CHAPTER 1

NEW KNOWLEDGE ENVIRONMENTS

All men by nature desire knowledge.
— **Aristotle** (384–322 B.C.), *Metaphysics*

CHAPTER SUMMARY

This Chapter deals with the synergy between computer and communications systems that makes the new knowledge environments urgent and feasible. Redundant information appears to overflow beyond all constraints and boundaries. A basic methodology to contain, organize, and deploy the overabundance of information in academia, business, medicine, electronic media, governments, and financial institutions is proposed for quick and effective separation and the subsequent deployment of sensitive information, valuable knowledge, key concepts, and lasting wisdom.

Key concepts necessary for building specialized computers and networks are introduced. Architectures of subsystems and standardized platforms for software are summarized from computer sciences. Specialized switching platforms and organizations are borrowed from communications systems engineering. The last three decades of fiber-optics development for the transmission of binary data and advent of packet switching technology for routing information are examined to incorporate intelligence in the networks. The novel strides in both computer and communication disciplines are interwoven to develop and design intelligent medical, educational, security, tsunami warning, and government systems.

Computational Framework for Knowledge. By Syed V. Ahamed

The historic landmarks in hardware, software, and firmware are now firmly embedded in these machines. Putting things in perspective, one realizes that knowledge processing is as feasible now as data processing that appeared in the late 1940s, or as feasible as very large-scale integration (VLSI) that appeared in the early 1950s. The ultimate success of many enduring methodologies depends on the collective will of the industrial community. Major trends are initiated by potential financial gains, provided the technology exists. For example, global information networks prevail because of fiber-optics technology, and modern diagnostic cancer and surgical procedures exist because of magnetic resonance imaging (MRI) techniques. Social demand plays a role in increasing potential rewards. In the same vein, if knowledge processing can solve some of the greater and global intellectual needs of human beings, then it is conceivable that machines will be built simply to address our curiosity at first and then to establish the foundations of wisdom for later generations.

1.1 THE NEED TO KNOW

In the modern world, precise and incisive knowledge is essential for accurate decision making. Maps of knowledge networks in the Internet domain are not unlike road maps in commercial centers or neural maps in the human mind. Knowledge environments influence intellectual settings in academia, business, and the financial markets. In the knowledge domain the confrontation between the knowledgeable and the ignorant leads to the survival of the deftest. Skill in the Internet society is based on possessing a mental map of knowledge bases around the globe and their access methodology. These concepts are well exploited by communications engineers. Telephone numbers, web addresses, and even satellites addresses are deployed effectively to reach out to anyone in any location. Implementation in the field of communications occurs via these numerical addresses and is based on the routing algorithms programmed. Such programs are decoded and executed in the VLSI circuits of large electronic switching systems [1], routers [2] and wireless stations [3].

The synergy between the intelligent Internet, computer, and network technologies has accelerated the growth of the information and knowledge society. This unprecedented growth calls for new knowledge based technologies for the powerful elite in society, thus enhancing their power.[1] The full synergy of knowledge and power acting in concert is being retraced now as it was in the days of Francis Bacon. *Human intelligence*, now supplemented by machine intelligence, *society*, now supplemented by global transportation, and *networks*, now supplemented by trans-oceanic fiber-optic information highways, form a tightly confined triad of forces that keeps the global economy moving in a long and sustained period of

[1]Knowledge and human power are synonymous, since the ignorance of the cause frustrates the effect. Francis Bacon (1561–1626), *Aphorism III*.

expansion. These three prime movers are discussed next in the context of the current social setting.

First, consider human intelligence. A gift of heredity in humans, intelligence flourishes in the lap of society. Sustained intelligent decisions propel positive social movements. This symbiotic relationship develops early and lasts for long periods of spiraling growth for peoples and nations alike. Nature and humans coexist in harmony as a gift of intelligence in human beings and intelligent societies composed of human beings. Such societies cultivate the healthy natural processes resulting in the social adaptations of humans. In a majority of cases, the cycle is broken by natural and self-imposed disasters. The symbiotic relationship between intelligence and society needs unbiased mentoring and maintenance for a positive cycle of growth.

In the information age, information and knowledge-based machines can maintain the stability of a triangular balance between intelligence, society, and nature. It appears impossible to maintain stability within the vertical axis of this triangular balance without premeditated and complementary changes to all the three mitigating factors and the newer society driven machines and networks can find the optimal blend for an intelligent society.

Far from being stationary, this compounded pendulum of intelligence, society, and nature swings continuously. Swings of the socioeconomic balance can be gentle and easy, or violent and brutal. On the one hand, appropriate human attitude nurtures societies, fosters intelligence, and preserves nature. On the other, improper attitude kills societies, forbids intelligence, and destroys nature. Enhancement of positive intelligence is social responsibility. The continued revival of negative intelligence is a human process fueled by greed, selfishness, and hate in those who suppress society.

In the present context, the mentoring and monitoring of the entire scenario dealing with the deployment of intelligence, movements in society and preservation of values are best accomplished by the precision of machines and by interconnectivity of networks. Numerous parallelisms exist. The Federal Reserve system and economic institutions mentor and monitor[2] the flow of monies, production of durable goods, and employment in nations. In monitoring patients in hospitals, machines perform well under human supervision. When the processes become sophisticated and complex, collaboration and synergy between machines and humans become desirable. Robotic production lines, corporate management, and petrochemical industries deploy such a strategy of collaborative and synergistic effort.

Second, consider society. Composed of individuals and leaders, society becomes a mirror. The collective self of a group and prolonged, well-accepted

[2]The econometric models of developed countries involve many hundreds of parameters and a set of interdependent equations that govern the economic activity. The equations embedded in the models are generally solved by matrix inversion methods and time series analysis by econometricians to make projections for the future. Such methodologies to govern and stabilize the social values and ethics of a nation can be developed and solved by the sociologists of the future.

attitudes of its constituents are reflected. When the mirror is concave and focused, it can integrate human activity toward a path of progress for the entire society. If the mirror becomes warped, the human activity clutters local hot spots, causing social unrest and violence in the community. When the mirror becomes rough and convex, individual activity is splintered and defused without bringing the due social rewards to the community. In reality, neglected societies experience every type of ill. Such sick societies are restored by the polished and geometric profiles by disciplined and charismatic leaders. Social progress follows. The intellect within society and the capability of leaders become the precursors to success.

Human beings playing a collaborative role do provide an environment for social progress, but machines can design and construct the tools for social change. Knowledge machines provide a basis for systematically cumulating the conditions and circumstances for such social change. In the medical field, MRI systems provide the demarcation between healthy and cancerous tissues in the human body for surgeons to perform delicate surgery. In the VLSI environment, simulation programs offer the circumstances when pulse shapes deteriorate beyond repair.

The monitoring of all the components for desirable social change is a full-time and relentless task. If it is human to err, then the errors are compounded much too fast to sustain steady social growth. If it is mechanistic for computers to be accurate, then accuracy is safeguarded, at least for a while. If it is human to be creative, then creativity can lead to a sustained and wise social goal. In this vein, it is our contention that accurate machines and creative humans be intertwined such that the combined system is better than machines or humans. It is possible to combine the positive qualities of machines and humans toward a steady social pattern for growth over relatively long periods. On the other hand, it is equally possible to couple killer machines with brutal humans.

Under ideal conditions, a balanced hybrid system of humans (creative, selfless, and well-intentioned) and machines (information, knowledge, and well-primed wisdom) will outperform the current mostly human and little machine system. It is apparent that the little machines presently in use are the plain computer systems of the past. It is also our contention that the humanistic machines proposed in this book are wisdom machines [4] when primed with human values and ethics.

Third, consider networks. Telecommunications is the backbone of commerce. Financial transactions drive humans and nations to search for the means to satisfy human and social needs. Society churns and life goes on. Telephone networks sufficed during the early days. The digital era made began with circuit-switched digital capability (CSDC) within the telephone networks during the late 1970s, during the 1980s, digital services were implanted in simple telephone networks such as the plain old telephone service or public service telephone network (POTS or PSTN) by deploying the integrated services digital network (ISDN). But a impact occurred dramatic and sustained since the inception of fiber-optic technology for the local and global networks. More recently plastic fiber optics have held the promise to making fiber networks robust, cheap, and universal for carrying digital data on local networks.

Apart from the strides made in for physical media, the switching technology has evolved dramatically. From human operators to the programmable electronic switching systems (ESSs) of the mid-1960s, progress has been slow. The switching speeds for modern communication systems needed the innovations of the transistor and its integration to be imported as fully evolved computer systems. Numerous versions of these ESSs served as the major building blocks in the networks of 1970s to 1990s.

Packet switching rather than circuit switching made an impact during the 1950s and 1960s. Having been developed for computer networks rather than telecommunications, packet switching offered a new approach to the design and deployment of switching protocol. The universal form of this transfer control protocol is the TCP/IP, used for Internet switching. Most modern networks deploy high-speed switches and routers.

Optical switching devices brought a dramatic impact in networking technology. Interconnection between globally dispersed locations occur via a network command and fibers transmit information at mega-rates—too much for the human senses to absorb and assimilate. The glut in the optical capacity of networks does not trigger faster human senses. Evolutionary by nature, optic and auditory nerves retain their capacities. Additionally, the processing of information into retained knowledge in the mind is much slower.

Minds retain wisdom and networks carry bits. Perceptually, the information divide between bits and wisdom is deep and wide. The mind is lost in this divide that it cannot take a quantum leap into the wisdom domain from the photonic data in optical fibers. This book presents a methodology to systematically traverse the divide along the knowledge highway that spans the two distant nodes. This book also extends this well-trodden span into the social norms and ethics that are the pinnacle of wisdom. A beautiful human face starts to appear in the cyber space of sharp binary pulses of data.

The simplest form of a graph is feasible with seven nodes (bits, data, information, knowledge, concept, wisdom, and ethics) and six links in between. A progression of order and reason is suggested by installing the six links between the seven nodes, with data and ethics at the extremities. Accordingly, these six links are:

1. Low-level logic circuits to respond to the binary bits
2. Computers to process the structured binary bits as data
3. Information technology platforms to instill order in the data
4. Knowledge machines to generalize and categorize information
5. Concept machines to construct a framework of rationality
6. Wisdom machines to derive universal axioms of wisdom for human beings to “plug and play” in other social settings

In reality, all the links between all the nodes are not ready, even though the links (1) through (3) and partly into (4) are well entrenched in technology. In the modern era, networks have evolved significantly to keep pace with the growing collections of human needs. Since the age of fiber optics, networks have grown at a pace faster than the financial activities to sustain society. Additional bandwidth has brought about the gadgets and devices that suit most whims and fancies of society rather than its needs. One of those needs is to continue to search, even if the search is for the unknown or the search itself is an unknown. The urge to search is a search for the unknown. Before the machine becomes lost in a wonderland (labyrinth) of fantasies, its human counterpart can stop the futile search for humanistic machines and realign to solve realistic social problems.

1.1.1 Global Power of Knowledge

On the positive side, information-rich societies, like networked nations, benefit from quick and global access to numerous knowledge bases around the world. A similar phenomenon occurred at the beginning of the Industrial Revolution, when access to technology provided a basis for the wealth of nations. On the negative side, lagging societies are likely to suffer the ill-effects of the growing knowledge divide between the two sectors within the same society. From an economic perspective, the wealth of information for networked nations can build a crag between knowledge-rich and knowledge-poor nations. However, the laws of economics governing the distribution and flow of wealth of knowledge are distinctly different from the laws of economics that govern the distribution and flow of money. The impact of the knowledge revolution is very likely to be different from that of the Industrial Revolution.

The struggle of nations is ridden with wars and deprivation. Yet, most nations have weathered the wave of the Industrial Revolution around the globe. Such a revolution is likely to reappear again in the future but in the knowledge domain. In the earlier era, the lower or more basic needs of societies were met by the products of the Industrial Revolution of the sixteenth century. In the current scenario, the higher-level needs of societies are likely to be chess pieces in the game of knowledge revolution now unfolding. The writings of Karl Marx who predicted the exploitation of labor (*Economic and Political Manuscripts* in 1844, *Theory of Surplus Value* in 1862, and *Das Capital* in 1867) are most likely to become relevant again during the exploitation of the ignorant, the illiterate, and undernetworked nations in the next two decades. Exploitation appears to be the only commonality between the two revolutions.

Wealth and power are built on a foundation of knowledge. Devices and machines have slowly taken over the functions of humans. A snapshot of the current and futuristic technologies to process knowledge and to extract concepts and wisdom from it is depicted in Figure 1.1. The forward pace is accelerating, and machines have already displaced the simpler functions of human thinking. More complex thinking falls in the domain of artificial intelligence (AI) embedded in machines. The roles of machines as the means for wealth by industrialization and power by military confrontation has become evident.

