Network topography in relation to TP allows a user to tailor advanced software to meet specific needs, making this type of software application independent. The application depends on what the user is doing, and not what the software wants to do. Some programs allow for such flexibility, thereby crossing the traditional software application boundaries. So-called "fourth generation software" supplies the end user with the building blocks for application. The user can then build applications for:

- project management
- software management
- financial planning
- marketing
- field engineering

and virtually any endeavor that requires manipulation, tracking, and the communication of ideas between people over time.

The following examples of TP software application will give one an indication of how advanced software can be useful and practical in our current business environment. Businesses that start using such software today may ensure that they will be competitive tomorrow.

Thought Processing—Sales *and Marketing*

TP is useful for improving sales and marketing strategies, and implementing those strategies toward the realization of a company's sales and marketing goals. What, then, are the goals of a sales and marketing organization?

- Enhanced competitive advantage
- Price leadership
- Stabilized pricing
- General lifting of price levels in the industry
- Greater market share
- Higher volume
- Increased customer goodwill

Achievement of these goals requires timely information and rapid networking as well as a high level of organization and management. A telemarketing operation needs even more rapid networking. Below is a quick sketch of how TP links with business in general and sales-marketing in particular.

TP facilitates the basic needs and objectives of all business because it:

- Simplifies activities
- Saves time
- Lowers costs
- Enhances networking

TP in business

TP can be justified even in a fairly small business and can benefit any organization. Sales-marketing firms in particular benefit by the incorporation of TP into their organizational structure, because sales-marketing firms are typically:

- Decentralized organizations that often require expensive travel or networking between different sites
- Organizations with a need for considerable control and coordination among functions
- Operations that depend on the rapid deployment of information—for example, when dynamic market conditions require quick feedback of sales data into the manufacturing process or when fast-changing operations create a need for prompt communications and response
- Groups with ongoing training requirements where TP can effectively supplement teaching and training situations

TP is especially suited to the typical organizational structure of sales-marketing firms, and can thus significantly increase the attainment of sales-marketing goals. First, TP will be discussed in terms of how it facilitates specific sales and marketing functions, and second in terms of how it enhances the components of a sales-marketing organization, such as structure, management, and coordination to sales and marketing goals.

TP specifically ties in with sales-marketing information/communication needs and goals, which are both external (the need to get information out to customers) and internal (the need to create and update information on products and services, then network to new and potential salespersons, other sales personnel, and other departments). These requirements are heavily dependent upon sales manuals, sales bulletins, sales aids, and sales reports.

Sales manuals and bulletins

Sales manuals and sales bulletins provide the specific information that backs up the product image. The functions of sales manuals and sales bulletins are supplemented by the correct use of sales aids. Sales manuals generally contain the following types of information:

- Price lists
- Parts lists description
- Organizational charts
- General employee policies
- Advertising portfolios
- Special sales aids
- Customer brochures

Information contained in sales manuals can be compiled and entered on the computer by the home office staff. Then, when needed, it is easily retrieved, updated, etc. Salespersons as well as personnel in other departments can have access to these ideas, which encourages innovative contributions to manuals from those not directly connected with sales. It is a simple matter for an interested party to make notes in the "on-line" sales manual for those on the front line.

Sales bulletins are a source of more general information covering several different areas: (1) organization, including company plans and policies, product documentation and development, selling, service, and market conditions; (2) education, including "how-to" approaches on selling: tips from top sellers, self-help advice; and (3) motivation, including stimulation and morale-builders of all kinds, feature articles, profiles of successful sellers, jokes and banter, and incentive plans.

In the past, sales manuals and bulletins have been severely limited by long delays in development, review, and implementation. Too often the salesperson has lacked necessary updated information on the product at the front line. Product updates can move slower than the U.S. mail. TP will change all that.

Sales aids, sales letters, and other sales communications may be easily kept on electronic file. Salespersons are typically reluctant to write "cold-call" letters as a means of soliciting business. Yet, such letters are a proven aid to sales. TP systems can facilitate this process in several ways. For instance, the home office can file a set of letter types, documents, phrases, and sayings appropriate to a product or service, allowing the salesperson to quickly review the material, even while on the road, and select the most appropriate version for use.

Sales reports form the basis of all sales activity. Information networked from the customer to the home office is crucial in developing sales strategy. In addition, formal reports about a salesperson's performance with respect to achievements and the manner in which they are achieved come to the sales manager. Most common are sales reports showing actual sales, usually by product line, achieved in specified time periods by each salesperson. Expense reports are also common.

The salesperson may provide a number of activity reports as well, informing the district manager of activities in several categories. Firms have varying uses of these activity reports, but the more common usages include: call reports showing customers visited, results achieved, and product lines discussed; new business reports, showing new accounts or "break-ins" to an account of a product line not previously sold; routing plans showing how the salesperson plans to spend time with customers; lost business reports showing competitors for business lost, and why; customer activity reports; and general market conditions reports.

These informative reports are vital sources of performance appraisal and general market conditions. With systems such as CROSS/POINT, each of these can be kept in an idea file which can be maintained and updated daily. This allows for home office review and contribution, and closer control over salespersons.

The sales-marketing system

A sales-marketing system should link TP to sales-marketing strategy. Achieving the varied, and sometimes conflicting, goals of sales and marketing is challenging. Managing and coordinating an effective information-communications process requires an efficient stratagem. This section examines how TP enhances a firm's capability to meet its sales-marketing goals.

For firms of any size and complexity, the networking process has a significant effect on the firm's sales efficiency. Yet, networking is poorly understood as a link between the internal and external function of a company. As one sales manager suggested, it is an activity "by which the manager develops an orderly pattern of group effort among distant or lower units, and secures compatibility of action in the pursuit of common goals."

The very nature of the sales-marketing operation requires sales managers to carefully coordinate networking activities, both within and outside of the firm. Within the sales organization, several intergroup relations are common. The first area is networking between teams. The sales manager may have diverse subunits for which interrelationships must be spelled out. Some of these are:

- Sales-Service
- Sales-Order Handling
- Sales-Warehouse Operation
- Sales-Customer Billing and Collection

Many potential incompatibilities exist here. The regional marketing order manager, for example, may legitimately perceive that certain organizational delays are reasonable, whereas the field sales manager may want to have an edge on competitors and be able to ship anything in the shortest possible time. Even simple incompatibilities may go unresolved. In this case, the first management level above the parties involved should work toward resolving the problem and coordinating the objectives and relationships of the two by defining a policy consistent with, and compatible to, each.

A second area of concern is coordination between sales and other elements of marketing. Rational and objective coordination is also required between the selling operation and other functional marketing groups. Some examples are:

- Sales-Market Research
- Sales-Forecasting
- Sales-Marketing Personnel
- Sales-Product Planning
- Sales-Headquarters Product Management
- Sales-Pricing Units
- Sales-Factory Liaison Groups
- Sales-Advertising

Again, the objectives perceived by sales management, and ensuing actions to achieve them, may not necessarily be in tune with the objectives and ensuing actions of other units in the marketing organization. For example, a sales administration unit responsible for pricing strategy and tactics may legitimately implement pricing actions to achieve the objectives of higher revenue via higher prices. The sales policy goals are to achieve price leadership, stability of pricing, and general lifting of price levels in the industry. But at the same time, the sales department may seek objectives of greater market share, higher volume, and increased customer goodwill. It is conceivable that this situation could create conflict between the two marketing groups, to the detriment of each. Moreover, these groups may frequently be located in cities a great distance from one another, further reducing the ability for conflict resolution.

A third dimension of the marketing-sales operation is networking between sales and elements in the firm's outside marketing. A telemarketing system facilitates input into sales from market research, product planning, and so on. Often, input and ideas come from elements outside the firm, such as suppliers. Here, a TP or idea management system like CROSS/POINT may be the best means for improving networking. For example, a defective part being assembled may be quickly brought to the attention of the supplier via the TP network.

In most firms, the selling operation interacts with many nonmarketing units of the firm. This is another potential conflict area in which coordination and telemanagement may bring about improvements. Some of the greatest problem areas are in:

- Sales and Production
- Sales and Finance/Contracts
- Sales and Engineering
- Sales and Traffic

Each of these units may have multiple interaction points with the other organizations, and they may interact with one another, separately from sales. Without adequate coordination, many objectives may be so mismanaged that the product suffers a competitive disadvantage in the marketplace. Engineers, for example, may design a product in a certain way simply because they have some kind of technical idealism directing them to do so, rather than a practical knowledge of what the market requires.

In another example, many salespeople have sold oil to the homesteaders only to find that the order is sitting on someone's desk in the home office. With new and rapid networking systems, the sales order can be placed from the customer's location. This not only reassures the customer that his or her needs are being taken care of, but also demonstrates the company's use of TP technology in sales improvements.

As mentioned earlier, XSEL, developed at Digital Equipment Corporation, is used to help sales staff configure the correct system components, making sure, for example, that the tape drive is compatible with the computer model. In other systems, other needs apply. In many organizations, coordination is required at all levels of the sales operation. However, with distant managers and time-zone-limited communications, the salesperson is often forced to think of him or herself as a lone ranger. Without careful networking, the selling operation can be ineffective and impersonal, requiring a minor miracle to mesh individual efforts. With ongoing networking, individuals coming from different departments in the organization can comprise an effective sales team.

Many efforts in marketing today are directed at team sales. Such sales may require one individual to act as "quarterback," masterminding the strategy and calling the plays. Normally, this is the individual closest to the customer—the salesperson, but it might be the regional manager, depending on the size of the organization. In any case, increased team sales require new forms of marketing management.

The scope and thrust of systems management is often misdirected. Coordinating the myriad dimensions of sales and marketing is no small feat, and it is often dealt with through meetings. TP allows meetings to occur when necessary and issues to be dealt with as they arise, instead of postponing them until the next scheduled meeting. This increases the speed and effectiveness of decision-making and has a positive impact on the work environment. With TP no one is left in the dark about major (or minor) policy decisions, and anyone can participate in the process. As a result, there is increased organizational loyalty and enhanced job satisfaction through improved quality and quantity of feedback from field to headquarters.

Key features of systems

Some key features of certain systems will provide detailed information to sales-marketing in the following ways:

- Policies and personnel news—Promotions and important changes in the organizational structure can be tracked via TP. Increasingly, evidence shows that sales personnel leave the organization not because of financial compensation but because of organizational bungling.
- Personals—Calendar annotations concerning anniversaries of various sorts, and other personal reminders, keep the "family" together, developing a closer feeling despite prolonged separations from the home office.
- Products—Other company products, possibly not the responsibility of sales, can be kept on file for salespeople to peruse as necessary.
- General economic and business news—Many corporations have developed their own news services to keep executives informed of business trends, government contracts, and international conditions. With TP, newsletters are easily made up and distributed to all levels of management.
- Training and career development—Here are some examples of report types most appreciated by sales personnel:
  - How to meet buyer objections
  - News of competitors—This may change daily, and the guy at the plant who supposedly knows all, is generally out to lunch
  - New selling strategies
  - More contributions from the salesperson
  - New product applications—A compendium of applications such as this one, applying a new technology (TP) to an old problem (selling)
  - Current price listings
  - Reasons for price changes
  - News of market conditions—The old adage of trying to keep up with what is going on minimally with the company you work for
  - Promotion ideas
  - Information on product sales figures in other territories—Get a chance to talk with other salespeople about new applications, problems, competitors, and strategies

TP is particularly suited for personnel training and ongoing career development. Salespersons can, at their own initiative and convenience (without time or involvement of other personnel), readily inform themselves of many facets of business, as well as make their own contribution, on file, for the benefit of others.

All the specific features of TP combine to enhance the structural dimensions of a firm so that effective management and the various goals of sales marketing are attained. TP makes possible:

- Consensus management—Toward this end, input is quickly accumulated from many sources for efficient, effective problem-solving. TP allows ongoing discussions and conferences concerning important topics: compensation plans, territories, product sales, etc.
- Product management—It is the ultimate goal of the marketing organization to push product service. Attainment of this goal is often blocked due to mistrust and misunderstanding between salespeople and home office personnel. Electronic meetings may help to break down mistrust. By calling electronic conferences on product size, price, features, delivery, etc., sales staff feel the engineering department is on the front lines with them.