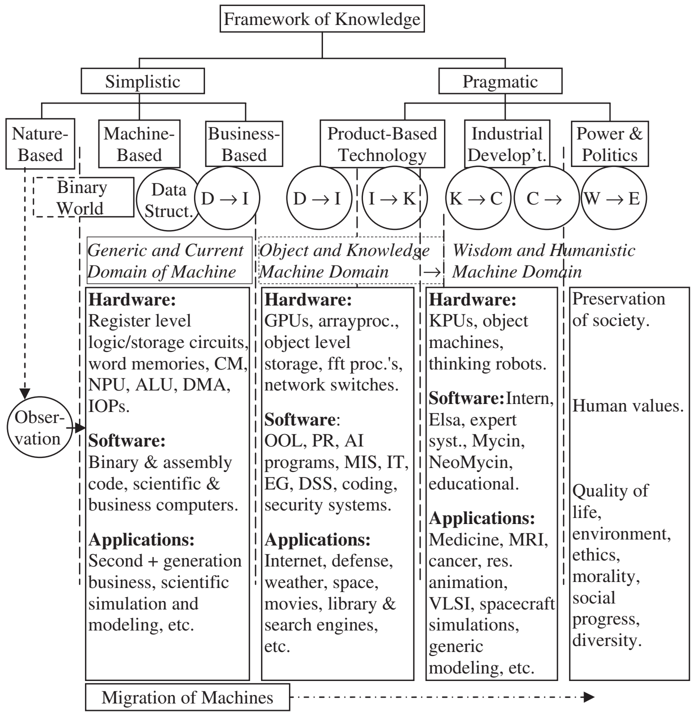

Figure 1.1 Overview of current and futuristic technologies to process knowledge and to extract concepts and wisdom from it. The letters B, D, I, K, C, W, and E stand for binary, data (and data structures), information, knowledge, concepts, wisdom, and ethics.

For underprivileged nations and societies, astute and accurate self-analysis in the early stage of knowledge revolution will prevent a life of intellectual slavery in the decades that follow. After all, the slave trade flourished for a century. Guns and ships allowed British and Portuguese sailors to exploit the social conditions in Africa. In the knowledge society, the strategic algorithms in AI and well-guarded knowledge banks are likely to become the new weapons and technology. The unfolding knowledge games that people and nations play are the early warnings of the knowledge wars to follow. It is proposed here that machines sense, maintain, and monitor an ethical framework and balance for the distribution of the wealth of knowledge.

Societies like humans have needs. In the Utopian knowledge society, monetary wealth becomes subservient to the wealth of knowledge. Knowledge (and wisdom) about monetary wealth will lead to its optimum utilization, and the marginal utility theory applies for the distribution of wealth. The classic writings in Sanskrit emphasize that wisdom without greed is the gateway to *unselfish* wealth. In the modern context, wealth is a transition but wisdom is a state. Knowledge, wisdom, and wealth make up a triangle of hope and fear for the struggles of

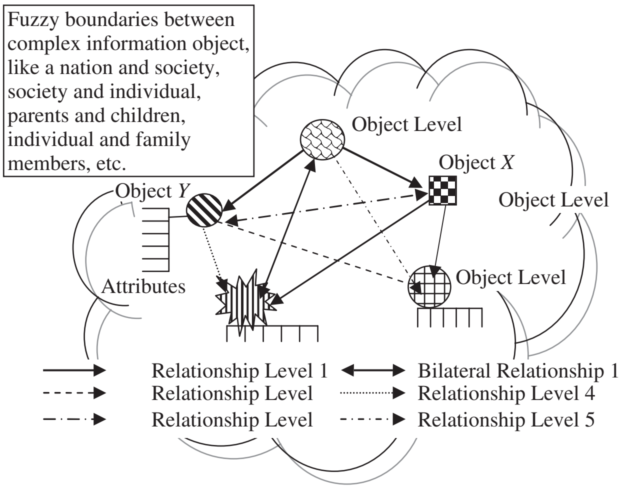

Figure 1.2 Representation of a complex information/knowledge object with five lower-level information objects. Strong, weak, casual, unilateral, and bilateral relationships are shown.

humans and nations alike. To capture the essence of this, we present the roles of humans and machines into two Figures 1.1 and 1.2.

Internet is the prime mover of information for the resolution of needs. In most instances, relevant information causes the mind to blossom but a flood of information drowns creativity. A rapid and unrestrained glut of information floods the senses and drenches thought. In fact, all the irrelevant information obtained via high-speed networks burdens the mind. In the post-information revolution, the mind has become specifically sensitive to the validity and pertinence of information. A tunable information filter serves the need to separate out junk from germane information.

In most cases, human beings are ill equipped for these tasks and the result is distraction and lack of focus to solve the immediate problem. The purpose of this book is to introduce methods of implanting some of the low-level human functions, such as selective filtering, pattern recognition, enhancing, and relevancy checking, in machines and knowledge-processing systems. Humans function at a higher level in terms of innovation, invention, creation, transformation, transmutation, etc. The interaction between a human being and a machine will be that of rider and an intelligent horse in the connected terrain of knowledge, concepts, and wisdom.

This capacity to carry through human concepts of communication in hardware is a skill of human beings. Human beings program, that is, fragment any complex function repeatedly until it becomes a hardware-realizable VLSI or photonic process, as a very systematic and scientific step-by-step task. Programming occurs at numerous layers, ranging from invoking a sequence of powerful global Internet commands to the most rudimentary binary-level instructions to invoke micro-functions in logic circuits. In many instances, it becomes impossible to "see through" the thought process of a human being represented as a sequence of logical processes in circuits. The fragmentation of tasks, and the layering and organization of software functions (encoded as routines) offer the ultimate methodology to build complex intelligent machines and networks.

Since the inception of the central processing unit (CPU) in early computers of the 1940s and 1950s, machine instructions have remained in extensive use. However, in order to make the computer more popular, languages for numerous applications were introduced. As the applications have become more universal, the languages and their compilers have also become sophisticated. In a sense, the evolution of higher-level languages (HLLs) has made the use of computers easy for the user. The introduction of application programs with a graphical user interface (GUI) has made any end-users capable of executing intricate software programs on blocks of input user data. The final manifestation is the ease and comfort with which Internet users may access and deploy the information and knowledge stored at any World Wide Web (WWW) address.

Logic circuits and their operations have not changed drastically for some time, but the organization and layering of hardware have evolved dramatically. The skill to compose large complex functions involving the fewest high-level end-user commands (including the clicking of a mouse) has now shifted to the designers of Internet and applications-level software, compilers, and assembly-level programs. The software to execute the user functions in the VLSI circuits embedded in sophisticated hardware is as much a part of the knowledge environment as automobiles are a part of human society.

1.1.2 Scientific Aspects

From the days of the Industrial Revolution, significant changes in society came about from some form of a scientific breakthrough. The foundation of social and materialistic progress generally rests on the well-founded law(s) of physics. Such scientific achievements may be singular or cascading. Once the origin of new scientific thought is defined, progress is generally fueled by society to deploy the invention and exploit its novelty. Current opportunities brought to bear by information technology only enhance the momentum of change.

Over earlier generations, science and wealth did not bear a direct correlation. However, the exploitation of guns and ammunitions to generate vast amounts of wealth by plundering natives was the proven strategy of thugs and pirates. British slave traders and Spanish conquistadors all left deep scars on the face of human civilization. Still practiced in the knowledge and information domain, this artifact of violating the privacy of humans and nations is not a scientific achievement. To some extent, it is indicative of the thievery and piracy of information. However distant or late secure network technology may appear, it offers a glimmer of hope against the abuse of information.

The pinnacle of information and knowledge machine performance is the ability to be ethical in transacting business and executing programs that are not detrimental to society. Initially, implanting this type of intelligence in machines appeared formidable, but the operating systems of present machines do not permit the execution of malicious code. Machines do not transmit virus-ridden information over the Internet. Current medical information code prevents the prescription of dangerous combinations of interacting drugs.

A different scenario emerges when scientific pursuits and human greed are blended in one human mind. Over the last few decades, the greed for wealth emanating from commercial enterprises has not diminished. In a sense, scientists who have acquired a taste for wealth have become greedier. The alarming result in the knowledge domain is the reincarnation of the exploitation (in Marxist terms) of the ignorant. Ill-informed humans stand to lose a lot in a deluge of print and fine print. A new breed of machines that retain a global perspective on the problem and the nature of the proposed solution will provide better solutions and warn users about all the positive and negative aspects from an unbiased perspective.

1.1.3 Wealth Aspects

The deployment of any scientific innovation for the pursuit of wealth is tolerated and sometimes desired by nations. In most cases, the conduct of humans and nations in the pursuit is generally less than ethical. The stringent enforcement of laws is expensive and time-consuming. When the choice lies between being wealthy or ethical, morality is generally shortchanged at an individual and national level.

1.1.3.1 Industrial Development Industrial development is an offshoot of technology and technology is based on innovative ways to satisfy human needs. National development occurs as a result of a chain of cause–effect relationships that lead to an enormous accumulation of wealth. By the same token, human opportunism is also a chain of economic events that govern the price of essential goods. As long as essential needs exist, the opportunity for the accumulation of wealth also exists. In a sense, price as it is determined by supply and demand leads to the accumulation of wealth and that is, in most cases, a precursor to the greed of individuals and nations.

When driven by an obsession for wealth, the manipulation of conditions for maximizing it becomes a preferred strategy for industrialists and industrialized nations. Adam Smith was the first to write about the wealth of nations and Alfred Marshall was the first to enunciate the laws of supply and demand. The superposition of Smith's notion about the wealth of nations on Marshall's law of supply and demand leads to the combined strategy for maximizing the wealth of nations that can curtail supply to maximize price. This drama has been played out by the OPEC countries (or by DeBeers Corporation) over the last few decades in growing wealthier. Such an obsession with profit or wealth by energy companies becomes evident every winter as the need for home heating reaches a peak.

In the knowledge domain, the derivation of a viable strategy for the accumulation of lucrative knowledge bases (KBs) is more devious. However, knowledge as a resource to generate technology based on inventions still prevails in its own niche. The pursuit of knowledge rarely becomes an obsession or greed for knowledge, except for a few scientists and philosophers. Knowledge wars are as unlikely as saintly killings, even though Bell and Edison, Tesla and Marconi fought many scientific duels in their claim to fame. Glory and fame are the objects of greed that conveniently spill over into greed for wealth.

1.1.3.2 Materialistic Achievement Scientific and materialistic achievements have a very fragile boundary except for the most ethical scientists. In the hierarchy of achievements, materialistic wealth provides the foundation for scientific progress. The wealth necessary to satisfy lower-level needs is the necessary and sufficient precursor for individuals and nations to develop the scientific methodology to satisfy higher-level needs and thus cross the barrier of knowledge. It becomes a personal challenge for an intellectual to resist the pull that drags one into the quicksand of materialistic greed.

1.1.3.3 Global Power of Nations Power is distinct from knowledge or wealth, even though wealth by itself may offer some power. However, knowledge is power, and the knowledge of deadly weapons is a basis for deadly power. For nations, an arsenal of knowledge on deadly weapons represents deadly power. In a somewhat surreptitious way, nations fund nuclear technology to build an arsenal of bombs, fund missile technology to instigate star wars, fund communications satellite technology to make spy satellites, etc. In most cases, the knowledge gained from funded research becomes a by-product that may have other marginal value.

In a deceptive game with intellectuals, nations siphon and store deadly knowledge for the supremacy of global power. Along the knowledge trail that is meant to benefit society and humankind, offshoots toward the national greed for power start to appear. The global superpowers have practiced this strategy with no uncertainty many times over. The greed of nations needs an open articulation of the wealth of nations as expressed by Adam Smith. Karl Marx had openly rallied against the greed of capitalistic society and the exploitation of labor. It remains to be determined if the historic voices of Smith and Marx, will rise again for the greed of nations for global supremacy and the exploitation of the human knowledge and intellect.

Knowledge and intellect are more illusive resources than money and economic goods. The laws of mirco- and macroeconomics governing knowledge and intellect have yet to be formulated. Virtual and distant as knowledge and intellect appear, more abstract and remote are the new breeds of economics for knowledge and intellect. In a sense, a viable theory of knowledge (Chapter 3) is only an entry into the domain of knowledge.

1.2 ROLE OF TECHNOLOGY

Technology advances human ambition and eases the burden of the mundane. From primitive tools to the spacecraft, inventions achieve immediate and concrete goals. Technology becomes self-perpetuating because human goals keep increasing and grow dynamic. The hierarchy of technology almost reflects the pyramid of human needs. Human beings have needs and inventions resolve such needs; the technologies to provide optimal solutions then to follow. The laws of economics emerge and a systematic collection of knowledge is accumulated. The expansion of needs-based knowledge is inevitable. In the current knowledge society, the expansion of knowledge accelerates further because of the expansion of needs, of innovations, and of the numerous technologies to resolve the needs. Human efforts to maintain a continuum of knowledge, is made feasible by a new breed of knowledge machines rather than conventional computer systems.

1.2.1 Three Major Contributions

1.2.1.1 Stored Program Control and Conventional Machines Eckert and Mauchly proposed the Electronic Numerical Integrator and Computer (ENIAC) in 1943, and von Neumann proposed the Electronic Discrete Variable Automatic Computer (EDVAC) in early 1945. The Institute of Advanced Study (IAS) unveiled its machine in late 1945 at Princeton. The IAS machine evolved amid a flurry of innovations in vacuum tube engineering and the inception of semiconductors. A rigorous systems approach to the overall design of the IAS computer system was launched rather than assembling different gadgets. Some of the basic gating functions of logic had been already implemented.

The quantum jump that von Neumann proposed was the design of the entire system. The IAS machine architecture established the concept of stored program control that permits the main programs as well as the data to be stored in the main memory as binary bits. The format and representation of these two entities are different. The program and data could thus occupy segments of main memory, and the execution of machine instructions could take place systematically according to binary/assembly-level programs. The program counter contains the address of the next executable instruction.

The design of the CPU was the basis of the breakthrough in the machine. Many modifications have followed since the 1950s, but the five-step sequence (fetch instruction, decode instruction, operand fetch, execute operation code or *opc*, and store interim results) in the execution of each binary instruction has not changed drastically. The main theme of the von Neumann machine is presented since some architectures of the knowledge-processing unit are derived from von Neumann's original proposals and the subsequent enhancements. such as the single instruction multiple data, (SIMD), multiple instruction multiple data (MIMD) and multiple instruction single data (MISD), pipeline, array processing, etc.

The concepts in von Neumann's earlier Electronic Discrete Variable Computer (EDVAC) also deployed the stored program control (SPC) concept for controlling the functions within the machine and used the binary arithmetic logic circuits within the CPU. It also used a two-level memory system for the computer: (1) a 1,024-word faster memory block, and (2) a second block about 20 times this capacity (but slower) as the secondary memory. Some of these concepts are still in use today.

The most distinguishing and innovative features of the IAS machine are its memory size, word length, operation code (OPC) length, and addressable memory space in binary bits. The machine has 4,096 addressable locations in its memory, and the word length at each location is 40 bits, holding two instructions each with one 8-bit byte for the OPC and a 12-bit address field. The machine also uses a fixed bit binary format (with 40-bit representation), with the first bit denoting the sign of the number in the next 39 bits. Thus, two instructions or one data word would occupy one memory location and the computer could execute one instruction after another and keep computing like any other modern machine.

1.2.1.2 Unix and C Environments The UNIX operating system and C language from Bell Laboratories brought the operating systems concept to a new level of freedom for the user. In 1965, when electronic switching systems were introduced [1], the need to control the ESS due to the growth and long-distance nature of telephone calls became apparent and a whole new language was essential to meet the needs of the communications industry. Essentially, a new operating systems (OS) environment (UNIX) and the C language [5] made computers more powerful to serve sophisticated and demanding users. The concepts introduced in the UNIX OS and their deployments in the C language have been enhanced further in the C++ language for midlevel users. For more sophisticated users, LISP [6], PROLOG [7], and more recently introduced Java [8] languages offer greater flexibility in programming complex tasks on machines.

In essence, the new operating systems and languages provide users with the flexibility to interact with the CPU functions (arithmetic, logical, branching, and switching), which was denied by HLL software designers. The UNIX OS simplified the numerous layers of older operating systems and the C languages made HLL software more universal and powerful. The ease of programming in HLLs was slightly compromised to achieve more powerful and optimal instruction sets to solve a more complex and generic breed of problems.

1.2.1.3 The Internet The Internet has brought about a profound revolution in modern society. General-purpose computing facilitated the popularity of computer systems in the 1950s and 1960s. The introduction of inexpensive personal computers in the 1980s and 1990s brought the revolution home. Since the early 1990s, Internet has provided access to information highways within the minds of the younger generation. In modern society, the Internet is the venue to satisfying the most natural instinct of curiosity by surfing and searching cyberspace. It has opened the conceptual dimension and shown that, like the human mind, knowledge derived from the intelligent Internet is infinite—well at least semi-infinite.

There is no generic patent for the Internet. It is free from any gains to be claimed by any commercial entity. Internet ownership does not exist even though current Internet service providers (ISPs) charge a fee for the access and services they provide. In a sense, the Internet concept freely floats from any country to another, any socio-intellectual circle to the next. When the backbone telecommunications network of any country can host the rather rudimentary requirements of packet switching, Internet access is readily provided, offering every user in one country an international gateway to other users and knowledge bases.

The Internet is a willful and determined consolidation of the inventions from many contributors over many decades. During the 1960s and 1970s, the federal government sponsored loosely related research topics as independent projects based on the explosive growth of computational systems. These projects generated islands of knowledge that were founded on sound scientific basis developed at universities and corporations. Later, these islands were bridged and made into a larger body of knowledge by additional investigations lasting for two or three decades, from the 1970s through 1990s. Information highways became a manifest reality.

The Internet is a perfect example of the evolution of two intertwined scientific and business strategies. Most of the significant contributions in the telecommunications arena from the 1960s through the 1990s were systematically accumulated on the Internet platform. One the one hand, the Internet shines brightly on a scientific and mathematical basis because of major inventions in communications. On the other, the Internet is fueled by the economic motives of its participants. Synergy still prevails. Inventions came about, and the Internet sustained its own growth in a socially beneficial and an economically viable fashion. The rewards of the intelligent Internet are already altering the direction of human thought, toward the possibility of processing knowledge. The processing of numbers, symbols, and objects is a well-established technology. Over the last decade, the pace has accelerated and global learning in the knowledge society further adds to Internet technology as it drives society toward greater intelligence, deeper wisdom, and beautiful ethics.

Two federal sponsors [the Office of Aerospace Research (SRMA) and Advanced Research Projects Agency (ARPA)] facilitated the fast track of the Internet. The Aloha system, initiated in the late 1960s, resulted in a novel way to share most transmission media. Although it was developed for radio networks linking numerous campuses of the University of Hawaii and other research facilities on the Hawaiian Islands, it paved the way for random access techniques based on CSMA/CD. Next, under the sponsorship of ARPA, the ARPANET evolved to effectively use computer resources. During the mid-1970s, ARPANET had gained full operational status serving the needs of the Defense Communications Agency. Later, it was used by the Department of Defense (DOD) to transfer both classified and unclassified information and to meet most of the DOD data communication needs. The seminal blending of information processing and mass communication started in the 1970s, and it was funded until the concept gained maturity in the 1980s. During the 1990s, most generic concepts and algorithms were firmly established. The packet network technology is now a cheap reality and has gained immense popularity.

1.2.2 A String of Secondary Contributions

The triadic effects among fiber optics, semiconductors, and the quantum technologies of the 1990s are also an example of both the symbiosis and synergy that have facilitated global gigabit nets. The entire evolution of technology and its implementation are quite recent. A platform of earlier inventions was essential for the string of recent innovations. The role of accelerated inventions and innovations is obvious through the 1980s (for VLSI technology) and 1990s (for the network and fiber-optics technology), and in the present decade at a more moderate rate. Perhaps the saturation that curtails the duration of the creative phase in any discipline is a social phenomenon.

1.2.2.1 VLSI and Ensuing Computing Systems In the early days of computers, gating was accomplished by vacuum tubes. The odds against building large computing systems were immense. The chain of inventions (transistor, planar transistor, integration, SSI, MSI, LSI, and finally VLSI) that followed quite quickly from 1948 to 1965 was indeed the pathway to sophisticated computing systems. The series of computational architectures (SPC, SIMD, MIMD, multiprocessing, parallel, array, distributed, and networking) have further accelerated the progress toward more efficient, widely distributed computer facilities. The series of programming, algorithmic, and software strategies have converged, giving computer technology an edge over any other technology. The closest competition comes from VLSI technology that is a direct beneficiary of computer technology because VLSI is totally dependent on computers (computer-assisted design or CAD programs) that are driven by the VLSI industry of the prior generation. The symbiotic cycle has continued for several generations and is likely to endure further. Quantum computing may well be the next frontier.

Computer devices function with their gates performing logic (and, or, ex-or, etc.) and arithmetic (add, subtract, multiply, divide, trigonometric, etc.) functions in the CPU environment. In an input/output (I/O) environment, the communicating devices are assigned and activated. In a storage environment, the bus access and store/retrieve functions are performed by a variety of digital devices. These devices may also provide signal processing functions by digital techniques, thus leading to digital signal processors. Microprocessors emerge when these processors are further integrated to perform generalized and programmable logic, plus control and arithmetic functions. And, with additional bus access and random access memories, or read-only memories, microcomputers emerge. Size, capacity, and facilities lead to larger and larger systems.

1.2.2.2 Switching and Communication Systems Electronic switching systems (ESSs) are computers in their own right. Massive parallelism (to handle many millions of call simultaneously) dominated the architecture. Dependent on

VLSI technology, ESSs have been the beneficiaries of a string of inventions in the semiconductor industry and the computational power of modern computing systems. The growth of massive switching systems was stymied by the viability of fiber-optics technology, by the global acceptability of the SONET frame relay systems, and then by the asynchronous transfer mode (ATM) cell relay technology. Much less expensive routers, bridges, and gateways had gained prominence for communicating packets through the national backbone networks.

The switching function in a computer system, although essential, is not dominant. The input/output channel, direct memory access, and cache memory channels exist and are switched under the operating system and users' commands. Akin to the virtual channels in communications systems, they are set up on demand and disbanded after the exchange of information occurs. In network environments, the switching function is essential and dominant. Real-time, concurrent control of many thousands of communications channels is essential at most of the nodes within the network. For this reason, the design and architecture of switching systems are a major area of specialty and can become as intricate as the design and architecture of any major mainframe computer system.

Modern digital network devices also function with gated logic. However, the channel management aspects of the network dominate, rather than digital and binary arithmetic. Switching and allocation of channels (switched or packet) and their monitoring become a major network function; the network devices, though digital, are designed for channel control. Control of the network to perform under dynamic conditions needs more adaptation than the control exerted by computer operating systems. Switching of communications channels needs specialized hardware (electronic switching systems), which closely parallels mainframe computers. Both are driven by stored programs, and both have similar architectures and track individual tasks. The communications tasks are shorter but much more numerous: One mid-sized ESS office may service up to 100,000 lines with as many as 10,000 independent channels being active at any one time. Specialized switching also occurs at channel banks that support these ESSs.

The more recent ESS environments handle up to 200,000 lines for every possible combination of services, such as local/toll operator services, wireless, intelligent networks, integrated services digital network (ISDN), and packet and all switching with ATM front-end processors. With the advent of ISDN, the functional demands on these switching systems are expected to increase dramatically, and the complexity of the tasks is also expected to increase. Furthermore, any elaborate national communications network may have hundreds of these switching centers or network nodes. Hence, the network hardware deviates from the conventional computer hardware and follows an expansive architecture to suit the increasingly demanding and intelligent network functions. Fortunately, the hierarchical steps followed by computer scientists in complex computer designs can be, and have been, adapted to network systems. The transmutation of the logical steps traced in both the hardware and software applies to the network architecture and its driving software. Complex computers become basic network building blocks, interspersed with transmission and access facilities, in the same way that general-purpose processor chips have become the basic building blocks of most complex computers. The software driving these computers differs, just as the microcode that differs between processor chips.

1.2.3 Peripheral Contributions

Business and financial environments also have specific needs. Over a period of time, numerous software configurations have come and gone. One of the languages for business applications developed during the 1950s and 1960s was ALGOrithmic Language (ALGOL). The extended use of ALGOL for rapidly increasing business needs and programming occurred in the 1960s and 1970s. In a broad sense, business users have not been as demanding and sophisticated as scientific and telecommunications users. Consequently, the effects of their use have been noticeably different. In most cases, the basic hardware for processing of data for business applications has not changed drastically except for the size and interconnectivity of peripheral devices.

When the demands on the applications processes have become intense [such as in magnetic resonance imaging (MRI), signal processing, radar tracking, missile technology, etc.], the hardware has undergone significant changes. New inventions and innovations have kept pace with the sophisticated demands. Battlefield robots were as much a fiction in the early 1990s as electronic switching systems (ESSs) during the early twentieth century. Yet, both are realities in the early twenty-first century.

Unimaginable progress has been made. Machines routinely assemble MRI scans [9] and generate three-dimensional images of cancerous malignancies in human beings, autopilots [10] navigate airplanes, robotic controls [11] make landings on planets, and drone planes [12] chart enemy territory. It may appear inconceivable that a machine will be able to process the knowledge embedded in information, much less be able to extract wisdom from information. It appears there is no problem unless it is defined. The definition of a problem is half its solution. The conceptual barriers are meant to be broken down, the paper tigers are meant to be burnt down, dark fibers are meant to be deployed, and every Everest is there to be climbed.

The origin or source of incisive knowledge appears immaterial, provided it is accurate, scientific, and deducible. The processing of knowledge can be machine-based, human, or a blend of the two. In the final analysis, the distillation of wisdom is a series of cyclic and coherent processes between the logical deductions of machines and the inherent creativity of humans.

1.3 KNOWLEDGE AND WEALTH

The domain of knowledge is more encompassing than that of wealth and materials. For dealing with the utility of knowledge, all factors (its scarcity, its total utility, its marginal utility, specifically its diminishing marginal utility, its utilitarian value, its exchange value, etc.) that influence the evaluation need to be considered. From a communications perspective, knowledge can be traced backward and extrapolated forward, much like scientific parameter(s). From a structural perspective, we propose that the processing of knowledge be based on the most basic and fewest truisms. These truisms are, in turn, based on reality and they permit the characterization of information and knowledge. To this extent, computational processing does not depend on the philosophic writings of earlier economists. However, the truisms are validated by a longer-term philosophic interpretation of how these truisms have survived so that they can be expanded and reused in scientific and computational environments. This approach permits machines to process knowledge based on the content of a particular piece of information and to enhance the content, presentation, and wealth of knowledge that the information communicates.

To face the reality of the current information revolution, the monumental advances in computer, communications, and information technologies need firm functional integration. Modern machines can process knowledge as easily as computers can process numbers. Fiber-optic networks offer (almost) unlimited bandwidth. Context-related information processing is as easy as a Unix-based search. With such strides in technology, an information glut almost drowns an ill-prepared mind. The Internet challenges the freedom of the human soul to remain free and to soar across oceans of ignorance. The human mind, destined to reign free and leap over the mountains of apathy, becomes trapped in the weeds of trivia. It becomes a paradox that the information society which offers freedom also corrupts the senses, preventing humankind from being socially responsible and astute and safeguarding global harmony and peace. The biases within the communications media that disseminate the information become insidious within it.

On the one hand, the truth, virtue, and beauty embedded in information and wisdom enable the mind to grow and migrate toward peace, social justice, and wisdom. Yet, on the other, the deception, arrogance, and hate that lie hidden in information and media clips cause the mind to spiral deep within the prehistoric caves of self-preservation, even in the absence of any threat. Fear of fear has an exponential growth. Such attitudes and accompanying behavior are common in individuals, corporations, cultures, and nations. The reactions to perceived threats become real in well-armed nations initiate wars for no reason expect to deplete the arsenal.