The greatest challenge, requiring the highest level of coordination and management, is the creation of a successful product image. (An example of a successful product image is "Let your fingers do the walking through the Yellow Pages.")

Because the product image interfaces both the internal and external information-networking dimensions of a firm, it is necessary for all departments to provide the correct facts, an agreement concerning the best images, and consensus about how and to whom the product image should be conveyed. Coordination from the lowest to the highest level is a must. This means coordination among engineers, salespersons, managers, and systems personnel. Achieving consensus concerning a product image is obviously a complex process.

TP is especially suited to consensus decision-making because it permits involvement between the greatest number of people. TP provides each person with full access to all facts and issues in the discussion, leaving no one out. Each has full opportunity to present positions and raise issues without being suppressed by others. Correspondingly, shy or inhibited persons are encouraged to become involved. Meetings are more likely to produce clear, implemented policy when all concerned are included.

Field Service Management

Thought processing specifically ties in with field/customer service communication needs—internally, to get information out to direct managers, product engineers, and upper management, and externally, to create/update information regarding products and services, and communicate it to customers. With a software package like CROSS/POINT, policy manuals are ideal on-line documents because they need to be revised and updated often. Safety and security information, management and benefits, vendor lists, general and administrative information, facilities, equipment and services, organizational charts, general employee policy, and communications can be compiled and entered on the computer at the home office and then, when needed, easily retrieved, updated, etc.

Field engineering (FE) staff as well as personnel in other departments may have access to, and easily retrieve this information. Top management or even engineers may have new ideas about field service. TP encourages innovative contributions to the manual from those not directly connected with the department through the suggestion box.

In the past, manuals and bulletins have been severely limited by long delays in development, review, and implementation. Too often, staff lacked necessary updated information on activity at the front line. TP keeps policy manuals updated and accessible.

Project Management

One interesting application of this TP technology is its use in project management. Project management requires the bringing together of many diverse and dispersed people to solve many of the most difficult and challenging problems faced by companies and organizations. Our research shows that even though solutions are often quite simple, reaching them is not so simple; consensus and commitment are necessary from the very outset to the completion of the decision-making process. TP lets people work together by building idea networks which encourage consensus thinking and decision-making.

TP is a management software tool for building idea networks that enable people to brainstorm, track projects, formulate ideas, and network easily and quickly. Without having to interrupt their work schedules and without having to pay for costly travel, these individuals can exchange information and examine documents, contracts, and agreements. Through keyboard terminals or personal computers, printers, and telephone lines, participants access a common computer for extremely efficient direct networking, and an electronic message system records their communication.

TP, to summarize, improves both productivity and management, and at the same time encourages qualitative participation and high morale. Management becomes a creative, innovative process, rather than the long and tedious chore of organizing seemingly endless meetings.

Summary

Metal modeling is very useful for cut-and-dried decision-making, such as determining when to turn off a thermostat or when a cutoff date has been reached. These decisions depend on preset formulas, rigid interpretation, and scrupulous data entry. Mental modeling allows the user considerable latitude in the conditions set up for decision-making, the way data are entered and processed, and when a decision should be made.

The framework presented in this chapter suggests an examination of business issues and conditions prior to the development of an automated system. In summary, before developing an automated system, you should:

1. nor proceed with the creation of automated systems without first modeling such a system manually
2. separately develop a "business case" that will help you understand the financial benefits, the value-added benefits, and the productivity improvements
3. attempt to project the organizational consequences, those results that change how the organization or its personnel work
4. test the manual results and then test again
5. then, prototype, that is, carve out a specific function for which the inputs are known and the outputs are known or can be anticipated, and develop a automated system for that function alone. After testing the results against those known from the manual system, it is relatively easy to expand the system.

In regard to TP systems, this concept is worthy of implementation. TP can involve communication between players to facilitate decision-making and information exchange, as well as provide customization of the decision-making process itself.

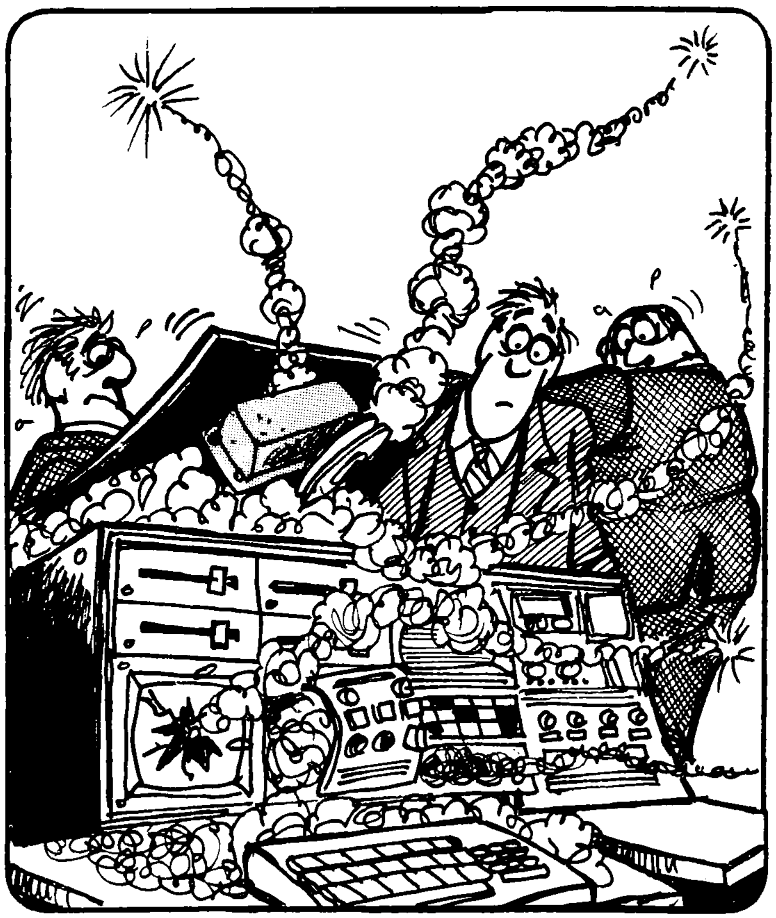
Last, the manner in which these models are implemented in software available to the user will have a great deal of impact on the success or failure of the modeling concepts themselves. There is a quantum leap between the lab and the desktop.

Endnote

1. Hilary Putnam. *Mind and Machines,* Ed. Alan Ross Anderson. Englewood Cliffs, NJ: Prentice-Hall, 1964, p. 82.

Chapter 8

Future Trends in Knowledge Engineering



Introduction

This section provides an overview of strategic planning and methodologies for the use of knowledge technology (KT). In the 1980s, strategy must be integrated with technology to accomplish the goals or objectives of the organization. Also, strategy and planning are beginning to merge; thus, technology will drive, and management will implement the plan. By using simulations and games, however, the planning process can be separate from strategy, as an auditing and monitoring system.

Tactical and Strategic Considerations

Before beginning the arduous process of planning and devising a strategy, management must set the stage in terms of philosophical outcomes. For example, management should develop a series of opinions that form the basis of the approach. Different corporate strategies require different philosophies, as the following three examples illustrate.

In his futurist work *2081: A Hopeful View of the Future,* Dr. Gerard K. O'Neill examined previous futurists and their forecasts. Jules Verne was the most prolific of the authors who wrote about the future for our sheer delight, and his tales of adventure covered everything from submarines to airships to airplanes. In examining Verne's perspective, one might overestimate how much the world will be improved by social change, and underestimate both the spread of governmental inefficiency and the rate of technological change. This perspective could be translated into a planning strategy which dictates that (1) technology always changes much faster than we can predict, and (2) society always changes much slower than we predict.

Another strategy can be based on a statement by Yoneji Masuda, the great Japanese theorist:

> An information network is seen in the transmission of information between a large number of people within an extensive area made possible by computers and communications . . . is a system that closely resembles information mechanisms as a living body, an organism.[1]

A third strategy comes from Prof. Alan R. Kantrow, of Harvard University:

> The past decade revealed managers' growing awareness of the need to incorporate technological issues within strategic decision making. They have increasingly discovered that technology and strategy are inseparable. A company's organizational structure—no less than its distinctive manufacturing competence—has an important technological dimension that managers ignore at their peril.

In strategic planning efforts for clients, I use a number of different approaches. Most clients only want the go or no-go answer rather than the in-depth historical or futuristic 20-year crystal ball review. Primarily, I use the following portfolio approach, which is also used by many other strategic planners.

Methodologies

Objectives are determined by analyzing business and industry attractiveness; businesses are then compared on a grid framework.

Industry Attractiveness
High----------------------------------Low
1-----------------2----------------- 3

Position 1 is the area for investment and growth. It is characterized by:

- Potential for high future earnings
- Case consumers
- Little contribution to today's earnings

Position 2 is characterized by:

- Generation of high earnings today
- Solid businesses
- Self-sufficiency
- Moderate cash throw-off

Position 3 is characterized by:

- Minimum reinvestment
- High cash throw-off for milking or selling

In the planning process, corporate executives or directors must establish where they are now and where they want to be. In many cases, there is a great disparity between where executives think they are and where they are in reality.

Determining ranks for business position and industry attractiveness involves a customized multidimensional analytical effort that concentrates on specific elements of a corporation.

The test for strategic and performance applications of a specific business plan can be conducted primarily on the following grid, arranging various plan features. The three fundamental types of businesses in the portfolio have different characteristics, objectives, and planning horizons.

TABLE 8.1 Some Issues Behind a Strategic Planning System

Business Position and Strengths	***Industry Attractiveness***
Profitability	Market size
Share	Market growth
Technology lead	Current competitors
Technology protection	Numbers
Market coverage	Who
Technical development	Strengths, weaknesses
Capability	Track records
Efficiency (vs. competitors)	Future competitors
"Real need" identified	Regulatory influence
Potential to satisfy need	Potential for industry change
Ability to protect market	Life-cycle characteristics
	Rates of change in:
	Technology
	Economics
	Applications
	Present stage of life cycle

TABLE 8.2 Industry/Company Attractiveness Grid

Business Position	*Attractiveness* ***High***	***Medium.***	***Low***
High	Rare but prime opportunity New industry Attracts: Competition High entry Reguires: Maximum commitment Good timing Longer-term cash-flow focus	Results from position Requires: Heavy resources Close monitoring	Mature industry on decline Limit competition Threat of obsolescence Cash generator Requires: Exploitation! of strenghts
Medium	Good position Critical timing Requires: Increase in strengths Continuous risk assessment	Core business Major source of earnings Requires: Selective investments for maintenance of position	Short future Requires: Close cash flow Minimum commitment
Low	High risk Requires: Selective positioning Continuous monitoring Adequate definition and enforcement	Unlikely payout Requires: No commitment of resources	Limited future-present performance Requires: No commitment Bullet-biting

TABLE 8.2 (continued)

Issues	***Invest-Grow***	*Selectivity—**Earnings***	***Harvest-Divest***
Goals	Long-term profit	Plateaued or weak	Peaked out
Planning	Worldwide	Short-term profit	High-risk opportunities
Horizon	From strength	Limited long-term	Special situations
	Containable risk	Self-financing	"Dogs"
	Market position	Short-term earnings	Short-term cash
	Long-term		Short term

There is no requirement that the portfolio be perfectly balanced at any point, but over time significant imbalances are not viable.

After analyzing each business entity, a top-management strategic review file for each business becomes meaningful and is targeted. A strategic thrust can then be determined, and its implications can be evaluated. These strategic positions and longer-term strategic thrusts can be displayed.

Implications for management and investment decisions

Table 8.3 represents the key issues and categories over time. Each company must evaluate where it stands in this regard, and determine what action should be taken.

The chronological steps in a typical planning system represent an orderly and gradual process of commitment to certain strategic alternatives. Each step in the process is linked, theoretically at least, to the steps that precede it. In financial terms, this link can be quite explicit; a division's budget forecast prepared in the first planning cycle can subsequently become the commitment for next year's operating budget. Although few companies expect to achieve this financial link in the process of examining the alternatives, all the parties involved in the process should understand the intended relationship between the cycles. How fast or slow this focusing process should be is controlled by the planning director.