The role of the Internet in bringing information and knowledge to every member of an educated society has increased rapidly over the last decade. Over the last few years, the four directions of human achievement have been intelligence (both human and artificial), the Internet (both conventional and semantic), wisdom (both traditional and web-based), and finally, networks (both modern and broadband). These four directions appear unrelated at first but soon become interwoven: They blend into each other in a synergistic and harmonious way without bounds. The four-dimensional space and our way of thinking are unified freely, encompassing intelligence, the Internet, knowledge, and networks. These concepts are explored further in Section 1.5.

1.4 EVOLVING KNOWLEDGE ENVIRONMENTS

The evolution of society is based on the systematic collection, validation, and deployment of gainful knowledge. Knowledge can range from gossip to well-guarded national secrets. Gossip and rumor that have little value are filtered out of the computational processes. On the other hand, knowledge that is rare or unique enters the computational domain to be examined, refined, and enhanced. Knowledge is collected systematically (from Internet traffic), validated extensively (from Web knowledge banks), and deployed widely (from the dictionary of axioms available from Web wisdom bases). The true wealth of knowledge (if there is any) is thus evaluated rather than the raw format in which it was presented. Knowledge processing becomes a precursor to the enrichment of knowledge or the distilling of wisdom.

In a symbolic sense, knowledge has two major components: (1) the embedded "objects" around which knowledge is gathered and (2) the process that such objects have undergone to modify the knowledge surrounding them. If there are attributes assigned to such objects, then such attributes need to be measured, documented, and/assigned. Hence, any object forms a nucleus of some knowledge around it. Nothing without any history has no knowledge associated with it, and the nothingness of nothing is no attribute. However, in a more positive sense, every object has some history and some attribute(s).

Knowledge is inclusive of objects around which knowledge is gathered. If objects are classified as nouns, then such objects undergo change through the verbs operating on and around them. Invariably, a verb causes a change in the status of a noun object and corresponds to a *kopc* (verb) executed on a *kopr* (noun). In this content, *kopc* stands for knowledge operation code and *kopr* stands for knowledge operand.

A sentence that is a part of any textual message in any language has at least one verb and one noun. Traditionally, most of the messages processed by the human mind enhance knowledge or understanding in the context (vectorial direction) in which the message is perceived.

In the same vein, every executable statement of a knowledge program needs at least one *kopc* and one *kopr*. The format of multiple *kopc*s and *kopr*s for the command structures of knowledge processors is discussed in [13]. Invariably, a certain duration of time is essential for the verb function (force) to complete any change in the status of the object. If the extent of change thus accomplished is ΔS in Δt seconds, then the symbolic representation of the incremental change in status is as follows:

$$\Delta(\text{Status of a noun object}) = (\text{Intensity of the verb function}) \cdot \Delta t$$

$$\Delta S = \text{Force} \cdot \Delta t$$

An object undergoes a change in its status ΔS depending on the intensity of the verb function exerting a force over an interval Δt of time.[3]

If status (energy) is considered entropy in a particular discipline, then the change of energy is the scalar product of force and displacement. The change of status ΔS of an object (i.e., the change of entropy for that object) is a vector in any given discipline and equals the intensity of verb function times the extent of change over an interval of time to achieve the desired change. For example, if status is wealth, then the change of wealth equals the earning rate (i.e., /hr) times wealth saved over the duration of the time worked.

In reality, such an interpretation becomes more complex in the knowledge domain. If status is the knowledge of a learner in a particular discipline, then the change of knowledge is the scalar product of intensity (e.g., the concentration of the learner dedicated to that subject equivalent to "force") and the duration is time of study.

In such cases, concentration toward study should be considered a vector in the direction of the discipline, and the knowledge gained is the scalar product of concentration toward study in that subject matter and the duration of time studied. The "object" is the learner; the "verb function" is the scalar product of concentration of the learner for that subject and the time spent. Once again, if the concentration varies with time, then the scalar product becomes a time span integral of scalar products at any instant t times dt.

The status (or entropy) of any one object or a group of objects becomes akin to the knowledge retained by a human being or group. In a sense, when an object group is formed, then the status of the combined knowledge undergoes change. Such changes can be slow and insidious or sudden and explosive depending on the intensity of the verb functions and nature of the noun objects.

In knowledge machines, the object environment is tuned and optimized much like the adjustments of social groups in society. The processing of objects within the knowledge machines thus leads to the optimality of performance and achievements of object groups. To this extent, the knowledge machine is capable of performing some preliminary managerial functions based on objects and their attributes.

[3]This equation is *similar* to the equation (work = force · displacement) in particle dynamics. If force and displacement are considered as vectors, then a scalar product is implied. In the knowledge domain, time is of greater essence. A measurable change ΔS occurs in the status of an object (or a collection of objects) by exerting one (or a series of) verb function(s) for a duration Δt. Stated alternatively, the equation states that the rate of change of status of noun object is the intensity of the verb function. The equations germane to particle dynamics quickly lose their analogy in the knowledge domain. The equations for rigid dynamics hold some similarity, but even these equations lose their true analogy. It remains to be seen if the entire set of rigid dynamics equations (that include translation and rotation) may have a better correspondence with entropy and its incremental change in the knowledge domain over a given period of time.

1.4.1 Components of Knowledge

There are at least three main components of knowledge: (a) the information regarding a group of n objects around which that knowledge is clustered, (b) the interrelation ships within the group, and (c) the status of each of the n objects. Other secondary knowledge classified below as (d) pertaining to the relationships between the attributes of objects, and attributes of the attributes also exist. It is unclear which of the components may significantly change the character of the clustered group. However, a knowledge machine is well equipped to determine (by scanning the existing knowledge banks) which objects, attributes, and attributes of attributes influence the traits of the group and their relationships. Such estimations may become necessary as the knowledge machine composes and recomposes new objects as it processes knowledge. Thus, knowledge about anything can be written down as:

(a) The n objects in the group that constitutes “anything”
(b) The web of implicit or explicit verbs (bondages) that retain the status of each of the n objects, and their structural relationships with each other to be constitutes as “anything”
(c) The status of each of the attributes, their relationships with objects, and their own interrelationships
(d) The secondary relationships

For developing a methodology for the machine representation of knowledge, if the list of the components is terminated at (b), then knowledge can be represented as an array of n objects and a matrix of the status of each object. The matrix can become cumbersome because each object may have numerous attributes, and each object and/or each attribute (at any given instant of time) would have undergone a series of verb functions to change its status.

To be totally accurate, the cumulative effect of each verb function from $-\infty$ to now ($t = t_1$) at this instant is necessary. However, the simplification and standardization of objects can be deployed to write down the (b) components of the n objects. For example, an “object” car is a vehicle with all the standard secondary objects/attributes (wheels, engine, steering wheel, etc.). If the application of this object is transportation, the machine does not need to have any more information. But, if the need arises, the machine can look up the database for the particular make of the car and find its secondary attributes and the attributes of attributes.

A symbolic representation of knowledge can thus be written with two terms representing the (a) and (b) constituents of knowledge:

$$(\text{Knowledge})_{t_1} \equiv \sum_{i=1}^{i=n} (\text{Group of NO}_i) \cdot \text{plus} \cdot \int_{t=0}^{t=t_1} \sum_{j=1}^{j=v_1} (\text{Series of VF}_j) \cdot \, dt$$

This equation should be considered representational rather than mathematical. The symbol ·plus· indicates that different kinds of elements are involved. The first term denotes noun objects NO_i and the second term indicates the integrated effects of a series of j verb functions VF_j for each ith of the n noun objects. This relationship is explored and enhanced further in Section 3.2.3.

In the context of allocating memory to a body of knowledge, two linked arrays are necessary for (a) and (b). The matrix for (b) may be numeric (integer, fixed point or floating point data), alphanumeric (to determine object identification), logical (linkage, types) relational (with degree of influence), and/or qualitative (e.g., excellent, very good, good, acceptable, unacceptable, etc.). Storage allocation becomes an integral part of programming knowledge-based problems.

1.4.2 The Processing of Knowledge

The processing of knowledge assumes two components: (1) the filtering of raw information to create "knowledge-rich" information by selecting appropriate "noun objects" with most dominant structural relationships with other noun objects and (2) the processing of "noun objects" with machine-executable "verb functions" or knowledge operation codes on such operand noun objects. The execution of a series of verb functions on a collection of interrelated noun objects thus modifies the structural relationship between the noun objects and creates new noun objects. The combined effect of a series of verb functions v operating on a group of n noun objects from time $t = 0$ to t_1 yields the net entropy of that body of knowledge (in the "noun object" group) and is recorded in Section 1.5.1. The implication is that:

1. Knowledge is dynamic.
2. v events (verb functions or VFs) operating on the n objects will alter the entropy of the body of knowledge encompassing the n objects.
3. The knowledge at any instant of time t_1 is a result of all the knowledge functions that the n objects have experienced over the *entire* history of that knowledge.

The well-designed knowledge program will enhance the entropy of information to suit a social, individual, or scientific need. It becomes desirable to make the new noun objects and their structural relationships practical, viable, and realistic. The new knowledge derived from the old knowledge and new "objects" (situations, scenarios, institutions, societies, etc.) is thus "computed" (and conceived) as the knowledge processing takes place. Knowledge processing becomes a process of creating new objects and enhancing their structural relationships. The distillation of wisdom becomes a series of cyclic and coherent processes between the logical deductions of machines and inherent creativity of humans. These concepts are explored further in Chapters 3–5.

1.5 STRUCTURE AND COMMUNICATION OF KNOWLEDGE

Material and monetary wealth was discussed Adam Smith and has evolved as the basis for national and international trade and commerce. John Maynard Keynes (1883–1946) and his fiscal policy issues are still held in esteem in monitoring the growth of nations [14]. Unlike monetary wealth, combined information and knowledge *(I«»K)* have many facets and implications. Whereas the measurement of wealth is scalar and has a numeric measure as the currency value, the wealth of knowledge has more numerous measures. After all, the evolution of society is based on the systematic collection, validation, and deployment of gainful knowledge. Knowledge can range from hearsay to well-guarded national secrets. Unfounded information and gossip have only marginal value and such information has no significance. On the other hand, if knowledge discloses a rare discovery, an invention, or a trade secret, then its value is at a premium. If the information has social significance, is rare, and is still not disclosed, then the value of that information is high. However, information kept in total secrecy has no value unless it is derogatory or damaging. Even long and extended periods of torture are justified for prisoners of war who supposedly have "information" about the enemy! Rare and damaging information has only blackmail value. For these reasons, the economics and strategy for dealing with knowledge and information require different considerations from those established in typical economics or game theory [15].

A certain commonality exists in the economics of knowledge and traditional macroeconomics. Money that becomes stagnant and does not get invested leads to the liquidity trap [14]. The business community is unable to invest and grow because economic opportunities are too few even though interest rates may be low. Valuable technological information that does not find its way into production lines remains dormant as paper in patent offices. In a sense, the possibility of an information-rich but stagnant society starts to become real, somewhat like Japanese society in the 1980s. Valuable knowledge and information (like money) need deployment. Like savings that are invested (savings = investment in classic macroeconomic theory), knowledge (knowledge = production in a knowledge economy) distilled from information needs to be channeled into corporations. Channeling such knowledge into institutions of learning creates a multiplier effect (like that in the national economy) in the *(I«»K)* domain.

1.5.1 Velocity of Flow of Knowledge

A certain *velocity in the flow* of *information and* knowledge *(I«»K)* is necessary for either information or knowledge to be productive. Information that grows too stagnant (like money during liquidity trap conditions) or too fluid (like money during rampant inflationary conditions) loses its potential to be socially valuable. A certain *viscosity in the flow* of *(I«»K)*, like money flow, makes the activity rewarding and economically justified. Information that finds no channel(s) for communication has exhausted its life cycle.

A limited commonality also exists in the economics of information and traditional microeconomics. The value of information and knowledge *(I«»K)* that is transacted is initially comparable to the value of goods or assets that are transacted. However, *(I«»K)* does not get depleted like goods or assets that are physically exchanged. The depletion of the value of *(I«»K)* involves exponential decay rather than a sudden change. The rate of decay of the worth of information can be quite sudden (high exponent) for some types of *(I«»K)* (e.g., weapons and warfare technologies) compared to others (e.g., educational or medical technologies). The sharing of *(I«»K)* may bring down the value as exponential decay, but it still retains some utility for both parties. Both parties benefit from the economic rewards yet retain the wealth of information. Monetary and material wealth that is shared loses value and utility simultaneously. The value of *(I«»K)* varies with server-client relationships. Conflictive and cooperative roles are both feasible, thus altering the laws of economics of knowledge and information.

Mainly, *(I«»K)* that has social, financial, ethical, or moral implications is a resource that is not as immediately exhaustible as monetary or materialistic wealth. Like any other resource, *(I«»K)* can be accumulated, enhanced, stored, or even squandered; however, this resource has special properties. The enhancement of *(I«»K)* is a mental/machine activity differing from the enhancement of material wealth, which is a production/robotic activity. For the differences cited above, *(I«»K)*, "objects" are treated as hyper-dimensional objects that follow the laws of processing but are not quite aligned with the processing of numbers, scalars (such as currency values), or text. Modern computers are capable of processing vectors and graphical objects. Current software packages that handle complex number $(x + iy)$, two-dimensional space for electrical engineers and mathematicians perform as smoothly as those that handle three-dimensional (X, Y, Z) space for graphic designers and movie makers. In dealing with *(I«»K)* "objects," special compilers are necessary. Such compilers should perform lexical, syntactic, and semantic analyses of information objects that can identify other information objects and relate them to the newly found objects by variable and adaptive role-based linkages. A recursive compiler can handle such a scenario.