The key issue is the conflict between budgeting and planning. For example, a close connection between planning and budgeting indicates that strategic commitments have been made at an early stage. An open connection, however, implies that many decisions are yet to be made, and that the budget for these items has not been determined. As in most situations, there are the "basics" that need little discussion, planning, or budgeting. It is the new items that are the most controversial and the least understood, and that, in many cases, have questionable payout, if any. Division managers are pitted against one another in order to determine whose new project gets funded. By requiring that these new ideas be put into a business plan (an outline follows this section), these managers can see what the real issues are.

TABLE 8.3 Some Recommendations From an Expert/AI System

Category	***Invest-Grow***	***Selectivity-Earnings***	***Harvest-Divest***
Primary Goal	Build market position for long-term profit	Maintain short-term earnings, medium cash flow	Maximize cash
Investment	Should be maximum digestible	Maintain selective, high-return segments	Maintain minimum, dispose opportunistically
Risk	Accept, contain with contingency	Limit	Avoid
Share	Build diverse markets	Target growth, protect position	Forego share for profit
Pricing	Lead, build experience	Stabilize for maximum contribution	Lag, even at expense of volume
Products	Lead in design and diversity	Differentiate: Specialization Applications Performance	Prune
Costs	Concentrate on long-term benefits of scale	Aggressively reduce variables Economize on fixed	Cut ruthlessly, consolidate
Marketing	Build coverage and capability	Cut creativity, keep coverage	Cut to minimum selling effort only
Management	Entrepreneurs should be highly variable	Skeptically balance	Have disciplined, strong cost control, maintain high base
Technology	Spend heavily in new products	Maintain strong position, defense	Maintain minimum necessary customer service

Risk Handling

I have observed that the long-term success of an organization's businesses depends to a large extent on the ability of the divisions to generate new ideas and commit to their long-term success. It should be noted that new strategic business project developments are, by nature, uncertain. The more risks that projects have, the more potential there is for reward. In choosing new items, each division will probably give priority to some "safe" projects as well as to some "risky but promising" projects. For the organization as a whole, the overall risk of a business project portfolio, given that the portfolio is of some size, will not increase significantly with the undertaking of a risky but potentially promising project; the risk will "average out" over the entire portfolio. In contrast, a division with a small portfolio has fewer projects among which to average out a risky project. Consequently, a division manager will be reluctant to take on the risky but potentially promising project because that division will be held accountable for performance and incentive compensation. In simple terms, no one wants to lose his or her job, much less an annual merit increase, because of a failure.

Thus, the traditional scheme for business planning promotes plans that involve the organization in a series of interdependent activities. In terms of risk-taking, the averages tend to smooth out big successes and failures. Risk-taking is steadily reduced as the organization increases in size; then the problem becomes inertia.

Several methods can be used to partially overcome inertia. The corporate planner might wish to focus the planning efforts primarily on the new projects. In this way, division managers can develop an understanding of risk-taking and top management's position on encouraging new development. Second, division managers can actively explore what new ideas exist in their areas and help first-level managers or workers bring these ideas to management's attention.

Risk-taking is essential for long-term growth not only in terms of increased revenue or service, but also in terms of managers' growth toward becoming top-level executives.

Business Strategy Analysis

I suggested a portfolio approach to decisions on appropriate corporate risks. The trend toward entrepreneurship that is taking place in many large corporations (3M, for example) attempts to reduce the corporate bureaucracy in order to get new products and services developed. Prior to the initiation of formal planning activity, the division manager might never have prepared a long-range projection for the department. The preparation of a document of this sort should be an educational activity in itself. Such projections help managers lengthen the time horizon of their thinking. At the same time, managers are making an explicit, intuitive economic model of the business explicit so that division forecasts can be made.

In the formal planning process, a division manager's efforts tend to be financially oriented; in many respects, these efforts are a form of long-range budgeting. Corporate management, aware of the pressures of formal planning on managers, should design the requirements of the plan to mitigate these pressures. A manager should never get so involved in the development of a business plan that the running of the division is not being done. Such interference might inhibit the division from devising a realistic business plan to commit to; this commitment is probably the most important aspect of the planning process.

The following sample business plan is provided as a model for examining new venture development. This model is suggested for new activities outside the existing corporate structure.

TABLE 8.4 Sample Business Plan

1. The Company
   Name, nature of business, stage of development, history, mergers, acquisitions, affiliates
2. Financing, Proposal Terms
   Valuation (fully diluted), conversion prices, covenants, registration rights

TABLE 8.4 (continued)

3. Uses for Funds
   Proposed uses for funds acquired
4. Product Lines
   Description, pricing, proprietary and patented features, lead times on competition, licenses
5. Research Development, Engineering, and Design
   Previous experience of engineering staff and relevant prior activities of similar projects
6. Manufacturing
   Production methods, operations cycle, capacity, subcontractors, significant sources of supply
7. Service
   Field engineering activities and marketing support
8. Management, Directors, and Organization
   Resumes and compensation of key executives and organizational chart
9. The Market and Competition
   Segments, product substitutes, size and growth, seasonal or cyclical market, share of market, rate of technological change
10. Company's Marketing
    Product literature, promotion, advertising, sales cycle (initial sales call to product installation), pricing, credit, sales organization, leasing and rental options, dominant customers, sales and distribution of product
11. Financial Summary and Projections
    Five-year summary of sales, profits, and order backlog, audited financial statement for last three years, latest monthly financial statements, three-year projections of profit and loss, balance sheet and cash flow and supporting assumptions
12. Financial Information
    Capitalization, credit lines, leasing agreements
13. Legal Considerations
    Contingent liabilities, legal counsel retained, litigation pending

The information resource management (IRM) long-range plan is suggested for activities that take place within existing corporate activities.

TABLE 8.5 Information Resource Management Long-Range Plan

1. Corporate Guidelines
   Strategic: markets and products, volume indicators, functional organizational changes
2. Environment
   Industry trends, technology scan, government regulations, work-force composition, customer-supplier relational changes
3. Current Operations
   Budget and organization, strengths and weaknesses, strategy projects, opportunities and potentials
4. Mission-Direction Statement
   Purpose or reason for IRM system, main business of IRM objectives, scope of users
5. Objectives and Goals
   Targets and time frame, results expected, qualitative and quantitative goals
6. Assumptions and Risks
   Internal and external constraints, assumptions and potential consequences, major risks

TABLE 8.5 (continued)

7. Strategies
   Major strategies to reach objectives, timing of strategies
8. Policies
   Major current policies (internal and external to IRM), projected policy changes required, and time frame
9. Programs and Projects
   Current programs and projects in process, new ones required
10. Management Control Tools
    New procedures and methods needed, timing and approach to develop new control techniques
11. Transition Plans
    Old environment, new environment, plan to go from old to new, necessary user and operational conditioning
12. Priorities and Schedules
    Ranking and prioritization of programs and projects, timing and schedule of programs and projects
13. Organization and Delegation
    Organization to manage IRM, delegation of authority and responsibility
14. Resource Projections
    Equipment projections, software projections, facility projections, personnel requirements (hiring, training, maintaining, developing)
15. Operating Budget
    Incremental budget by new program or project or zero-based, new budget projected for each planned year

Monitoring and Environmental Tracking

The key issue is not so much tracking but understanding and evaluating new product services and competitive inroads into existing areas, and becoming market-aware.

With respect to tracking future competitive activity, the following issues provide an effective mechanism for an organization that wants to stay current with market information:

- In-house intelligence system: It is necessary to integrate market-product-competition information into planning efforts. The key issue is to gather and conduct substantial market research to understand trends in the technology.
- Large research companies (Booz-Allen, SRI, ADL, etc.) can provide a global perspective of the changing telecommunications marketplace. Developments in distant places such as Viewdata developed by British Telecom are also critical to a long-term strategy.
- Consultant focus groups: Monthly consultant meetings provide regional and local intelligence on market activity, user trends, and new competitive offerings.

Strategic management planning

Long ago in the agrarian age, the producer was close to the customer. Farmers sold eggs to passersby. If the customer had a complaint regarding the eggs, the farmer was immediately aware of the complaint, and, if he wanted to stay in business, he corrected the problem. As castles grew into cities and the world became larger, goods were often made in or acquired from distant "new" worlds and sailed across the seas to buyers. A buyer of defective goods probably never knew where these goods originated. As smoke stacks appeared and goods increasingly were made in small ports and assembled in faraway cities or lands, ownership of the goods was forever lost somewhere along this worldly assembly line.

In this age of information, goods, in this sense, are assembled, packaged, manipulated, and distributed with no human handiwork. Strategically, information is a powerful commodity. It has characteristics that make it important, cheap to transport, and easy to recycle. For example, information can be used to destroy the enemy quickly and decisively—loose lips sink ships. In today's modern corporation this reality applies even more than in actual war.

The issues facing strategic planners are (1) obtaining information; (2) manipulating, analyzing, and packaging it; and (3) getting others to make decisions based on this newly refined information. Obtaining information is easy or difficult, depending on the type of information. Census data and custom-product market statistics, for example, can be obtained relatively easily and with increasing immediacy through on-line services. Information can come from internal memos or from some corporate data processing system that then tracks each part into manufacturing, shipping, installation, billing, field engineering (repair), rehab, and salvage. General management throughout this process is concerned with controlling the resource and restricting abuse or waste. In planning terms, these operational activities are concerned with minimizing cost and maximizing control to an infinite degree, as well as managing the project, product, or task.

The next area of manipulating, analyzing, and packaging deals with the systems or product line concerns. As activities move out of the factory and into the market, a market customer posture is critical. Keep the farmer in perspective! This process is concerned with short-term and month-to-month target sights, as well as day-to-day.

The most strategic area of decision-making is that which is complex, farsighted, and global in nature. An environmental understanding of trends and directions is critical to operations. If strategy is in fact to be initiated into the corporate enterprise, it must be incorporated at every level of the company. It must exist everywhere and be with everyone; it must be acted upon in all daily activity. This might sound obvious, but many books on strategic planning concentrate solely on the portfolio approach (see the Bibliography) to global markets and the company's relative position in the matrix. However, the key to long-term strategic success is the leadership of people within the organization. Never has there been a corporate portfolio approach to maximizing the potential of corporate personnel.

The portfolio approach by itself is a good device for planning, but it is only a means to an end, and strategic planning is more an organizational and directional activity than a management control mechanism. The subsequent implementation of this strategy is a question of technology, which currently has so vastly outstripped the pace of acceptance by users and customers that the computer industry is now (and will continue to be) floundering. The strategic need, then, is for "userware" that increases the understanding and the resulting application of knowledge engineering. Thus, corporate strategy is a mix of personnel and technology, a dynamic balance of talent and information-age power tools.

Corporate Culture and Strategic Alliances

So much has been written about corporate culture it seems that few stones have been left unturned. IBM, AT&T, and the rest of the corporate giants have been examined to the point of sounding like a corporate soap opera. Yet, in the face of all of this corporate society, there are fundamental changes going on within these companies. The concept of corporate alliance is a key structural issue that crosses corporate cultural boundaries, begging the question, Whose culture is operating here?

Certainly, the automotive giants such as GM, Chrysler, and Ford have developed intimate relationships with Japanese and other foreign companies. Domestic alliances also abound. It might be a case of extended distribution channels, but there is more involved than just this. The systems concept has emerged strongly and offers more than the so-called total-solution companies have been able to provide. The integration of voice and data, and now image and video, as well as integrated software packages such as Lotus Development Corporation's Symphony, is being demanded by customers on a much larger scale than ever imagined. Thus, corporate alliances have been born from distribution, product integration, product support, and product management.

The concept of a corporate culture supplying everything the customer needs has vanished. IBM and AT&T, combined with all of their competitors, probably could not satisfy the wishes of today's "intelligent customer." The problems that customers demand solutions to would stagger the engineering talent and the research and development budget of even the Japanese. The concept of corporate alliance is going to change the corporation in order to supply customer needs at a profit. Currently, the computer, telecommunications, office automation, and related industries are facing the worst depression since their conception. The once-rising sales curve is now flat and falling. Many reasons are given, and these rising new customer demands are but one of them.

Customers have complex problems to solve. Even the most sophisticated information system suppliers cannot be expected to fulfill every need. Yet in many cases, these suppliers have created the illusion that they can do just this. When the user spoke, however, the suppliers were unable to deliver. Example number one: The intelligent building is one of the most exciting ideas since the invention of the skyscraper. The systems required are by no means trivial. No one company can centrally supply all of the elements, much less integrate them into a truly effective system. Honeywell, AT&T, IBM, Johnson Controls, and Steelcase each supply a large number of the building blocks, but it takes all of them, plus quite a few more, to provide a truly intelligent building to the satisfaction of the sophisticated facility manager.

Anticipation Technologies

Anticipation of an event has affected all of us at one time or another. Waiting for a weekend, promotion, graduation, or even the elevator is something that many people have in common. In a technical sense, anticipation is living in the future. Time is shifting from a historial (past reference) perspective to a future-oriented (what might happen next) approach. Culturally, society is moving from a historical perspective to a future one.

Traditionally, machines have been objects that react to events, from operational control to electrical stimulus. Machines are devices that live in the past. Computers at present are no different; they react to outside stimuli, programming, user interaction, and electrical current.

Computers become living devices when they operate around the clock. Anticipation technologies are an entirely different approach to thinking machines, which can separate the machine from the thinking aspect and move from a purely reactive mode to one of continuous self-analysis.

An exciting aspect of these technologies is the ability to have the machine work all the time. Instead of waiting for the user to provide additional information, the machine can work through complex scenarios, discuss problems with other machines, calculate options, consider the preferences and biases of its owner-user, and then present acceptable recommendations.

The reality of this anticipation system is available today. Any personal computer with communications capability and a freeze-frame board can call up the National Weather Service and retrieve not just the current temperature but complete up-to-the-minute weather maps. Upon retrieval, the computer could then analyze the incoming weather events, compare them with existing data, and give the successes or failures of previous weather predictions. When asked, the PC could also give as accurate a weather prediction as can be found in most television reports.

If connected to other PCs, this computer could act as a network node and reporting device for other mother machines. This allows machines to act in unison with other devices and, therefore, facilitate and coordinate the distribution of information. This machine will be so powerful and versatile that it can act as a home weather vane as well as a community, if not regional, weather reporting station with an ability to discuss the day's problems with its owner at the same time.

Anticipating events, from life-threatening weather to business cycles, has tremendous economic advantage. As people and companies need to know more about the future, various anticipation technologies will emerge. Some of the primary tools might be a **body watcher** and a **career path adviser.**

Body Watcher

This system will work essentially like an airport metal detector. The user walks through the device, and it performs a range of derivative scans. These devices will emerge initially in business and then in the home as modular scanning systems (which are like mainframe computers were 35 years ago) evolve into portable devices.

The body watcher will give the user an immediate status report on all bodily functions and, if properly trained by the user, will furnish a complete medical history. As medical research evolves, various recommendations can be suggested to the user concerning diet, exercise, or work habits. In addition, because this function could be integrated into a building, apartment, or home security system, it could offer an even more foolproof security device than a retina scan identification system.

Another useful, though definitely vanity-oriented function will be to make recommendations about losing weight, building up muscles, or correcting diet plans to help people live longer. The health community, from insurance companies to medical practitioners, as well as an enormous public, will fuel this market.

Essentially, the latest expert recommendations or advice will be delivered to the body watcher system through wire cable systems or over the air, just as stock market reports are being transmitted today via FM subcarrier systems. New advances will be delivered almost immediately to subscribers. Moreover, the user will be able to gather advice from many different experts, and merge them like sentences. This advice will then be incorporated into an individual's personal dossier.

Doctors and other practitioners will interact with the body watcher system, not the patient. Prescriptions will be tested against body chemistry and modeled to determine any possible side effects. If the recommended drug passes the test, samples will be used on the real person. Continuous monitoring by the doctor's machine will mean a new source of revenue for the doctor, as well as better health and even beauty for the patient.

Career Path

Many people already know their path to the top of their corporation. The American dream is to climb the ladder to the top. At the same time, new careers and job classifications are developing faster than the job descriptions can be written. Pressures on interpreneurial and entrepreneurial activity are increasing.

Corporations are also changing: Fewer levels of management, independent business units, and technology are redesigning the corporate hierarchy. Competition in the work force for fewer upper-management positions is putting pressure on even the most adept in corporate circles.

A new approach to personnel, as well as personal, development is needed. Instead of being educated by teachers, who will act as coordinators of social events and athletics, people will be educated by machines. Machines have certain key advantages, such as individual pacing, enormous patience, and a virtually unlimited computational capacity that make them better suited for training than humans. The teacher will be a concept developer, having to do more with the architectural design of curriculum than with actual teaching. Architects have done this for centuries—designing buildings that they don't actually live in.

As with the body watcher, the career path adviser will meet us at an early stage in life, accumulating data that the program thinks is important. The machine will make recommendations about natural aptitudes, suggest courses to overcome deficiencies, and discuss social events.

The diversity and demand for key jobs will be the driving factor. Corporations will be forced, as some are now, to begin cultivating future talent at an earlier age. (IBM and Apple are but two striking examples.) Career path advisers will discuss different approaches to action with the teacher-turned-designer or other specialists. The flexibility of the machine to interact or network with a broad range of experts will offer remotely located rural Americans the opportunity to receive specialized guidance from Nobel laureates in London.

This might also mitigate the central, "big brother" aspects of student education. Current teaching techniques limit teacher/student contact to a small number of individuals, which can adversely impact future career opportunities. Career path counseling will offer new avenues of communication with other students, teachers, and interested parties. Expert networks will be attended by eighth-grade students without disturbing the sequence of educational or social events. Career counseling will be available at any step in the process.

As the individual enters the work place, the machine will assume the larger role of a corporate-organizational opportunity networking system. A profile of the overall individual will be distributed by the machine upon request, or as important discoveries are made. This individual concept, or holographic resume, will be compared with the type of person the corporation is seeking. A tremendous amount of detailed information will become available, which can be incorporated into a personnel record or organized with the records of other workers to create a highly productive work unit.

Development of anticipation technology

Development of anticipation technology (AT) will require a different interpretation of reality from the concrete universe we generally accept today. It will also require multidimensional thinking in perhaps a number of different ways. As with present nonmachine-based decision-making processes, there are no rules, no fixed means to an end, and no single process for all. Games, sports, and businesses each have their own attributes that can be the most effective or efficient, depending on the circumstances or need. Holographic models, for example, have emerged from a number of different research disciplines and can be effective tools in higher-level thinking as well as machine intelligence.

In a paper called "Holonomic Knowing," Bob Samples notes that

> Without question the emergence of the holographic brain and holographic universe represents the most exciting paradigm shift in modern times. . . . The gift of the holographic model is that its metaphors are more appropriately linked to ecology. That is, as each person gains experience which becomes encoded into the brain, a multidimensional energy field is set up. This pattern of energy (i.e., the thought) is simultaneously generated throughout the brain.[3]

Other researchers have developed their own theories and approaches to this basic premise of holographic representation. Some suggest that certain other activities form "contexts" in which information is retrieved, stored, reported, and integrated with other information. CROSS/POINT is a field grid of information linked as necessary or appropriate to facilitate an outcome; it is the graphic representation of information that is suggested as the next paradigm. It is also suggested that these macrons, mandalas, or cross/points in some contexts, are capable of mathematical analysis, which makes the graphic representation and its associated data compatible with machine technology. The interpretation of these graphic representations by machine or human is the object of considerable research.

Information theory

The development of an information theory that incorporates this new perspective is bringing together machine technologists and behavioral scientists. There is a blending of consciousness and stark reality that provides new insight into both of these states. In *The Holographic Model, Holistic Paradigm, Information Theory and Consciousness,*[4] Dr. John R. Battista argues that the holographic model is not a panacea and is not capable of representing every possible outcome. The brain operates neither in a purely digital nor a purely analog world. These worlds operate simultaneously with, and independently of, one another.

Battista also developed a hierarchical approach to information and consciousness:

TABLE 8.6 Information of Consciousness

State of Consciousness	Level of Information
Sensation	Information 1
Perception	Information 2, information about information 1 (the meaning of sensation)
Emotion	Information 3, information about information 2 (the meaning of perception)
Awareness	
Cognition	Information 4a, information about informations 2, 3, 5, 6, and 7 (reflective knowledge of the other forms of awareness)
Intuition	Information 4b, information about information levels 2, 3, 5, and 6 (nonreflective knowledge of the other forms of awareness)
Self-awareness	Information 5, information about information 4 and 6 (knowing the nature of one's own awareness)
Unition	Information 6, information about informations 5 and 7 (experience of the process of awareness itself)
Absolute	Information 7, an integrated awareness of all the levels of awareness (pure awareness)

Holographic concepts

The information of consciousness is a holistic approach that includes holographic concepts which emerge from this table. The merging of early holostic processing, which emphasizes independent, linear, sequential processing of information, with a new holographic model, which stresses the interdependent, parallel, distributed, and simultaneous processing of information, gives rise to AT, which approaches a level of understanding by machine. AT might then yield machines that are intuitive and truly anticipatory.

Before leaving holograms, there are a few technological points for those interested in pursuing the construction of holographic models for information processing. In *Languages of the Brain: Experimental Paradoxes and Principles in Neuropsychology,* Dr. Karl H. Pribram notes,

> All holograms have some interesting properties in common which make them potentially important in understanding brain function. First, the information about a point in the original image is distributed throughout the hologram, making it resistant to damage.[5]

In other words, every element of the hologram is related to every other, and if some are lost, the hologram still retains the image, though sharpness or resolution diminish. Pribram also points out that "the hologram has a fantastic capacity to usefully (store, retrieve) manage information. Information incorporated in a suitable retrieval system can be immediately located and accurately reconstructed."[6] For example, various images can be layered onto one another without impacting one another. Information can be retrieved by altering the wave length or angle, using a different spatial-frequency carrier for each picture. According to Pribram, some ten billion bits of information have been usefully "stored holographically in a cubic centimeter." At current sampling rates for video television of approximately 100,000 bits per second, this translates into 27 hours, or a little more than one day per cubic centimeter.

With current technology, we are approaching the point where light-based computing systems are a distinct reality. In addition, silicon or germanium-based systems can also simulate holographic images with increased ability to view from many different angles inside the computer's "brain." However, each of these possible systems has its own attributes that can be used together in parallel processing or distributed architectures. Elements such as speed, as in the ability to recognize a person and all associated background instantaneously (friend, enemy, and so on); numeric versus cognitive processing (adding numbers versus compassion); storage (short- or long-term); filtering (patterns of knowledge); and a myriad of others that are needed and are at the disposal of the average human in machine terms can be designed for specific applications from military to business to home to niche applications for vertical markets (banking, manufacturing, education).

The quest for AT is also a pursuit of economy in optimizing the elements needed to know something. Sometimes called **predictive** or **interpretive models,** these technologies reject unnecessary information and optimize selection of appropriate action. In *On Machine Intelligence,* Donald Michie describes an intelligent robot's cycle of activity as it reacts with its environment:

> It operates by means of an internal model of external reality (gray boxes). This internal model is composed of an interpretive model, which reduces stimulation to features and objects, and a predictive model which combines these interpretations with past experience to determine the likely consequences of alternative actions. This short circuit from "recognition" to "action" is for skills which are either inborn or have been automatic by means of practice.[8]

This quotation is not meant to definitively describe an AT; however, predictive models are needed to give a historical basis. The key element missing from this model is the assumption of the past. As discussed in holographic models, the theme is to develop a state of consciousness within the system that can then make intuitive jumps when encountering unknown situations. All that has been written over the eons of time is of little comfort to humans when they get out of bed each day; each day is a new encounter with the future. It should be the same with AT. This theory does not negate trial and error or any other human trait such as forgetting, fear, or anxiety. Models can and should give us insight into historical behavior patterns. There is no assurance that these patterns will exist in the future, which is the dilemma faced by designers of KE systems that are obsolete by the time they are introduced. These new systems, however, have childlike abilities to change and adapt to whatever situation they encounter. What makes this field so truly exciting is that the issues are as old as the sun, the problems faced daily might never have been encountered before, and the challenge is to design a machine that not only "knows" the difference, but can do something about it.