The processing of graphic entities [16] starts to assume the initial flavor of the processing of information objects. Some of the steps suggested in this chapter are initial and rudimentary, but they can be modified and enhanced[4] to suit different types of information object(s) and their interactions. Processing of information objects depends on the application. On the one hand, mechanical and routine transactions of information objects are akin to data processing in banking and commerce. On the other, when information has human and social implications, then a new software layer that emulates human processes (such as love, hate, needs, feelings, education, counseling) becomes necessary. Generally, human interactions follow the underlying economic framework of the exchange

[4]Algebraic (multiply, divide, matrix, etc.) operations for complex numbers, the development of software routines followed much later, after the development of assembly-level programs for processing real numbers.

of resources. On a very short-term basis, the marginal utility theory [17] starts to unfold in most transactions. Perceived fairness and valuation are of essence in most cases. In dealing with information, most humans follow a fairness and value judgment analysis unless it is willfully transgressed.

The rational component of human processes follows simple programming approaches. The emotional component is tackled by suggesting (and adapting) a series of statistical paths ranging from common to rare reactions. Such reactions are documented in knowledge bases around the world, and steps are adapted in neural networks. In such instances, the machine-generated resolution of information can be superior to an all-human solution because machines can evaluate every type of emotional response in every culture and can suggest a customized response closer to the tastes of the humans involved.

While machines are communicating or exchanging information, they strictly abide by the I/O commands of humans or of the core operating system. While human beings process information, the value and worth of the information are initially assessed and modified by learning, clarification, and negotiation. While machines are processing information, the information-processing units[5] (IPUs) alter the structural relationships between objects and other objects, objects and their attributes, and relationships between object *X* attributes with object *Y* attributes. This scenario is depicted in Figure 1.2. The alteration and redistribution of relationships are not altogether random (unless they are the last resort).

Instead, they are based on laws of probabilities as to which of the relationships are most common and likely to form secure bonds (e.g., information about gasoline and octane values, or information about hang gliders and the wing span of birds). In the process, the machines also investigate unusual and uncommon relationships (e.g., information about the design of hang gliders for Australian coasts and those for Scandinavian coasts), giving rise to novel and unique information, knowledge, or scientific principles (if any).

Machines have an advantage in processing vast amounts of information quickly and accurately. The incremental changes in information are tallied to the incremental changes in external conditions to optimize and predict the information for a given set of new conditions. Incremental changes over any of the parameters (such as time, attributes, or environmental conditions) are accurately tracked and labeled. Processing the key information object(s) that forms the nucleus (nuclei) of the raw information and then reconstituting the information object(s) identify opportunities for possibly new and valuable information, knowledge, or scientific principles. This is the fundamental clue to crossing from the information mode to the knowledge mode.

[5]Information processing and knowledge processing are used interchangeably in this paper since the forward processing (distilling) of information leads to knowledge and the backward processing (parsing) of knowledge leads to information. The same machine may be able to process in either direction, perhaps by changing its control memory chip sets. At this stage, it is premature to speak specifically of the many possibilities that still lie ahead.

Unlike monetary wealth and the wealth of nations [18] that are depleted, the wealth of information is shared. Unlike monetary wealth, *(I«»K)* has significantly different attributes. Whereas universal and numerical values can be assigned to monetary wealth, information has overlapping qualities and fuzzy parameters to transact information.

Complexity theory [19] starts to resemble knowledge theory because of the highly variable nature of *(I«»K)* "objects" and their interrelationships. Most of the precepts of complexity theory become applicable when dealing with information and knowledge. However, in dealing with *(I«»K)*, we limit the processing to a confined number of objects that will not make the information processing chaotic. The self-contained structure is statistically prioritized with weighted relationships between the objects that are considered valid for the processing of *(I«»K)* "objects." In addition, the limitations of the computer system (accuracy, memory size, speed, and possible switching capability) define the size and "body of knowledge" (or "complex initial object") that the machines will handle.

The knowledge-processing system filters out any "objects" that are likely to cause chaotic and unstable oscillations in the processing. It refuses to process inconsistent information, much like computers that refuse garbled data. During the execution phase, irrational requests to process information are terminated and the error condition introduced, just like computers that refuse to execute impossible numeric operations. Unlike complexity theory, knowledge theory will perform legitimate functions on objects for which some earlier statistical information is available in world-wide knowledge banks. If the extent of information is too restrictive, the learn mode [20] is invoked to build a knowledge base for the unknown object. The machine guards itself from being drawn into an execution mode that will end in catastrophe by establishing noncircular forward and backward pointers. Even though recursion is permitted, the depth of recursion is made consistent with machine capacity. Rationality is given higher priority than the task of executing a knowledge program. These bounds of rationality contain the fuzzy bounds of knowledge that is under process. To this extent, the machine regains its own stable operating condition, just as a human being would attempt to do. Thus, overall knowledge-processing systems have a fair chance of solving complex knowledge problems that human beings by themselves cannot attempt.

The knowledge-processing system limits the size of the body of knowledge processed by a quantitative measure of the capacity of the machine in relation to the requirement of a "complex initial object." No such limitation is imposed in complexity theory. For this reason, knowledge theory is based on the computer systems that will attempt to solve a knowledge problem. Knowledge theory is a valid tool in initially formulating a problem and adopting a strategic solution to it. The system resources expended to change the status of information and knowledge (see T2 in 1.5.2 also see P3 in 1.5.3) during the course of the problem's solution will be (in most instances) the bottleneck. In essence, complexity theory is an open-ended theory, but knowledge theory works in the context of machines having discrete (binary or hyperspace) representations, limited in their memory, I/O, switching capacities, and speed of operation.

To this extent, knowledge theory is like information theory that works in most nonchaotic but extremely noisy environments. Knowledge theory does not violate any of the principles (such as auto-organization, edge of chaos, power of connections, circular causality, try and learn, and ologrammatic principle) set forth by complexity theory. To some extent, auto-organization and try and learn are based on a survey of the world-wide knowledge bases on the Internet to find out how other complex knowledge objects have accomplished auto-organization and adaptation. To this extent, quantification within knowledge theory (like that within information theory) becomes feasible.

Shared information loses value at a relatively low rate. Whereas there is a suggestion of the strict zero-sum game [21] in transacting the wealth of nations and individuals, there is an impression of the *elastic zero-sum game* as two parties share knowledge and information. Wealth (i.e., all the derived utilities combined together) and value rather than just the price of information are perceived at the time of sharing information. The sale price of a commodity or an asset can only rise in a free-market environment. The price for sharing information is arrived at by both buyer and seller and not determined by market forces. Sometimes, the value of information in a document or book far exceeds the price of the written work, sometimes, the converse can be the case.

In the knowledge domain, an approximation of the scarcity, value, and life of the information is feasible. In terms of scarcity, value, and life (a three-dimensional curve), five coordinate points may be readily identified: (1) totally unshared and secret information that has no value and an indeterminate life, (2) guarded information that has high value and a relatively long life, (3) information shared with a select clientele that has the highest value until it starts to leak and slowly erodes in value, (4) media information that has a media-established price and a short life, and finally, (5) gossip and trivia that have junk value and dissipate without a trace. The value of information in a socioeconomic setting has at least three additional dimensions: the truth contained, the elegance or appeal conveyed, and the social benefit that can be derived from the information.

To deal with the complex nature of information from a computational and processing perspective, we propose four dimensions or senses (truism, philosophic, scientific, and economic), as shown in Figure 1.3, in which information can be characterized. In dealing with information as an object, the truism of all information objects (not their content) states the truth (as well as it is known) about the entire object class. Similarly, the philosophic characterization of all information objects (not their content) states the philosophic nature (as well as it is known) of the entire object class, etc.

Processing an information object can alter its four characteristics (T, P, S, and E). In fact, constructive processing will make marginal information objects into significant information objects, if any significance exists. Worthless information

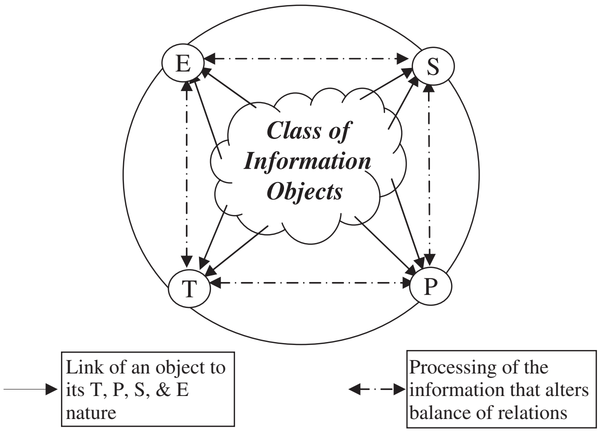

Figure 1.3 Representation of the class of knowledge and information objects with four characteristics: truism, philosophic, scientific, and economic nature of knowledge.

is filtered out from any scientific knowledge processing.[6] The process may be to deduce, interpret, derive, systematize, analogize, categorize, conceptualize, rationalize, and generalize any other process that has a scientific basis.

In order to initiate the information processing that will search out new information or new knowledge from vast amounts of information, three steps are proposed: observation of reality, philosophic validation, and scientific principles that can be generalized and deployed elsewhere. The observation of reality is fundamental to all sciences. Because information has illusive boundaries and flexible formats, the concept resides in the content of information and goes deeper than a statement or representation of information. In a sense, information is the water that can be poured into any vessel. The water represents a real information object with its own properties and the vessel the secondary information object. Together, they form a (partially) stable object group.

Philosophic validation is necessary to provide the long-term continuity and stability of information, such that any inference/scientific conclusion can be drawn. To continue with the earlier example, if the water is poured into a vessel carved out of ice, neither water nor ice will form a stable[7] object group (i.e., water in a vessel). It then becomes necessary to probe the wealth of knowledge and information (water) in society (vessel) to validate their reality as a stable object group.

[6]Most compilers block programs (program objects) from proceeding to the execution phase unless they are free of all syntactic, semantic, and linkage errors. In a similar vein, information that is inherently false or malicious, or ridden with pornography, will not gain access to information-object-processing systems.
[7]Unless the situation is adiabatic at 32°F, which becomes too specific to draw any general conclusions.

The derivation of scientific principle(s) becomes an act of courage: standing firm in the observation of reality and a philosophic validation to make a universal statement or hypothesize about the object–object relationship (H and OH in H_2O, or electrons beams and electromagnetic fields in cathode ray tubes) as a scientific truth. The bold steps of scientists (e.g., Hamming, Shannon, Bose, Hocquenghem, Ampere, Gauss, Maxwell) as they formulated their significant conclusions, based on their own human information-processing capabilities, are still valid. To continue with the earlier example, the scientific principle that water, which can be poured, has low viscosity is universal and it can be used in other instances and situations. In the information domain, very fluid and fast-flowing gossip would not have value, because it is not stable enough to become useful as a scientific principle.

We attempt to follow the three-step procedure (reality, philosophy, and science) to get a computational handle on processing information. It becomes possible to extend the three-step procedure into a fourth step and derive an economic basis for dealing with knowledge and information. Both knowledge and information are known to have value. The rules for dealing with them as object-based abstract commodities start to become significantly different from the economics of materialistic wealth.

1.5.2 Truisms in the Knowledge Domain

The observation of reality over long periods leads to generality or truism. In dealing with knowledge, three important concepts are suggested:

T1: *Knowledge has a life cycle*.

T2: *Knowledge can be altered, but any alteration of it requires an expenditure of energy*.

T3: *Knowledge has impact*.

This list is short and other dependent truisms can be derived from the three listed above. The truism layer is shown at the top of Figure 1.4. The T1 to T3 list is kept deliberately short in the hope that a listing of derived scientific principles will also be elementary and short. This would reduce the basic operations that a computer system will have to perform while processing knowledge.

1.5.3 Philosophic Validation of Knowledge

Only four philosophic validations (P_1–P_4) are suggested and the list is deliberately kept short to reduce the instruction set for the machine to process knowledge. It is depicted as the middle layer of Figure 10.3.

Based on T1, the justified philosophic validation (at this time) is as follows:

P1: Knowledge is timely or obsolete, and it can change its characteristics over time. Typically, human or machine processing changes derived knowledge.