Anticipation machines

In order to anticipate the actions of a human, or for that matter an object, such as an airplane in flight, an accumulation of knowledge that far exceeds present data-gathering technologies must be obtained. To predict weather to a slightly more accurate degree, a significantly higher number of weather reporting stations is required. Even familiar and relatively simple routine tasks are difficult to understand in technological terms. How do we design systems that approach the novice or apprentice stage? Before addressing the qualities and attributes of proactive or anticipation machines, the problems to overcome are:

- Inaccurate data gathering
- Ambiguous or irrelevant information
- Inappropriate linking to reference knowledge
- Knowledge that is too complex
- Knowledge from an unexpected "wild-card" source
- Inappropriate output or outcome
- Incorrect timing

The development of anticipation machines is based on "getting to know" the circumstance or the user. Football games are played without knowing the winner, yet coaches "know" the probability of certain plays. Experimental programming and modeling are being used to validate theoretical formulas and to pose new results. These activities might be insights or even magic to others, yet they lead to the development of machine-world situations of real-world events. However simplistic a view of the world, this approach is hardly more than sophisticated logical inference techniques, search systems, and if-then-else rules.

In order to express the unknown, which is the challenge, new techniques are needed. These can take the form of global games, vast human networks, or even linear systems. Such technology will be free of doubt about its own view of the world. At present, as H. Zemanek in *Associative Information Techniques* states,

> The corporation is a perfect machine for running data through unambiguous grammatical processing rules. But the computer lacks the brain's fantastic ability to maintain and control meaning during its operations. So we dispense with the expectation of more and more precise results coming out of more and more computers—the meaning of all of these results becomes less and less established and no computer specialist agrees to the newspaper statement that "the computer is always right"—but we all have a tendency to inadvertently think along such

In reading this, it is obvious that computers have been designed the wrong way. Until now, they have been designed to reject the wrong input, errors, or common human mistakes, with the cost of the components, dollars per operation, and space (heating, lighting, security) as additional considerations. The next generation of knowledge systems is being designed with a very different approach.

Logical processing is not the primary function of the brain. Some would argue that the brain is not at all logical. In order to design systems that can anticipate, that is, be productive and react to a situation before it occurs, new notions of these systems must be considered. This is not to say that new digital, parallel analog, distributed inference, perception, computer, or other machinelike systems need to be erected in the chip works of some factory. A new approach to thinking is necessary. The journals of artificial intelligence (AI), expert systems, and so on, lack a definite approach to avoiding logical thinking at all costs. The challenge is to avoid thinking about the cost of the machine and to think about the problems that need to be solved. A cognitive, behavioral approach is in order; such rudimentary research is being conducted today. The anticipation systems that will emerge might have better insight into the outcomes of decisions. Certainly, billions of dollars are wasted every year by not anticipating problems.

Beyond the Information Age

One can speculate on the future in much the same way that previous "futurists" viewed our present. What did they say was going to happen, and what, in fact, did happen? The fundamental theorem that emerged was that technology has changed and presumably always will change much faster than we can predict. At the same time, society will probably always change much more slowly than can be predicted. Many researchers have discussed the global society. However, managing in a global corporate society remains illusive. The strategic concern is the need to be part of McLuhan's "global village," whether it be a city, institution, corporation, or mixed organization. We must be able to share or gather information from the global data base to help others and ourselves in problem-solving. In the realm of global management, virtual management (VM) is a network management environment set up and dismantled at the user's whim. VM is a network set up to accomplish rapid decisions, utilizing optimized support systems and decision-center management tools. Participants are chosen for their unique skills. The VM system is based on a concept similar to the seminar or conference model.

The problems posed by network limitations are principally due to foreign government restrictions on computer communications. Transnational data flow, the ability to easily move massive amounts of vital or proprietary information from one point on the globe to another using these networks, is the concern of any organization or government. This issue will be the basis for global conflict in the future as information becomes an economic issue. Moving this information, much like moving goods through a water canal, is a tax issue for many countries. Future global networking will also be limited by technical standards that are set. Although there is a small push by some countries to interconnect, many others might not want to change their standards to do so.

Future Management

The key issue to management in the future will probably be defined by the rate of technological absorption, both in terms of internal utilization by employees and effective distribution to customers. Companies installing terminals with links to suppliers abound. Orders are sent by electronic mail to suppliers in order to reduce the communications lag or information float of conventional systems. In addition, technological links for remote diagnostics of installed equipment, training of new and existing users, downloading of new software features, and telemarketing to reduce in-person sales expenses are all cost-effective ways to improve communication with customers. The rate of success will be based on expanding these options: forward to customers and backward to staff.

In exploring internal technology to improve productivity, competitive attitude, and intrapreneurship, communications are generally regarded as management's difficult and challenging function. Throughout this book, we have examined specific ways communications technology and other information systems form a basis for improved performance. Yet there is growing concern on the part of users that the technologies being placed on their desks fail to address their own often very personal needs. As in any office, there are generally accepted and standard management practices. However, each personal task or rule is likely to be dramatically different from another. Automating these functions, in many cases, is likely to be impossible or, at best, extremely difficult. Moreover, because most activity in an office is communications-oriented, without electronic communications systems, there is little hope for improving the quality of life in an office.

The issues concerning the rate of absorption have to do with confused and overloaded users, complex systems that are not user friendly, company policy for user choice of systems, communications limitations of sharing files, sending and receiving information, and the controversy over where technology is going.

These issues are a challenge to management and must be addressed immediately, before discussions turn into confrontations and lead to the downfall of the company. In order to rise above this situation, a corporate strategy needs to emerge that incorporates technology into the management team. Now that technology is understood and accepted as both a necessity and an opportunity, it can become one of management's strategic weapons. The concept of VM is based on the fundamental understanding that technology is critical to the survival of companies today and in the future. However, it incorporates strong safeguards and allowances for its use in a humanistic manner. VM presupposes a working relationship between people and machines. Rather than pose a threat to management or employees, VM recognizes that without both, technology will gather dust and people will not be as effective as employers expect in today's fast-paced corporate environment. In planning for this environment, an innovative approach is recommended. It has been called the "Grapefruit Diet" because of the tongue-in-cheek feeling commonly held that most office automation plans are similar to diet plans. This approach was developed along the principles that it should be easy to understand and remember, cope with the user's wants as well as needs, and force the user to recognize personal limitations.

Summary

In this book, an attempt has been made to discuss present and future technologies, theories, trends, and even philosophies. A common thread has been that none of these elements can operate in a vacuum and succeed. The interdependence of technology and behavior cannot be overemphasized. The "new technologies," whether they are hardware, software, or a hybrid called "firmware," must take the user to new levels of productivity. The "computer age" must advance past the current electronic-pencil mindset of performing tasks previously done mechanically, only faster. The "new computer age" will open our minds to new ways of thinking about things, new things to think about, and better ways to manage our new ideas.

New management tools are gradually migrating from R&D into the marketplace. The new manager will be using these tools in the very near future.

Forewarned is forearmed.

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Afterword

There are still some key issues requiring further research.

1. Even with the explosive pace of technology, human endeavors in artificial intelligence are still very primitive.

2. The pace of the pursuit of human-made systems remains, for the most part, an extension of machines rather than an extension of human knowledge processing. If this approach continues, there will be vastly sophisticated high-speed processing devices that will provide elegant simulations of real-world conditions. However, these conditions will *parallel* the real world rather than *interact* with it.

3. The development of new technology continues to outstrip society's ability to absorb its effects, much less its potential consequences. However, technology is like the extension of a rubber band stretched far ahead. While society is anchored in the past and holds the rubber band back, technological change stretches the rubber band ahead. The rubber band keeps getting stretched further until, sometime, it will break, splintering society into widely diverse factions. Everything from terrorism to AIDS is being impacted by the increasing rate of communication and the knowledge of underlying issues.

4. With the acceleration of technology, the concept of artificial intelligence becomes an even more perplexing enigma. There have been business problems that have always existed: labor, working conditions, inventory, supply, and finance, and now there are issues, such as environmental impact, career planning, telecommuting, and productivity. Other new problems are on the horizon, and these merge with the old problems. Together with the needs of competitive advantage, new market demands, and global distribution, networks provide little opportunity for human-made systems to be up-to-the-moment. This doesn't make the study of artificial intelligence worthless. AI permits organizations to exist where none were possible before. Much as one 100-horsepower motor took the place of 100 workers in textile mills a century ago, AI will become the intelligent worker of the future.

Some of the major technologies that offer the greatest potential are:

1. Neural networks. The subtle but truly amazing ability of the mind, upon a second's glance, to recognize a face unseen for ten years and, at the same moment, forget where the car keys are. Automated neural networks offer nearly all industries and humankind new intelligent tools that become increasingly more human with use. This is partially due to the fact that most business is based on human interaction and human thinking processes. Systems that begin to learn about humans in humanlike ways, rather than humans adapting to machinelike ways, offer an incredible business opportunity.

2. **Visualization systems.** Visualization systems are those systems that convey and process information graphically. Rather than machines that see, these are complex machines that are able to potentially understand doodles, notes, ideas, and images as humans do. Humans interact with one another and their world in nearly a totally sensory way, and for the most part, in a totally visual way. Images are formed, sequences are organized, events are cataloged, and life-spans are archived, frame after frame. Visualization systems process information and provide, like pages in a book, frames or windows of events, concepts, and emotional situations. With advances in image processing and storage technology, within a few years people will be able to start recording important events in their lives at a phenomenally low cost. The ability to record *every* moment is less critical in itself than the ability to *use* this information as part of a person's expertise or skill, not unlike the skill of a successful CEO or manager whose ability and related compensation come from their knowledge, manipulation, and organization of certain facts to the financial benefit of an organization. By capturing personal information and by organizing it in a certain way, individuals will be able to market their own automated data bases to organizations, much like "human" software programs. Throughout history, the power of information derives from, among other things, its ability to move from one point to another—its portability—and its usability when it arrives. Employment potential has also meant being in the right place with the right skill at the right time. The greatest problem with the demise of the industrial era is that in an information society skills can rarely be transmitted from one generation to the next. New skills are required, and people's ability to organize information and themselves is critical to their overall success.

The development of systems and software that allow people to develop their own personal data bases of information and provide that as marketable information will be as important in the near future as the latest generation of hybrid was to a farmer one hundred years ago. Visualization systems are not robot vision devices that can navigate through a maze; they are systems that interact with humans and with the world in a visual way. More than intelligent graphics, these systems convey knowledge and interact with other visual systems via visual language, operating in much the same way as a speaker who might begin a presentation by saying, "Let me tell you a story."

3. **Idiot systems (dumb expert systems).** The problem that presently exists with most expert systems is that they either require so much expertise that it takes an expert to use one, or they solve problems within too narrow a scope to be

useful in the real world. What is really needed is an ignorant machine or idiot system (IS) machine. An IS knows nothing but is willing to learn about anything; it's a system that does not pretend to be the expert, but makes a good apprentice. This system can tolerate enormous amounts of ambiguity, logic jumps, and gut reactions. It's more like a pencil than a word processor. (The word processor can do many great things—like move copy, add infinitely, or delete anything—but it lacks the ability to go everywhere you go.)

4. **Training tools.** The greatest limitation to computer technology is the instruction manual. People, whether they know how to or not, do not read the manuals. On-line "help" files are hardly any better. Tools are needed that communicate with the students/users rather than teach them. Use of the computer as a communication tool may be its single most useful function for most people. It may take voice recognition to make the computer really useful, and it will probably take a lot more than that, because most people don't have computers today. Learning systems in the future may take the form of not only the idiot system mentioned above, but also those systems designed to learn about you. Future teaching and training systems will not only have to provoke and motivate the student into learning what is needed today, but also teach people how to learn. In this sense, the people and the learning system can adapt to whatever working or living situation they encounter in the future.

5. **Implant computing (IC).** The evolution of the computer now permits serious consideration of machine-based systems that replace, or more importantly, augment or enhance biological functions. Much like technological steroids, there are systems that offer humans not only an aid to their biological functions but increased potential as well. Early systems of this type are now in the laboratories, such as those which allow persons with spinal injury to walk again and those devices that are able to detect certain types of diseases. With the expansion of IC, enormous improvements in medicine are possible. Detection and automatic insertion of corrective medicine may eliminate many diseases. This does not necessarily mean that the disease is eradicated but, in many cases, the disease can be stopped with early detection and some corrective measures can be taken. The development of implant computing will also allow direct access (at the user's choice) to and from other "true" machines as well as other people. This will, over the long term, blur the distinction between humans and machines, supporting and enhancing each other's ability to survive and function.

In conclusion, technology always changes over the long-term much faster than we are able to predict, and society always changes at rates equally unpredictable, though often vastly slower than we think possible.

I would like to leave you with my favorite quote from the Scottish psychiatrist, R.D. Laing:

> But what we think is less than what we know; what we know is less than what we love; what we love so much less than what there is. And to that precise extent we are so much less than what we are.'

It may be impossible for a machine to understand this, but when one does, and I think it will, we will understand so much more about ourselves than we ever thought possible.

THOMAS B. CROSS

[1] R.D. Laing, *The Politics of Experience,* New York: Ballantine Books, 1967.

Glossary

ABEL Experimental medical system for diagnosing acid/base electrolyte disorders.

Access-Oriented Methods Programming methods based on the use of probes that trigger new computations when data are changed or read.

Active Value A procedure invoked when program data are changed or read, often used to drive graphical displays of gauges that show the values of the program variables.

Actor Procedure that does its work by generating new actors and by sending messages to other actors.

ADA General-purpose computer programming language intended to be the primary language used in U.S. defense applications.

Address A location within a computer operating system memory referred to in a software program. The location of a physically and/or electronically logical entity in a network.

Advisory Systems Expert system that interacts with a person in the style of giving advice rather than in the style of dictating commands. Generally advisory systems have mechanisms for explaining their advice and for allowing their users to interact at a detail level comfortable to the user.

ALGOL Early post-FORTRAN, general-purpose, high-level programming language. In the United States ALGOL has mostly given way to PASCAL, a descendant, which is better structured and easier to use.

Algorithm A step-by-step procedure which has a specific beginning and end and is guaranteed to solve specific problems.

Alphanumeric Term used to refer to all the characters of the alphabet, and all special characters; also, numbers if treated as characters by a program.

Analog **A** communications channel or signal which uses a continuous electromagnetic waveform to convey information.

ANSI American National Standards Institute. An organization affiliated with International Standards Organization (ISO) that establishes standards for protocols, transmission codes, and languages.

APL Acronym for *a* programming /anguage. APL is popular because of its ability to do certain mathematical calculations. Developed by **IBM.**

217

ARPANET Advanced Research Projects network.

Artificial Intelligence The subfield of computer science concerned with developing intelligent computer programs that can solve problems, learn from experience, understand language, interpret visual scenes, and, in general, behave in a way that would be considered intelligent if observed in a human.

ASCII American Standard Code for Information Interchange. This is a standard 7-bit symbol code used to represent letters, numbers, and special functions as a series of zeros and ones.

Assembly Language A low-level language where each instruction is assembled into one machine-language instruction.

Asynchronous Not synchronized. Can be sent or received when participants choose, as opposed to at fixed intervals.

Atom A number or symbol in LISP programming.

Backward Chaining A search technique that starts in a goal state and works toward an initial state.

Bandwidth The difference between the highest and lowest frequencies a transmission channel can carry. In terms of signal frequency, the range between the lowest and the highest frequencies used in a signal transmitted from one site to another. Bandwidth is a measure of an analog signal and is measured in cycles per second (hertz). Wider ranges (e.g., six million cycles per second, the bandwidth of a television channel) are called broadband. Frequency ranges of 3,200 cycles/hertz per second (the bandwidth of telephone voice transmission) is referred to as narrowband.

BASIC A simple, easy-to-learn programming language introduced at Dartmouth College.

Binary The fundamental number system used with computers. Binary numbers are represented by only two numerals, 0 and 1. The binary system is necessary because electrical circuits store and sense only two states: on and off.

Bit (Binary Digit) A unit of information that designates one of two possible values. A bit is usually written as a 1 or 0 to represent the on or off status of an electrical switch. A bit is the smallest entity of a memory word in which a value can be stored. A computer term denoting the smallest logical piece of information. The smallest entity of a memory word in which a value can be stored.

Bit-Mapped Display A display screen that allows a programmer to turn each individual pixel on or off.

Blackboard A data base accessible to independent knowledge sources and used by them to communicate with one another. The information they provide each other consists primarily of intermediate results of problem solving.

Blackboard Architecture **A** way of representing and controlling knowledge based on using independent groups of rules called knowledge sources that communicate through a central data base called a blackboard.

BORIS An experimental, narrative-understanding natural language system developed by Roger Schank and his students.

bps (Bits per Second) The basic unit of data communications rate.

Breadth-First Search A search technique that evaluates every node at a given level of the search space before moving to the next level.

Bulletin Board An electronic file within an electronic mail or teleconferencing system. All participants can place public messages there.

Bus A topology for local area networks that functions like a single line shared by a number of nodes. A group of parallel electrical connections that carry signals between computer components or devices within a local area network.

Byte A string of bits operated upon as a unit and usually shorter than a computer word, e.g., six-bit or eight-bit bytes. A byte is almost always the amount of storage needed to store one character, and generally consists of eight bits.

C Popular programming language, especially for systems programming, created by **AT&T.**

CAD Acronym for computer-aided design.

CADUCEUS Diagnostic system for internal medicine under development by Harry E. Pople, Jr. and Jack D. Myers, M.D. at the University of Pittsburgh. Formerly called INTERNIST.

CAI Computer-assisted instruction; the application of computers to education. The computer monitors and controls the student's learning, adjusting its presentation based on the responses of the student.

CALISTO Experimental system for modeling and monitoring large projects.

CASNET Experimental system for dealing with disease processes. Usually associated with a specific application focusing on glaucoma. Also the acronym for casual-associative network.

Causal Model Model in which the causal relations among various actions and events are represented explicitly.

CBMS Computer 6ased message system that receives, stores, and transmits messages. Messages are delivered to electronic mailboxes assigned to each user.

CCITT Consultative Committee for International Telephony and Telegraphy, a part of the International Telecommunications Union that sets standards for the world.

Cell The structure used in a computer to represent a list. Each cell has two areas for storing data and pointing to other cells in the list.

Central Processing Unit (CPU) Electronic components that cause processing in a computer to occur by interpreting instructions, performing calculations, moving data in main computer storage, and controlling the input-output operations. A CPU consists of the arithmetic-logic unit and the control unit.

Certainty Factor **A** percentage supplied by a computer or expert system that indicates the probability that the conclusion reached by the system is valid.

Character **A** single printable letter (A-Z), numeral (0-9), or symbol (,%$.) used to represent data. Text symbols such as a space, tab, or carriage return are not visible as characters.

Cognitive Science The field that investigates the details of the mechanics of human intelligence to determine the processes that produce intelligence in a given situation.

CommonLISP Popular dialect of LISP that is likely to become a sort of standard.

Compatibility (1) The potential of an instruction, program, or component to be used on more than one computer. (2) The ability of computers to work with other computers that are not necessarily similar in design or capabilities.

Compiler A program that converts an entire high-level language program into machine language.

Computer A programmable electric machine made up of a (micro) processor, memory, keyboard, and monitor. It performs high-speed operations using prewritten instructions.

Computer Architecture Internal computer design based on the types of programs that will run on it, and the number that can be run at one time.

Computer Graphics Images generated as a result of interaction between a computer and its user. This ranges from simple token selection and display to manipulation of tokens, to generation of images using an interactive programming language.

Computer Network An interconnection of computer systems, terminals, and communications facilities.

Computer Port The physical location where a communication channel interfaces with a computer.

Computer Teleconferencing Interactive group communication in which a computer is used to receive, hold, and distribute messages between participants. Generally referred to as "store and mail." In addition, the conferencing participants communicate using keyboards to transmit written messages to one another. Communication may be synchronous (interactive in real time), but is commonly asynchronous (messages are stored in a central computer until retrieved by their intended recipients).

Computer Terminal A typewriter-like device that can be connected to a computer for the input and output of data.

Computer Vision An area of AI research that is attempting to enable computers to understand visual images.

Configuration The assortment of equipment (disks, diskettes, terminals, printers, etc.) in a particular system.

Configure To specify how the various parts of a computer system are to be arranged.

Conflict Resolution The technique of resolving the problem of multiple matches in a rule-based system. When more than one rule's antecedent matches the data base, a conflict arises since every rule could be executed next and only one rule can actually be executed next. A common conflict resolution method is valued, where each rule has an assigned value and the maximum value rule that currently matches the data base is executed next.

Connected Word Recognition An approach to speech recognition that recognizes words spoken in normal context.

Contention A conflict between two or more devices trying simultaneously to access a common channel.

Cooperating Knowledge Sources Specialized modules in an expert system that independently analyze the data and communicate via a central, structured data base called a blackboard.

CPU Acronym for central processing unit, that part of a computer that does the computing. Other key parts are the memory modules and the input-output modules.

DARPA Acronym for the Defense Advanced Research Projects Agency of the U.S. Defense Department.

Data Information, in the form of facts, numbers, letters, and symbols, that can be stored in a computer. For personal computer users, data can be thought of as the basic elements of information created or processed by an application program.

Data Bank A collection of data that is stored on auxiliary storage devices.

Data Base **A** large collection of organized data that is required for performing a task. Typical examples are personnel files or stock quotations. An organized set of data accessible by a computer program for purposes of updating, deletion, and reporting.

Data Base Management Software **A** system of integrated tools to store, retrieve, and maintain a large collection of data. Some of the tools support functions like batch reporting, interactive query, and decision support.

Data Base Management System (DBMS) A collection of hardware and software to organize and access a database.

Data Channel (or Communication) Equipment (DCE) A device that interfaces a transmission facility to a transmitting/receiving device. (A modem is a DCE.)

The equipment that provides the functions required to establish, maintain, and terminate a connection, the signal conversion, and coding required for communications between data terminal equipment and data circuit.

Data Communication The movement of coded data from a sender to a receiver by means of electrically transmitted signals.

Data Processing The application in which a computer works primarily with numerical data, as opposed to text. Many computers can perform data and word processing. The catch-all term for all facets of computing. More precisely, data processing involves the use of computers for the manipulation of large quantities of data, with relatively low emphasis on calculation.

Decentralized Processing An arrangement of computers at remote locations communicating with a central processing unit, but not communicating directly with each other.

Default Value **A** value that is used if no other value is specified.

Degrees of Freedom The number of "joints" in a robot arm; the number of independent values needed to determine the state of a system.

DENDRAL Early rule-based expert system that helps determine organic-compounded structure using data from mass spectrometers and nuclear magnetic resonance machines.

Dependency-Directed Backtracking A programming technique that allows a system to remove the effects of incorrect assumptions during its search for a solution to a problem. As the system infers new information, it keeps dependency records of all its deductions and assumptions, showing how they were derived. When the system finds that an assumption was incorrect, it backtracks through the chains of inferences, removing conclusions based on the faulty assumption.

Depth-First Search A search technique that advances from the first level to a lowest or terminal node. If the lowest node is a goal state, the search is finished. If not, the process is repeated.

Development Tool A program designed to assist programmers in the development of software. Intelligent tools incorporate AI techniques.

Digital A method of representing information using a sequence of ones and zeros for storage and interpretation by a computer. In digital transmission, analog signals that are originally in a continuous form are converted to discrete signals of zeros or ones to be transmitted to a receive site, interpreted, and used to reconstruct the original analog signal.

Digital Signal A series of electrical impulses that carry information in computer circuits.

DIPMETER ADVISOR Expert system that helps analyze dipmeter data. The dipmeter is an important tool used in the oil industry to determine subsurface tilt. The dipmeter produces tilt and tilt-direction data as it moves through an oil well bore hole.

Directory An index used by a control program to locate blocks of data that are stored in separate areas of a data set in direct access storage.

Disk A flat, circular plate with a magnetic coating for storing data. Physical size and storage capacity of disks can vary. There are hard disks and diskettes, also called floppy disks, and optical disks.