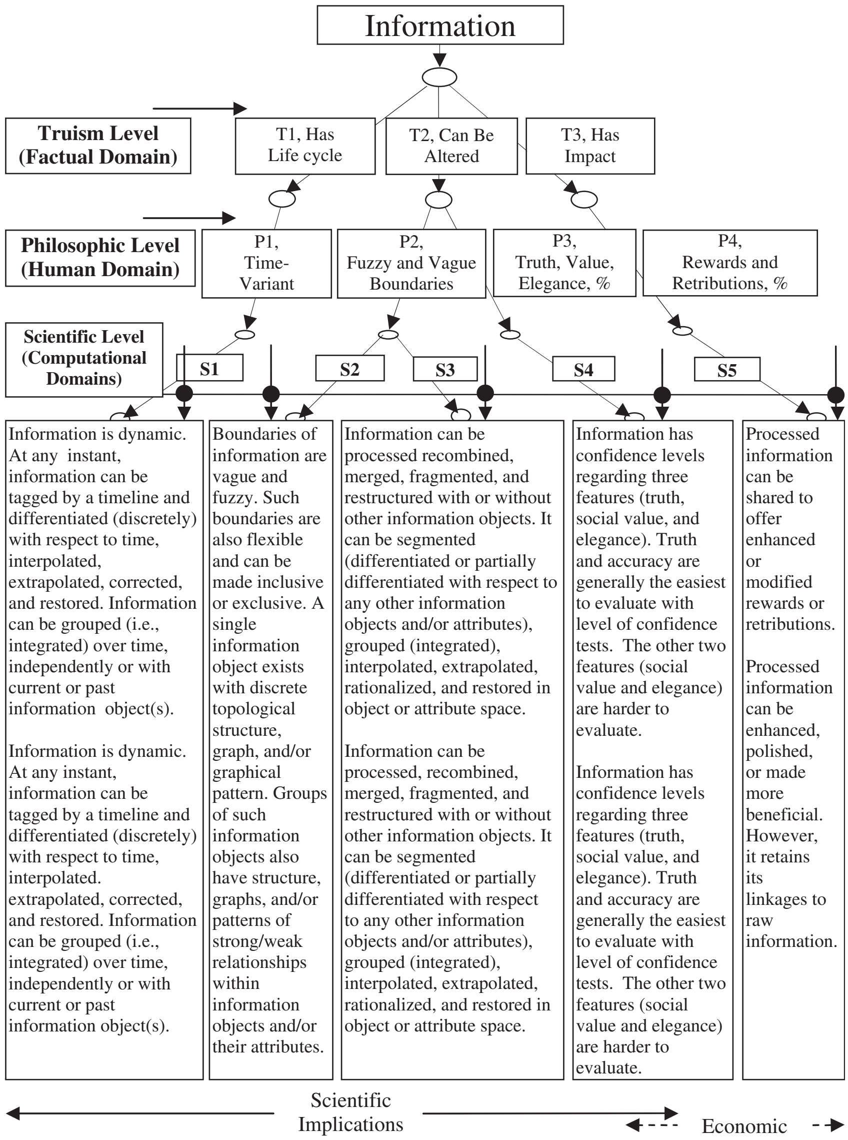

Figure 1.4 Separation of the factual, human, and computational realms of information to derive knowledge, wisdom, and concepts from it.

It ranges from mere gossip to a scientific principle or an equation in physics. When the linkages to raw knowledge are not retained, the processed knowledge may assume the identity of a new knowledge object. Hence, Aristotle's concept of beginning, middle, and end becomes subjective in the knowledge domain. We refer to this particular validation as P1.

Based on T2, two philosophic validations (P2 and P3) are feasible and presented separately because their implications are different:

P2: The boundaries of knowledge and information are vague and fuzzy. Returning to the example of water in a vessel, information is blended in human perception. Much like the features of beauty that lie in the eye of the beholder, the boundaries of knowledge lie in the mind of the receptor. Human perception becomes a fading memory (or a leaky bucket) to hold knowledge (water). When a machine receives knowledge, the knowledge objects, their structure, and their relationships are analyzed and stored with the timeline for that specific "body" of knowledge. In a sense, the "knowledge compiler" performs a lexical, syntactic, semantic, and timeline analysis on "knowledge inputs" and identifies the knowledge objects, their structures, and their relationships.

Implication P3 based on T2 is:

P3: Knowledge has three qualitative features; truth contained, social value conveyed, and the inherent elegance of content in variable proportions. Knowledge can also have the opposite features (falsehood, social malice, and ugliness) in variable proportions. An equally important principle is that the change of status of knowledge implies an effort (equivalent to force) to bring about the change sustained over the displacement of the status, thus invoking a concept of psychological or social energy or the deployment of resources.

To fall back on the example of water in a vessel, if the water carries three partially dissolved solutes (sugar, sweetener, and honey), then the viscosity changes, thus altering the fluid mechanics and concentration levels in different sections of the vessel. Furthermore, any alteration of the concentration level, after an equilibrium condition is reached, needs energy for the change (such as stirring, shaking, vibrating, or adding more water). The scientific basis for predicting the concentration contours becomes quite complex and even unpredictable (like the weather). However, when a machine has a basis for estimating the truth (sugar), social value (sweetener), and elegance (honey) independently (based on a statistical sampling of other knowledge objects and their relationships), then the raw/processed knowledge can be scientifically evaluated with appropriate confidence levels.

Based on T3, the validation for P4 is stated as follows:

P4: The sharing of knowledge can bring rewards or retributions in any variable proportion. This particular implication carries little impact in the scientific domain but becomes significant in the social and economic domains. In the socioeconomic realm, it is a generally accepted practice to exchange items of similar value (including knowledge, patents, techniques, and ideas).

It is also frequent to find the extent of damage inflicted as retribution. In the knowledge domain, litigation and penalties are imposed when negative knowledge and bad publicity are purposely circulated.

1.5.4 Scientific Principles in the Knowledge Domain

Five scientific principles (S1–S5) are derived from the four philosophic validations (P1–P4). The first principle, S1, results from P1 and is stated as follows:

S1: It is implied that knowledge is dynamic. At any instant, knowledge can be segmented (differentiated with respect to time, culture, nations, etc.), encoded, communicated, corrected, interpolated, extrapolated, restored, and even reconstituted. Knowledge can be grouped (i.e., integrated over time, etc.), independently or with current or past knowledge object(s). If knowledge objects are treated as dynamic and continuous in the time domain, then differentiation and integration become possible. The analog and closed-form operations are irrelevant, but finite and event-driven changes are sensed from information and knowledge bases. For instance, every scientific meeting or conference adds or subtracts from the collective knowledge base of a community. Human beings and/or machines can process new knowledge objects continuously. When finite changes are necessary, then the commitment of resources becomes essential. Hence, the concept of (expected) incremental or marginal costs is evaluated and equated to the (expected) incremental or marginal benefit that is gained.

The second principle, S2, is derived as an extension of P2 and is stated as follows:

S2: The boundaries of knowledge and information are vague and fuzzy. Such boundaries are also flexible and can be made inclusive or exclusive of other knowledge objects. Single knowledge objects exist as topological structures, "graphs," and/or graphical patterns. Groups of information objects also have structure, graphs, and/or patterns of relationships within the information objects and/or their attributes. Structures, graphs, and patterns (see Figure 1.4) can have scientific implications for stability. In the domain of knowledge, the knowledge objects need reasonable bonds to remain in existentence for any length of time. Insecure bonds between objects only result in short-lived rumors and gossip.

The third principle, S3, also results as an extension of P2 and is stated as follows:

S3: A knowledge object can be processed, corrected, recombined, merged, fragmented, and restructured by itself or in conjunction with other knowledge objects. It (they) can also be segmented (differentiated or partially differentiated with respect to other knowledge objects or attributes), grouped (integrated), interpolated, extrapolated, rationalized, and restored in object or attribute space. The basic tools of discrete mathematics become applicable in dealing with the continuity of knowledge over time and the continuity of structural relationships or discrete contours with respect to other objects or their attributes.

The fourth principle, S4, results from P3 and is stated as follows:

S4: Knowledge has confidence levels regarding three features (truth, social value, and elegance). Truth and accuracy are generally the easiest to evaluate in the context of other similar single or multiple knowledge objects with level of confidence tests. Generally, (local and global) knowledge bases that contain knowledge about similar objects can provide a basis for confidence tests. The other two features (social value and elegance) become harder to evaluate.

The fifth principle, S5, results from P4 and is stated as follows:

S5: Processed knowledge can be shared to offer enhanced or modified rewards or retributions. Processed knowledge retains its linkages to raw knowledge. The human processing of knowledge has taken a firm hold in society. Transitory knowledge processed by the human mind is dispersed as conversation. Knowledge that is more important is documented and retained for further reference. In the realm of processing by intelligent machines or systems, knowledge can provide more value (truth, social significance, or elegance) in the processed mode, especially if the processing is done on a scientific basis by following principles S1–S4. For example, segmentation and recombination offer a slightly different form of truth (that is equally valid) than the original truth. Similarly, the mere rearranging of the words can sometimes make a hidden context or idea become more apparent, etc. From a computational perspective, simple differentiation tests (i.e., event analysis and correlation studies) can reveal the more sensitive knowledge objects with a complex knowledge structure.

1.5.5 Aspects of Knowledge

In the comprehension of knowledge, two aspects need to be addressed. *First*, in dealing with knowledge, the truism tempered by long-term philosophic validation leads to scientific principles. These principles are formulated as qualitative and statistical relationships to start a basis of knowledge theory by which the differentiation, integration, and sensitivity of knowledge can be estimated. Primary and secondary knowledge objects are introduced to offer knowledge structure and dependence. The quantitative basis and content of a body of knowledge are established by the number of secondary objects, their structural relationships, the number of attributes of each secondary object, and their own relationship matrices.

Granularity of the knowledge space is defined as the smallest prism formed by the numerical precision of the computer systems, the lowest Hamming distance between the code words that the networks can carry at their maximum speed, and the perception of human beings who will sense the microprism of knowledge. At least one dimension of this prism is personality-dependent, even though the numerical precision of the computers and lowest Hamming distance through the network can be accurately quantified for that particular human–machine system.

Second, in dealing with the theory of knowledge, the comparison with complexity theory shows that knowledge theory is closely intertwined with the quantity of knowledge (see the paragraph above) in any primary knowledge object. However, knowledge theory is always retractable and (almost) never becomes chaotic for three reasons:

1. The linkage (forward and backward pointers, depth of recursion, size of memory) built in the operating systems of computers will prevent tail-chasing loops through the many knowledge objects.
2. The seven OSI layers will automatically prevent networks from getting trapped in endless send–resend cycles of packets, sessions, blocks, knowledge objects, etc.
3. The human beings who monitor the machines are capable of preventing them from senseless and silly pursuits in the knowledge domain.

Knowledge-processing systems are based firmly on the triad of machines, networks, and humans working in conjunction and cooperation. Three mechanisms—the machines (their architectures and operating systems), the networks (their layering and protocol), and the human beings (their natural intelligentsia)—work synergistically in making a complex but manageable knowledge environment.

1.6 INTELLIGENT INTERNET AND KNOWLEDGE SOCIETY

In some industrial societies that drive their local environments, the profit motive is dominant. Sometimes, the motive is well camouflaged and almost invisible to unsuspecting individuals and social entities. Social viruses such as deception in advertising, misrepresentation of the facts, and willful distortion of the truth are taken casually in most societies. The open practice of swaying public opinion (especially during elections and in public speeches) challenges the foundations of honesty and integrity in the audience. In an urgent sense, the tolerance of such a practice represents a willingness to slide down into greater deception. The defense against such a downward spiral lies in education and the reinforcement of ethical conduct in business, education, government, and community integrated as the modern society.

1.6.1 Four Precursors of Modern Wisdom

Modern wisdom is an important by-product of computer-driven communications systems and human beings who constantly strive for perfection in (almost) everything they do. In the domain of overlap lie the axioms of modern wisdom. Although not eternal and infinitely encompassing, these axioms stretch beyond common knowledge and daily events. We approach this domain of overlap from four directions to identify and use these four precursors of modern wisdom.

First, consider human and artificial intelligence. At the pinnacle resides natural intelligence ready to tackle any problem of which the mind can conceive. At the intermediate level, the role of artificial intelligence (AI) becomes dominant in carrying out slightly higher-level tasks, blending machine intelligence with previously programmed human intelligence. At the lowest rung resides encoded machine intelligence that is cast in silicon and Pentium and that carries out mundane tasks synchronized to the cycles of a cesium clock.

Second, consider the conventional and semantic Internet. At the (current) pinnacle resides the Internet, ready to interface with any Web site in its validated TCP/IP format. Intelligence and the Internet will be fused in the next-generation internets lurking beyond the end of the decade. At the intermediate level, all digital networks are well synchronized and properly interfaced to accept information in an orderly and hierarchical format and to take on the optical paths or ether space. At the lowest rung of networks reside analog networks, cast in copper, space, and any conceivable media in an unsynchronized and imprecise fashion just to get information across.

Third, consider traditional and conventional wisdom. At the pinnacle reside values, ethics, and social benevolence. Here, the process of unification starts to have significance. Intelligence, the Internet, knowledge, and networking commingle to produce a composite fabric of human bondage and long-lasting human values. At the lowest rung of knowledge are binary bits, somewhat like the raw cells in a body. Bits soon blend to become bytes and data blocks, data become information, information turns into knowledge, knowledge gives rise to concepts, concepts lead to wisdom, and wisdom offers values and ethics.

Finally, consider modern and broadband networks. Computer applications exist to serve human beings, but machines do have their limitations. If the traditional seven-layer OSI model is downsized to three layers and then topped with four additional layers (global concern, human ethics, the national environment, and an economic/financial basis), then the new seven-layer network model would encompass the networks as they exist now and include human values in its makeup. The convergence of the four dimensions (intelligence, the Internet, knowledge, and networks) starts to become evident at the top. Currently, the application layer (AL) of the OSI model falls short of satisfying any human needs. At the lowest rung is the physical layer (PL) with six higher layers to make the new OSI model and discussed further in Chapter 10.

1.6.2 Knowledge Bases to Derive Wisdom

Knowledge bases (KBs) are relatively new but becoming [22, 23] increasingly popular. As they are relatively few, still evolving, and proprietary, the algorithms and techniques for knowledge base management systems (KBMSs) have not become as popular as DBMSs. KBs provide logical and textual linkages between the objects stored in databases or object bases, in addition to storing basic information about the database or object entities. Objects and their attributes are structured in fixed or flexible formats. Both information and the structural relationships between the pieces of information or the attributes of objects are retained for consistency and inter-operability. Tight and compact structure results in efficient KB functions such as searches, comparisons, and evaluation of objects/attributes stored. If the run length of entities such as objects, attributes, or linkages becomes fixed, then KB functions become highly programmable.