Disk Drive The machine that contains the disk pack. The disk drive has read/write heads that can deposit data on the disk and retrieve data from it.

Diskette A flexible, flat, circular plate that is permanently housed in a black paper envelope. It stores data and software on its magnetic coating. Standard sizes are 14, 8, *S[l]A,* and 3V2 inches in diameter, and probably even smaller sizes will emerge. Diskettes are often called floppy disks.

Document Transmission The electronic transmission of information shown on the surface of a fiat document. Often referred to as facsimile, as the original document stays in one location while a facsimile of that document is printed at the receive sites. Also includes high-speed document scanners which are used in video conferencing rooms.

Domain The problem area of an expert system.

Domain Expert A person with expertise in the domain of the expert system being developed. The domain expert works closely with the knowledge engineer.

Domain Knowledge Knowledge about the problem domain, e.g., knowledge about geology in an expert system for finding mineral deposits.

Download The process of loading software or data into the nodes of a network from one node or device over the network media, typically used for transmission from a mainframe to a another (micro)computer.

Dumb Terminal A terminal that consists of a keyboard and an output device such as a printer or a screen. A dumb terminal is used for simple input-output operations. It has no intelligence of its own, and is not capable of processing information.

EBCDIC (Extended Binary Coded Decimal Interchange Code) An outdated eight-level code set used on communication lines with IBM terminals.

Edge Detection A computer vision technique that helps the computer understand the visual images it receives by locating the edges of an object.

Electronic Mail A system by which written messages are entered through a keyboard and distributed to individuals or groups subscribing to the service. Messages are generally stored on a computer and forwarded to recipients when they request messages through the use of a data terminal or other keyboard device.

Emulation The act of imitating or performing as if a device or program were something else.

EMYCIN Nonspecific part of MYCIN consisting of what is left when the rules are removed. EMYCIN becomes a new problem solver by adding rules for a different problem domain.

End Effector Robot's hand or gripper.

End User The person who uses the finished expert system; the person for whom the system was developed.

Ergonomics The scientific study and planning of the workplace in order to adapt it to the mental and physical needs of the worker. One of the office design industry's buzz words.

ES Expert system.

Evaluation Function A procedure used to determine the value or worth of proposed intermediate steps during a hunt through a search space for a solution to a problem.

Exchange, Private Branch (PBX) A private automatic telephone exchange that provides for the transmission of calls internally and to and from the public telephone network.

Exhaustive Search A problem-solving technique in which the problem solver systematically tries all possible solutions in some "brute force" manner until it finds an acceptable one.

Expert System A computer program that uses expert knowledge to attain high levels of performance in a narrow problem area. These programs typically represent knowledge symbolically, examine and explain their reasoning processes, and address problem areas that require years of special training and education for humans to master.

Expert System Building Tool The programming language and support package used to build the expert system.

Explanation Facility That part of an expert system that explains how solutions were reached and justifies the steps used to reach them.

Facsimile (Fax) A device that electronically transmits information written or printed on paper. The text or graphic material is scanned, and the image is converted to signals. These are transmitted by telephone to a compatible terminal that is able to produce a copy. At the receive site, the image is reproduced on a sheet of paper. Facsimile devices are commonly referred to as fax, telecopiers, or datafax.

Field **A** piece of information that is the smallest unit normally manipulated by a

DBMS. A person's age might be a field in a personnel file, for example. Records are made up of one or more fields.

Fifth-Generation Computer Label used by the Japanese for their futuristic program to achieve dominance in the computer business. Separated from previous generations by higher speed and by employment of artificial intelligence.

File One or more records of information stored as a unit. A collection of logically related records or data. A file is the means by which data are stored on a disk or diskette so it can be used at a later time.

File Manager In microcomputers, an information storage program that has limited retrieval ability. A little brother to a DBMS.

First-Order Predicate Calculus A system of formal logic that is based on predicate calculus with the addition of functions and other analytical features.

Flaming The strongly negative response to generally unoffensive text messages in an electronic mail environment.

Flow Control A process of developing the orderly flow of data traffic across a data communications channel.

FORTRAN Early programming language that still dominates scientific computing by virtue of the massive amount of accumulated software that has been written using it. FORTRAN is the acronym for formula translator.

Forward Chaining Problem-solving technique characterized by working forward from known facts toward conclusions.

Frame A way of representing knowledge that stores a list of an object's typical attributes with the object. Each attribute is stored in a separate slot.

Frame-Based CAI A computer-assisted instruction technique based on the method used in a programmed instruction text. The material presented to the student depends on how the questions asked are answered.

FRUMP Acronym for *fast* reading and understanding memory program. FRUMP is an experimental language understanding system developed by Gerald F. Dejong to scan the **UPI** news wire, locating and summarizing stories belonging to certain classes.

Fuzzy Logic An approach to approximate reasoning in which truth values and quantifiers are defined as possibility distributions that carry linguistic labels, such as true, very true, not very true, many, not very many, few, and several. The rules of inference are approximate, incomplete, or unreliable.

Generate and Test A problem-solving technique involving a generator that produces possible solutions and an evaluator that tests the acceptability of those solutions.

Granularity The level of detail in a chunk of information, e.g., a rule or frame.

Graphics The use of lines and figures to display data, as opposed to the use of printed characters.

Hacker Person devoted to security or complex computer programming, particularly that programming done for its own sake.

Hard Copy Data or information printed on paper copy.

Hardware Components of a computer system that have a physical substance, as opposed to software.

Hardware Debugging Process of finding and fixing malfunctioning electronic equipment, particularly digital equipment.

Hard-Wired A permanent physical connection between two points in an electrical circuit, or between two devices linked by a communication line. Personal computer local connections are typically hard-wired. In contrast, all connections through a modem are switched (turned on and off) because they use telephone lines.

HDLC High-level data link control. A bit-oriented protocol designated by ISO, originally developed by **IBM.**

HEARSAY II Sophisticated experimental speech-understanding system stressing the importance of multiple specialized procedures and complicated techniques for procedure interaction.

Hertz Named after Heinrich Rudolph Hertz, a German physicist. A measure of frequency, one cycle or complete oscillation of a radio waveform per second. A unit of frequency equal to one cycle per second (CPS). 1 KHz = 1,000 CPS, 1 MHz = 1 megahertz or 1,000,000 CPS.

Heuristic A process that helps to guide problem solving. Use is generally restricted to those things that are not absolutely assured. A "rule of thumb" commonsense understanding.

Hierarchical Plan One category of AI techniques used for planning. A hierarchical plan starts at a general level of planning and moves down to a specific, detailed plan.

Host Computer The primary or controlling computer in a multiple computer operation upon which the smaller computers depend to do most of the work.

Hypothetical Worlds A way of structuring knowledge in a knowledge-based system that defines the contexts (hypothetical worlds) in which facts and rules apply.

IC Acronym for integrated circuit, an electronic circuit consisting of a chunk of semiconducting material on which many electronic devices have been simultaneously fabricated. Modern techniques make it possible for individual ICs to contain tens of thousands of transistors.

ICAI Intelligent computer-assisted instruction; the application of AI methods to the CAI problem.

Image Understanding The use of AI methods to process and interpret visual images, e.g., analyzing the signals produced by a TV camera to recognize and classify the types of objects in the picture.

Inference Chain The sequence of steps or rule applications used by a rule-based system to reach a conclusion.

Inference Engine That part of a knowledge-based system or expert system that contains either specific or general problem-solving knowledge. The inference engine processes the domain knowledge (located in the knowledge base) to solve problems, reach solutions, or lead to further steps.

Inference Method The technique used by the inference engine to access and apply the domain knowledge, e.g., forward chaining and backward chaining.

Inference Net All possible inference chains that can be generated from the rules in a rule-based system.

Information Management Evaluation and modeling tools that use the information stored in a well-structured data collection.

Inheritance Hierarchy A structure in a semantic network, screen, or frame system that permits items lower in the context to inherit properties from items higher up in the net.

INPUT-OUTPUT (I/O) Device A system component used to transfer data between the main storage and other devices, such as the CPU, terminals, or printers.

Intellect First commercially successful natural language interface. Intellect is sold by Artificial Intelligence, Incorporated of Waltham, Massachusetts.

Intelligent Robot Robot backed by powerful reasoning software for things like sensing, recognition, mating, trajectory planning, and error recovery.

Intelligent Terminal A terminal that is capable of processing information; many store and retrieve information on their own tapes, disks, and printers. An intelligent terminal can be adapted to communicate with various host computers simply by changing the protocol programmed into it.

Interactive Capable of carrying on a dialogue with the user through a keyboard, rather than simply responding to commands.

Interactive Software Package A program that provides the user with commands with which to submit his requests and exercise control over the execution of the program.

Interface **A** component that acts as a translator between circuits and other components of a system or other systems. A hardware connection that provides an electronic pathway for signals, or software that enables information to be exchanged between programs. Keyboards interface people and processors. A common boundary—for example, the connection point between two subsystems or devices. The interconnection between business machines and the data set, modem, or communications channel.

InterLISP D Dialect of LISP championed particularly by Xerox.

INTERNIST Former name (now CADUCEUS) of a diagnostic system for internal medicine.

Interpreter In an expert system, that part of the inference engine that decides how to apply the domain knowledge. In a programming system, that part of the system that analyzes the code to decide what actions to take next.

I/O /nput-output; the communication between a computer program and its user.

ISO International Standards Organization.

Isolated Word Recognition An approach to speech recognition that uses a pattern forerunner of **LISP.**

Iterative Deepening A powerful method of organizing depth-first search so that it proceeds to look deeper and deeper into possible choices, using earlier results to guide the search. Iterative deepening is the technique now used in all of the best computer chess systems, and has numerous other applications to searching that are now beginning to be investigated.

Knowledge Acquisition The process of extracting, structuring, and organizing knowledge from some source, usually human experts, so it can be used in a program.

Knowledge Base The portion of a knowledge-based system or expert system that contains the domain knowledge.

Knowledge-Based System A program in which the domain knowledge is explicit and separate from the program's other knowledge.

Knowledge Engineering The process of building expert systems.

Knowledge Representation The process of structuring knowledge about a problem in a way that makes the problem easier to solve.

LAN Local area network, a communications network connecting computer terminals and other devices within an organization. LANs may also connect with other private or public networks.

Line Printer A device that prints, at high speed, hard-copy data information that is outputted by a computer.

LISP Popular programming language for use in artificial intelligence. LISP is the acronym for *list* processing language. LISP was the first language to concentrate on working with symbols instead of numbers.

LISP Machine Powerful individual computers specifically designed for LISP programming developed by Symbolics Corporation, Texas Instruments, and Xerox.

Logical Inferences per Second (LIPS) A means of measuring the speed of computers used for AI applications.

Logic-Based Methods Programming methods that use predicate calculus to structure the program and guide execution.

LOGO Education-oriented programming language conceived by Seymour Papert and his associates. LOGO is intended to help people learn about powerful ideas, such as feedback, by seeing those ideas at work in a program. Based on LISP.

LSI Large scale integration (see **VLSI).**

Machine Language The language in binary code that the computer understands.

Machine Translation An area of AI research that is attempting to use computers to translate text from one language to another. These programs often use a combination of natural language understanding and generation.

MACSYMA A computer system with procedures for helping people do complex mathematics.

Magnetic Tape (Magtape) Tape used as a mass storage medium and packaged on reels.

Mainframe Centralized computer facility (CPU and main memory). It may delegate some of its workload to specialized processors.

Mail Qualifier An attribute of information. Examples are: recipient, sender, forwarding permission, copy permission, special mailcode, request for response, site ID, modification capability, keep capability.

Manipulator Another name for a robot arm.

Manipulator-Oriented Language Programming language for describing exactly where a robot's arm and gripper should go and when. To be contrasted with task-oriented languages for describing what the effect of robot action should be.

Megassembly Systems Multistation, multiproduct assembly systems containing many robots.

Menu A list of the options available at a particular place in a computer program, as presented on a monitor. The user selects an action to be performed by typing a letter, using a mouse, or by positioning the cursor.

Menu-Driven Term that refers to a computer system that primarily uses menus rather than a command language for its directions.

META-DENDRAL Learning system designed to generate rules for DENDRAL automatically.

Metarule A rule that describes how other rules should be used or modified.

Microcomputer A computer that uses a microprocessor chip (integrated circuit) as its central processing unit. A small computer that has all the hardware components of a large computer but in smaller sizes, sometimes called a personal computer (PC) or small business computer. They usually support one user, but with increased power, may provide processing for several terminals. They are physically very small and can fit on or under a desk. Microcomputer technology is based on large-scale integration (LSI) circuitry. Micros are usually the least expensive of the computer types.

Microprocessor An integrated circuit using semiconductor technology which incorporates all the elements for performing arithmetic operations and manipulating data.

Minicomputer A small computer that has all the hardware components of a large computer but in smaller sizes. A minicomputer is usually slower in processing speed than a large computer.

Model-Based System A type of expert system that is based on a model of the structure and behavior of the device it is designed to understand.

Model-Based Vision A computer vision technique in which image templates or descriptions of features of objects are stored to help the computer identify an object.

Modem (MOdulator/DEModulator) A hardware device that permits computers and terminals to communicate with each other using analog circuits such as telephone lines. The modem's modulator translates the digital computer signals into analog signals that can be transmitted over a telephone line. The modem's demodulator converts analog signals into digital signals for computer use.

Mouse Hand-held device that is rolled about on a table to move a cursor, make selections from a menu or move text, or graphic objects on a screen. Developed at Xerox Palo Alto Research Center.

Multiple Lines of Reasoning A problem-solving technique in which a limited number of possibly independent approaches to solving the problem are developed in parallel.

Multiprocessing Processing by two or more computers connected to run jobs concurrently for faster results or by one computer with multiple independent internal units.

Multi-to-Single Transmission of signals from a number of sites to a single location.

MYCIN Early rule-based expert system, developed by Edward H. Shortliffe, M.D., that helps to determine the exact identity of an infection of the blood and that helps to prescribe the appropriate antibiotic.

NAND Basic logical circuit used in designing digital hardware. The acronym for not and.

Natural Language The standard method of exchanging information between people, such as English (contrasted with artificial languages, such as programming languages).

Nonalgorithmic A problem-solving approach that does not follow a step-by-step procedure.

Nonhierarchical Plan One category of AI techniques used for planning. A nonhierarchical plan represents a plan on one level only, or on a multitude of levels that do not decompose into a pyramidal hierarchy of superiors/inferiors.

Nonmonotonic Reasoning A reasoning approach that aids often diverse multiple lines of reasoning (multiple ways to reach the same conclusion) and the retraction of facts or conclusions, given new information. It is useful for processing often uncertain or unreliable knowledge and data.

Nonprocedural Query Language Computer language for interaction with a data base that specifies what the user wishes to know instead of the steps necessary to produce the information. These steps are worked out by the computer.

Nonsimultaneous Communication Messages being received and transmitted at a terminal while the operator is performing other functions.

NOR Basic logical circuit used in designing digital hardware. The acronym for not or.

Object-Oriented Programming Programming methods based on the use of items called objects that communicate with one another via messages.

On-Line Equipment or information that is presently part of or connected to the operating computer system. Used commonly in computer teleconferencing to indicate that a site is active and that participants are able to receive and/or transmit during a teleconference.

Operating System The basic system program that ensures orderly execution of all computer actions.

Optical Disk Computer storage (memory) disk. Optical disks have potential for far greater capacity than magnetic disks. Some can be rerecorded.

Output Information produced as a result of processing input data.

Parallel Processing The computer technique of performing several processing actions at the same time.

Parallel Port An interface where data is trasmitted in groups of N bits over N wires to a computer or computer-type device, where N is frequently equal to 8.

Parameter A range of characteristics of a program/record or other area.

Parity An extra bit that is added to characters being transmitted between computers and their peripherals which verifies whether the character received is actually the character sent.

PASCAL Popular, general-purpose, high-level programming language, descendant of **ALGOL.**

Pattern-Matching An **AI** technique that recognizes relationships and patterns in objects, events, and processes.

PC Acronym for personal computer, a computer that is inexpensive enough to be used primarily in a stand-alone environment by a single person.

Peripheral A device that is external to the CPU and main memory, but connected to it. A printer, modem, or terminal would be an example.

PERT (Program Evaluation and Review Technique) Technique for charting project plans that exposes the dependency of each task on prior tasks. A principal use is in identifying a project's critical path, that is, that set of tasks for which any completion delay ensures delay of the entire project.

PL/1 Popular, general-purpose programming language.

Planning and Decision Support An area of AI research that is applying AI techniques to the planning and decision-making process to help managers who have decision-making responsibilities.

Plotter **A** graphic drawing device.

POLITICS Experimental narrative-understanding natural language system developed by Roger Schank and his students.

Power Tool Any powerful programming device that dramaticaly increases programmer/user productivity.

Predicate Calculus A system of formal logic that is based on propositional calculus with the added capabilities of specifying relationships and making generalizations.

Primary Station The main station in a telecommunications network. In an SDLC environment, the main station is usually a front end processor.

Printer **A** device that prints data output from a computer in paper copy.

Printout Any computer-generated hard copy.

Probability Propagation The adjusting of probabilities at the nodes in an inference net to account for the effect of new information about the probability at a particular node.

Problem-Oriented Language **A** computer language designed for a particular class of problems, e.g., FORTRAN designed for efficiently performing algebraic computations and COBOL with features for business transactions.

Problem Reformulation Converting a problem stated in some arbitrary way to a form that lends itself to an efficient solution.

Problem-Solving Expertise The component of a CAI program that contains the information being presented to the student.

Procedure-Oriented Methods Programming methods using embedded or nested subroutines to organize and control program execution.

Processor The controlling unit or processing part of the computer system that reads, interprets, and executes instructions.

Production Rule A rule in the form of an "if-then" or "condition-action" statement which is often used in expert systems.

Program The complete sequence of instructions and routines needed to solve a problem, explore alternatives, or execute directions in a computer.

Programming Language The words, mnemonics, and/or symbols, along with the specific rules allowed in constructing computer programs. Some examples are C, **LISP,** PROLOG, BASIC, FORTRAN, and COBOL.

PROLOG An acronym for programming in *logic.* An AI programming language that is especially popular in Europe and Japan.

Propositional Calculus A system of formal logic that provides a step-by-step inference system for determining whether a given proposition is true or false.

Pruning **A** means of reducing the size of a searching process.

RAM Random access memory, a memory into which data can be placed (written) and from which data can be retrieved (read).

Real Time The actual time at which an event is occurring. A term used to describe an on-line interactive application. A computer conference can be held in real time or asynchronously.

Record **A** collection of related data items. The description of an item in a data base. Each item is represented by one or more fields that make up a record. An example of an everyday record is a listing in the phone book.

Recursion Defining an item in terms of itself. For example, to sort a list, one could sort the first half, sort the second half, and then merge the two sorted sublists.

Relation **A** table or list, in the relational model, where data is stored.

Remote Terminal Input/output equipment attached to a system through a transmission network.

Representation The process of formulating or viewing a problem or statement so it will be easy to solve.

Resolution The degree of detail that can be seen on a display screen. The number of pixels per inch or similar measure.

Resolution Theorem Proving A particular use of deductive logic for proving theorems in predicate calculus.

Robotics Science Science of connecting perception or mechanical action to action through intelligent programs.

Rule A computer format for specifying a recommendation, directive, or strategy, expressed as if premise then conclusion or if condition then action.

Scaling Problem The complexity associated with attempting to apply problem-solving techniques created for a means of allowing the problem in relation to the actual problem itself.

Scheduler The part of the inference engine that decides when and in what order to apply different pieces of domain knowledge.

SDLC (Synchronous Data Link Control) An IBM data communications message protocol.

Search The process of starting in some initial state and attempting to reach a goal state by evaluating possible alternative solutions.

Search Space All of the potential states that could be considered during a search.

Semantic Network A means of representing facts, graphics, ideas, and other often complex subjects as nodes in a graph and their relationships to other facts as the links or arcs.

Sequential Processing The computer technique of performing actions one at a time in sequence.

Servomechanism **A** device that can correct a robot's actions.

Set In the hierarchical model, a many-to-many, one-to-many, or some other relationship.

Signal Security Scrambling of a signal to block eavesdropping of teleconferences. Also known as encryption.

Simplex Communications Allows movement in a single direction only.

Simulation A computer approach that uses a model of intelligent human behavior to determine if the computer will exhibit a "real-world" presentation.

Size Usually refers to the amount of storage a system has available on-line; also refers to the number of words a memory contains, and to the processing capacity of the **CPU.**

Slot A system associated with a node in a frame system. The node may stand for an example, object, concept, or event.

Software A custom or packaged program, produced as either data, video, or audio cassette that contains information that can be presented or processed. Instructions that make a computer perform a specific task or program.

Speaker-Dependent Recognition An approach to speech recognition that recognizes the speech of a particular person.

Speaker-Independent Recognition An approach to speech recognition that recognizes the speech of any speaker.

Speech Recognition An area of AI research with the ultimate goal of allowing computers to recognize and understand human speech, regardless of the speaker.

Speech Synthesis The generation of speech by a computer.

Storage Also called data storage. Usually refers to disk packs and/or magnetic tapes.

String Alphanumeric data that is treated as a unit.

Symbol A string of characters that stands for some real-word concept.

Symbol-Manipulation Language A computer language designed expressly for representing and manipulating complex concepts, ideas, or events, e.g., **LISP** and **PROLOG.**

Symbolic Reasoning Problem-solving based on the application of a strategies, algorithms, and heuristics to manipulate symbols standing for concepts.

Task-Oriented Language Programming language for describing robot action. Other robot languages are involved with manipulator-oriented languages for describing exactly where a robot's arm and gripper should go and when.

Telecommunications Communications over distance using electronic means; types of telecommunications channels include twisted pair telephone lines, coaxial cable, microwave, satellite, and fiber optic cable.

Teleconferencing The use of telecommunications systems by groups of three or more people, at two or more locations, for the purpose of conferring with one another. Also the two-way communication between two or more groups, or three or more individuals, remote from each other, using a telecommunications medium. Also the interactive group communication through an electronic medium.

Terminal Any device capable of sending and/or receiving information over a communications channel.

Time Sharing An approach to using computers that allows many people to share the resources of a computer at the same time.

Tool An expression for expert-system-building tool.

Topology Network topology can be centralized or distributed. Centralized net-works, or starlike networks, have all nodes connected to a single node. Alternative topology is distributed; that is, in the limit, each node is connected to every other node. Typical topology names include bus, ring, and star.

Tracing Facility A mechanism in a programming or knowledge engineering language that can present the rules or subroutines in the program.

Tree Structure A way of organizing data as a connected graph where each node can branch/node into other nodes deeper in the structure.

UNIX Popular operating system developed and licensed by Bell Telephone Laboratories.

Uploading Shifting information from memory banks of one computer to another.

User A person who uses an expert system, such as an end-user, a domain expert, a knowledge engineer, a tool builder, or a clerical staff member.

User Interface The means of presentation of information from the machine/computer to the user.

Very Large Scale Integration (VLSI) The process of combining several hundred thousand electronic components on a single chip of semiconductor material.

Virtual Memory A system of managing RAM and disk space so that a computer appears to have more memory than it really does.

Videotex A service that uses a part or all of a TV screen for information displays called pages or frames. The information could range from weather or news to advertising for various services.

VLSI Very large scale integration.

WAVE Early experimental robot programming language on which VAL was based in part.

Windowing A means of dividing the computer screen into several miniscreens or areas so that a variety of information can be displayed simultaneously.

Word Processor A dedicated device, or a software package on a computer, which allows sophisticated text editing of documents stored on an electronic medium, such as a floppy disk.

Workstation A location at which an individual works; generally used to denote electronic, usually computer-linked, devices which an individual uses in the course of his/her job in an automated office setting.

X.25 A CCITT standard that defines the interface between a public display network (PDN) and a packet-mode user device (DTE). It also defines the services that these devices can expect from the X.25 PDN, including the ability to establish virtual circuits through a PDN to another user device, to move data from one user device to another, and to destroy the virtual circuit when through.

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Index

257

Engineering, including pre- and post-implementation strategies

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