In many instances, any subject matter is assigned a unique identifier number. This methodology is common in the Library of Congress (LoC) classification and the Dewey Decimal System (DDS) used in most standard libraries. The electronic libraries deploy the KB methodology with an almost unlimited depth of search algorithms. Close identifier numbers indicate subject/logical linkage and can imply the physical proximity of storage space in massive storage facilities. Most Internet KBs are highly organized for quick and efficient searches. For instance, IP network addressing is a hierarchy of the physical location of servers and the computer nodes accessible on the Internet. This standard makes Web addressing, switching, and access very straightforward and quick.

Peripherals, networks, databases (specifically those used in recent executive information systems such as SAP environments [24]), and knowledge bases (specifically those used in the PeopleSoft environments [25]) are expanding at an alarming rate in the current information-based society. The dramatic fall in the price of IC chips and customized chip sets coupled with the cost of communicating very high-speed data locally and globally has permitted society to enjoy an enhancement of in quality of life and literacy. However, the truest contribution of the knowledge worker appears to be solving the issues of wisdom and values at a global level rather than rehashing the invention issues at a local level.

1.6.3 Role of National Governments

One of the roles of a national government is to provide authentic and significant information to its citizens. After the impact of the digital revolution and then the emergence of the knowledge society, that information has been most effectively provided and disseminated by information technology (IT) platforms. Numerous advantages follow in order to manage almost all aspects of the government and its functionality.

One such methodology for the implementation of electronic governments and a secure national network to communicate and monitor the flow of information

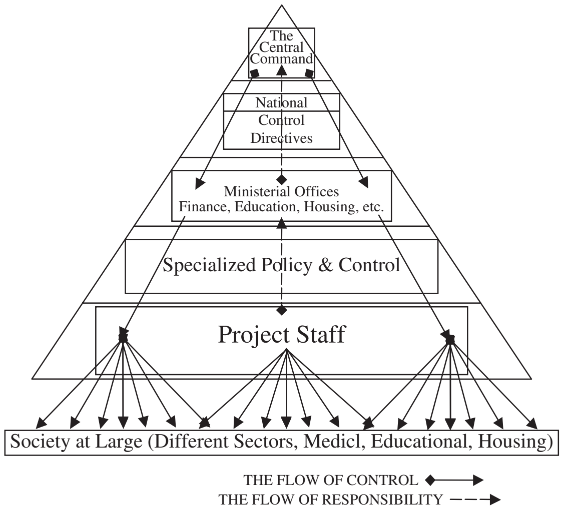

Figure 1.5 Hierarchy of a typical government structure before the introduction of an electronic government platform.

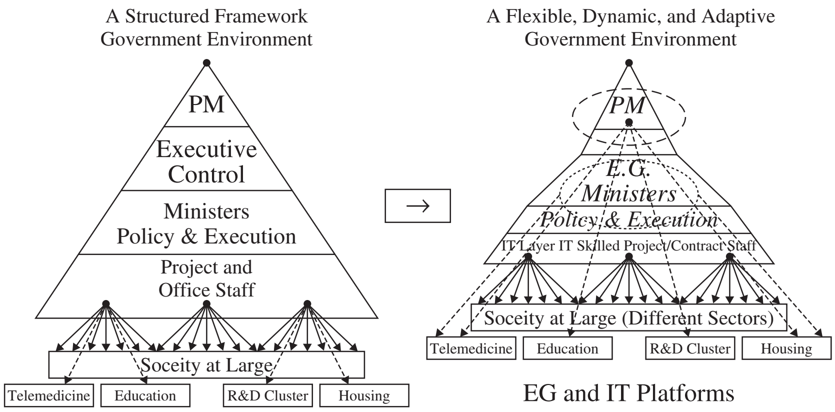

Figure 1.6 Use of an electronic government structure and an information technology platform to facilitate quick social and government changes in a nation.

is shown in Figures 1.5 through 1.7. The conventional pyramid of human power by authority and control is depicted in Figure 1.5.

Generally, a cabinet or the democratic process formulates national policy and provides the general direction for a nation. The executive office (head of state) executes the policy as well as assuming full-time managerial and executive responsibilities. For this reason, the electronic government-IT (EG-IT) architecture for any developing nation should have the capacity to retain extensive information on all managerial functions, such as planning, organizing, staffing,

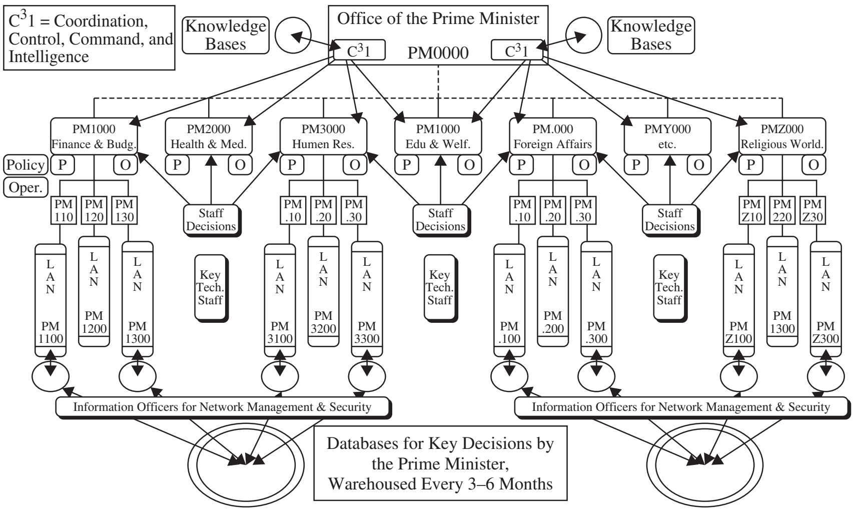

Figure 1.7 An information technology platform at a prime minister's office to support C^3I (coordination, control, and communication with inherent intelligence) to facilitate a quick and efficient response from the government sector. This enables a country to move quickly, dynamically, and decisively.

implementing, and controlling most critical and significant projects, as well as commanding, controlling, and coordinating other ongoing projects of national importance.

The introduction of the most rudimentary IT platforms in the government makes the completion of functions within the government more efficient and offers greater control over the utilization of governmental staff and resources. The attendant organizational change is illustrated in Figure 1.7.

Typically, an EG needs to retain the most recent information for all sectors of the government and the history of that information. The funding for and coordination of the other divisions of the government (such as defense, education, commerce, communication, or social welfare) occur at one physical location, and a dedicated, secure, and centralized data warehouse is essential to track, update, justify, and explain important changes in the government on a regular basis. These same requirements also exist in most large corporations and multinational organizations. The difference is the size, security, and importance of programs that national governments have to address, guarantee, and deliver. Some of these considerations are discussed in [26]

1.6.3.1 Control, Coordination, and Flow of Information A centralized EG is unique in terms of funding and the coordination of various divisions of government (such as defense, education, commerce, communication, and social welfare) and projects arising within the government (such as telemedicine, distance learning, and electronic commerce). The organization and structure of

IT within the EG must reflect this rather unique focus and concentration on management and administration (of itself) as well as the other branches of government.

To accommodate the flow of information based on the nature of functions specific to the executive office and other ministries, a suitable EG architecture is proposed in Figure 1.7. Whereas the government's departments, ministries, and project office may have a unified blueprint for local ITs, the IT of the centralized executive office (head of state) needs special consideration. It is strongly suggested that the network and IT engineers designing the EG of any country incorporate the different functions of the executive office in the initial design of the IT system and the networks that support these functions (coordination, control, and command with embedded intelligence referred to as C^3I and discussed further below). The network is equipped to interface well with the other departments or ministries. If the trend is to use generic programmable network components, then the network and netware that control the operations of these components (to facilitate the EG functions for the executive office) should be endowed with enough intelligence to perform the IT-EG functions in conjunction with those of the other ministries.

To some extent, this matter is not trivial, unless the network designers have facilitated these functions as being programmable or already have assigned paths and addresses unique to the offices and databases within the ministries.

This architecture is neither optimized nor customized to any particular country. A possible blueprint of one of many configurations is documented here. Several rounds of optimization of architecture, components, links, and server (databases) characteristics are essential before embarking on the direct application of this architecture. The customization of the network to a particular nation is as essential as the funding of the project. All the necessary aspects of the detailed planning must be undertaken in the most conscientious way.

Divisions, agencies, or departments of the government handle projects arising within the government (such as telemedicine, distance learning, or electronic commerce). The organization and structure of IT for the various departments start to differ from those of the centralized government of the executive office (president, prime minister, etc.). The architecture and configuration for the EG for the executive office reflect this rather unique focus and concentration on management and administration.

Figure 1.5 depicts the hierarchy of a typical government structure before the introduction of an EG platform. The EG platform shown in Figure 1.7 enhances the connectivity between the central command (the Prime Minister, in this case) and the various ministries and reduces the workforce over time. The transition to an EG platform is time-consuming and the government remains functional during it. Entirely self-sufficient electronic government systems have not been successfully implemented in any country. Sometimes, in organizing EG platforms, it becomes desirable to allocate a numbering system to the many branches of the government. Numbering allocation facilitates the allocation of storage, networks, and processes to the documents, interactions, and activities in the computer systems that house the IT for the EG.

When the document tracking of references to prior or similar tasks becomes necessary, machines can perform most of the routine or AI-based intelligent functions. The design of an electronic government information system (EGIS) can be made akin to a typical large-scale management information system (MIS) or executive information system (EIS) such that a scaled version of current software systems may be used as the modular building blocks of the EGIS.

Examples of such numbering systems are the Dewey Decimal System and Library of Congress classification system. These systems draw a boundary (though vague) between the branches of knowledge. A similar numbering system that broadly identifies the particular branch of government would facilitate classification of all activities within it. Funding, activities, and projects could be tracked and controlled much like the tracking systems in typical human resource applications such as PeopleSoft or SAP.

In the section, a simplified number tracking system is suggested. The alpha numbers are two alphabet letter, four-digit entities, where the first two letters denote the particular office, such as PM for the prime minister's office, EW for the education and welfare office, HR for the human resources office, etc. The next four digits signify the organizational segment, such as 0000 for the Office of the Prime Minister, 1000 for the Office of Finance and Budget, or 2000 for the Office of Health and Welfare, etc. The tree structure continues. The numbering system is quite flexible and can be adjusted as the structure of the government changes.

In most cases, the role of EG platforms is essentially that of a communications provider and provider of routine transactions processing, where there are very few policy decisions. In the support facilities for the government, decision support systems help human beings to acquire better insight into intelligent and informed decision making. When the role of decision making becomes sensitive and crucial, wisdom machines [4] become more desirable, with EG platforms providing the intelligent control coordination and communication within the government. Figures 1.6 and 1.7 depict two stages in the transition of a hierarchy of any typical EG to that of a typical service-based EG.

In the design of EGs, the location of the center for coordination, control, and command needs precise identification. In the particular example presented in this book, the logical concentration of power lies in the Office of the Prime Minister. The physical location can be moved at a later date over wide-area broadband networks. If the databases and servers are not physically moved, then the access time for critical information is enhanced by the transit time between the old and new locations. The logical identification of the center of power serves to strategically place the routers and high-capacity links. Architecture for an IT platform for the prime minister's office supporting the C^3I (coordination, control, command, and intelligence) approach is shown in Figure 1.6. The communications aspect is built in to the hierarchy of the prime minister's own office network in conjunction with the horizontal layout of the local-area networks for the various ministries.

Data warehousing becomes necessary to maintain continuity in the operation of the government over an extended period. The long-term economic and growth trends of a small nation can be planned, organized, staffed, implemented, and also monitored and controlled in the EG framework for the country. The three facets of intelligent coordination, control, and command start with the Office of the Prime Minister, feedback derived from the offices of the ministries and the 13 key indicators measuring economic activity within the country.

1.6.4 Universal Knowledge-Processing Systems

The architectural concepts of a complex knowledge-based system dubbed the universal knowledge-processing system[8] (UKPS) are viewed as wisdom machines (WM) capable of solving both simple and complex problems. Knowledge bases accessible at any Web location offer broad and generic solutions. The UKPs is, in turn, formed of several knowledge-processing systems (KPSs) connected through any backbone or global network. In this section, we present the key components that make up the architecture of this sophisticated system. Some of the concepts presented here are abstract and require further investigation to complete the entire cycle of evolution of machines and development of systems.

1.6.4.1 Knowledge-Processing and Wisdom Machines The architecture of knowledge-processing systems over time has changed just as the philosophy of computing within the organization has: from mainframe-dominated, centralized computing systems to network-based distributed computing systems. Fundamental features that distinguish a distributed system from a previous system are the distribution of resources and functions among several computers at workstations that are networked together using present-day communications protocols such as TCP/IP and RISC processors. The operating systems could be UNIX, Windows NT, or any other adaptations of UNIX. Internet/Intranet technology has undergone lot of changes and, as a result, we see it being applied to various fields. These technologies have reached far into our office and home environment.

The important issue to be resolved for Intranet-based KPSs is real-time performance and the reliability of decision-based control. A brief introduction to the client–server architecture is given, after which the model of the UKPs or wisdom machine is proposed. The features of this model that distinguish it from distributed systems are the use of a browser, a wide-area network (WAN), a wide-area cluster of servers on the WAN, and multicast communication based on IP. The Intranet-based UKPS provides the basic underpinning for improved flexibility and expandability. Several of the KPSs could be integrated to form the UKPS or wisdom machine. The architecture also enables the knowledge-processing centers that contain these KPSs to be rearranged as necessary and when required.

[8]The concepts presented in this section were presented by Ajit Reddy and Syed Ahamed at the 2006 International Conference on Information & Knowledge Engineering, Las Vegas, NV, June 26–29, 2006. See *Proceedings of IKE 2006*, Worldcomp'06 Publications, 2006 pp. 65–70.

1.6.4.2 Client–Server Architectures The client–server software architecture is a versatile, message-based, and modular infrastructure that is intended to improve usability, flexibility, interoperability, and scalability as compared to centralized, mainframe, time-sharing computing. A client is the requester of services and a server is the provider of services. A single machine can be both a client and a server depending on the software configuration. Commonly used client–server architectures are either two-tier or three-tier.

Two-Tier Architecture In the two-tier architecture, the client machine has a user interface and the server machine is a powerful machine serving a number of clients at a time. The server could be offering database management services, in which case the server provides stored procedures and triggers. In this case, process management is split between the user system interface environment and the database management server environment. The server maintains a connection with its client through keep-alive messages, even at time when no useful work is done. The limitation on its flexibility to move program functionality from one server to another is seen as a liability of the two-tier architecture system.

Three-Tier Architecture In this architecture, the limitations observed in two-tier architectures are overcome, and a middle tier is introduced between the user system interface environment and the database management server environment. The middle tier can perform queuing, application execution, scheduling, prioritization, and database staging. The middle tier can be implemented in the form of transaction-processing monitors, message servers, or application servers.

In addition to computers and their operating systems, programming languages and their compilers play an important role in writing code in a simple and efficient way such that even complex programs could be developed in a reasonable amount of time with the required manpower needed for development. With this grows the complexity of the code and software that is developed, and hence, different methodologies must be adopted to design, validate, and maintain the software.

1.6.4.3 Knowledge-Processing System A simplistic view of a knowledge-processing system is that it is a system that can make or provide a decision based on certain input information or query together with the knowledge base. In order to process information and arrive at a decision, these systems should be equipped with the necessary knowledge stored within it.

From an architectural perspective, the basic components of such a system are as follows:

- Hardware
- Operating system
- Storage
- Network
- Knowledge processing

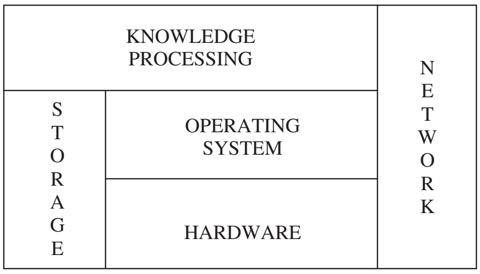

Figure 1.8 Basic components of a knowledge-processing system.

Figure 1.8 provides a block diagram view of how these components are assembled together to form the knowledge-processing system. The hardware component of the KPS could be a chemical, optical, or silicon-based platform. As the technology evolves, platforms could be based on some other technology as well. Operating systems like UNIX and, Windows XP in the evolution path should be able to work independently of the platform technologies, storage and communication networks. In the evolution path, the operating system, hardware, storage, and network could change, but the knowledge-processing functions and data developed and collected over a period of time should be able to function irrespective of the changes in the basic components of the KPS.

If we apply the three-tier model to this architecture as shown in Figure 1.9, applications such as the monitoring and decision control functions are installed in the second layer. Data in the form of real-time input are stored in the third layer. The application and database layers are installed in the server. The graphical user interface (GUI), command line interface (CLI), or Web browser installed in the first layer enables the operator to monitor and display pages and to control the KPS if required. To control the KPS, an operator connects the GUI or browser to the corresponding system, then requests authority to control the decision process

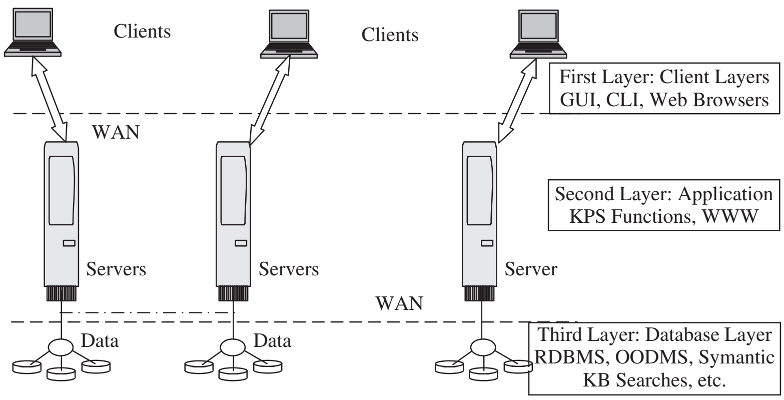

Figure 1.9 A three-tier model of a knowledge-processing system.

through the pages displayed on the browser. Since the servers of the KPS could be located anywhere, the operator needs to know their location. In this model, an authorized operator could use the application in any KPS connected to the WAN and suitably control the decision process if necessary in a positive manner.

Using the wide-area cluster architecture, the servers of the KPS are separated geographically and connected through a WAN. If the server, or servers, in the cluster fails, then the other healthy servers back up the functions automatically. Once the failed server is brought up again, the server is put back in the cluster as a healthy server, thereby providing fault tolerance. Each of the KPSs could have a single server or multiple ones representing the second and third layers.

The architecture considered here exists for high performance, provideing the high-speed response of the human–machine interface. Whenever an application such as the monitoring function or decision control function in the second layer updates the database layer, the high-performance architecture distributes the updated data to the relevant KPS. Multicast communication based on IP is applied to this replication process.

1.6.4.4 Universal Knowledge- or Wisdom-Processing System The wisdom-processing systems architecture depicted in Figure 1.10 shows the different levels of knowledge-processing systems that are required to arrive at a decision or solution based on wisdom. The systems at all these levels have the same set of basic components as illustrated in Figure 1.8. However, the knowledge contained at each of these levels together with the processing power of these systems could vary, the systems at the top being the most powerful in terms of computing power, storage, network bandwidth, operating systems, and other capabilities and those at the bottom level being the least powerful. The systems at all these different levels are networked together either by a dedicated network or through a shared network.

Level 1 The systems at this level are knowledge-primitive machines with the ability to store user-entered data or data received from external sources, process data, analyze/model data, suggest or make a decision for less complex problems, thus serving as decision support systems. They should also be able to compile data for higher-level systems. The systems at this level have the necessary intelligence

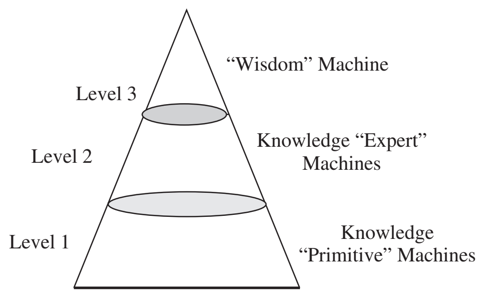

Figure 1.10 Conceptual representation of a wisdom-processing system.

and knowledge to process the preliminary data for any given task by extracting the necessary information and sending the compiled results to the next-level machines for a more thorough processing for the given task or problem.

Level 2 At this level, the systems are knowledge-expert machines that will act as expert systems with access to a knowledge base consisting of the views of experts, sets of rules, and sets of relationships. They contain a database rich with information related to a specific task. They simulate an expert thought process using knowledge-processing library functions and methods for logic and reasoning for the tasks to be analyzed and for the decisions to be provided based on the query or input information. On the development front, they have the means of programming that will enhance the knowledge base and inference process. With this capability, the level 2 machines have the ability to provide recommendations or decisions, solve complex problems, adapt to problem solutions, learn and continually refine the methods in the inference engine. Since these machines reside at a level between that of the level 1 machines and the level 3 machines, they have the necessary knowledge and intelligence on how to interface with these levels. These systems also have the ability to compile data and transmit it to the higher levels.

Level 3 This level consists of a group of very powerful systems connected together using a dedicated network. From the basic knowledge-processing component perspective, they are the same except that they are much more powerful in terms of processing power, storage capabilities, and network capabilities. These systems can independently solve a complex problem or get the preprocessed information compiled together from the levels below, extract the information, and then decide. The compiled results obtained from the different expert or experts for the same problem are collected and further analyzed by giving a certain weight to each of them. It could be that given the nature of the complex problem, there may not be any experts so these systems are in a position to reach a partial decision by using the available expertise and making a judgment. During this process, the level 3 systems could use some other expert system or systems, or possibly the same expert systems as before. By exchanging information back and forth between this network of systems at all levels, it is quite possible to arrive at a conclusive result for a problem of such complexity. If a knowledge base does not exist for the given problem, then it could be obtained by unleashing several queries to the experts that could be systems or humans, in which case the unavailable knowledge base is compiled in real time.

Solving problems in this manner could introduce delays. However for time-critical tasks, decisions must be arrived at without any delays, in which case the system will continue with the decision that would be based on the decisions of the expert systems with the current knowledge base with a certain confidence level. Human interaction is necessary at this critical juncture, either to go ahead with the decision made or to do something different. These systems will also oversee the decision process of the systems at the levels below if the systems at levels 1 and 2 are granted access.

Although in this present architecture only three different levels are shown, in reality each of these levels could be further subdivided in sublevels. The systems at level 2, which are experts, could be classified into different sublevels based on their degree of expertise and systems at level 1 could be divided into sublevels based on their storage, processing, modeling, and analysis capabilities. At level 3, we assume that all the systems are of the same degree in terms of wisdom: They may not be experts in the related area, but given the available information and problem at hand, they have the necessary wisdom to reach a suitable conclusion. Because at this level there is a network of such systems, the final decision is based on the majority of decisions of these systems, so a check on arriving at a wrong decision is maintained. The postprocessing of extracted wisdom is discussed in [4].

Since the Intranet-based UKPS could be accessed from many terminals, a secure socket layer (SSL) should be applied to any communication between the GUI, CLI, or browser and the WWW server, and each of the operators should be allowed to access only predefined contents.

1.6.4.5 Methods of Reasoning Decisions at all levels are arrived at by using different methods of reasoning, such as reasoning by induction, reasoning by both deduction and prediction, and logical reasoning. Inductive reasoning is usually based on observation whereby the premises of inductive arguments are bits of evidence gathered either directly or indirectly, and its conclusions are tentative generalizations about groups, relationships, or predictions. So with inductive reasoning, conclusions based on premises however accurate they may seem could possibly involve other conclusions as well, which is to say that the conclusion drawn is a possible but not necessarily reasonable one for the problem at hand. Thus, inductive conclusions do not follow of necessity from the premises. Nevertheless, inductive reasoning helps us to start building a knowledge base with the general statements and principles we have learned thus far.

In deductive reasoning, necessary conclusions are generated based on the premises of the arguments. If the argument is a syllogism, then it draws conclusion about the member of a group from generalizations about the group and the relationship between the member and the group. If the argument is a hypothetical chain, then it draws conclusions from a general prediction and the given situation. Although the deductive method puts the generalizations of the inductive method to the test, it has to be adaptive so that the generalizations can be finetuned for a specific task or problem.

Critical thought process requires both inductive and deductive reasoning, whereby through inductive methods we get to identify and formulate certain generalizations that need to be put to test by deductive methods to see if they hold.

1.6.4.6 Applications Two applications for knowledge- and wisdom-processing systems are (1) power outage detection and prevention and (2) a tsunami early warning system. The details of both the electrical power outage example and its consequences, and the tsunami warning system fall in the public Internet domain.

Power Outage Detection and Prevention The power outages that have occurred in several major cities in recent times across the globe have affected trains, elevators, and the normal flow of traffic and life. In some cities, water supplies were affected because water is distributed through electric pumps. Airports across the affected region experienced delays and some shut down temporarily. The outage slowed the Internet due to rerouting of its traffic, and Web sites powered by servers in affected cities were unable to respond to requests from their clients. In order to detect and prevent a disaster such as major power outage, KPS could make a determination in advance by isolating the defective power center (s) that is likely to trigger the tripping of all the power grids, thus minimizing the damage caused by overload.

The proposed KPS-based model and architecture are shown in Figure 1.11. The model consists of data acquisition and control units (DACU) connected to the KPS, which sends the acquired data of the power systems to the servers of the KPS, in which the collected data are processed using the knowledge-processing functions. The data from each power center are collected by means of a client used by the operator either manually or automatically from the DACU and sent to the KPS via the WAN. Multicast communication is used between the DACU and KPS servers, and all servers can receive data from each and every DACU.

Each server and each client are connected directly to the WAN. Browsers installed in each client enable the operator to monitor and control the process manually, and allow access to any server that is transparent to the client. Critical functions installed in each of the KPS servers along with the incoming data are constantly backed up. The UKPS, which is an Intranet, connects to the Internet through a firewall. A satellite link is provided so that critical data are sent to another geographic location where a similar KPS setup exists and also to transmit collected data and receive control signals from KPS in another geographic location in the event of a natural calamity that could paralyze the local KPS setup.

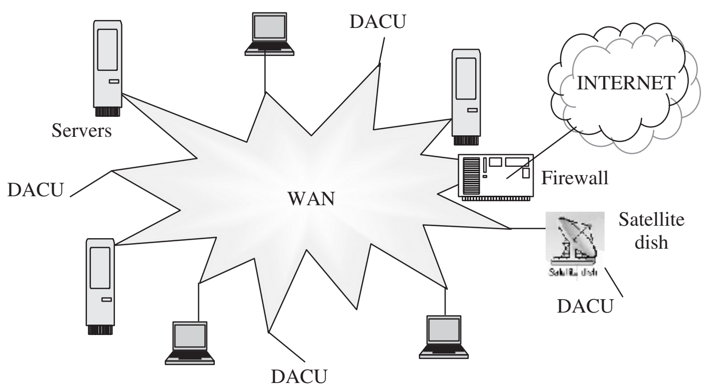

Figure 1.11 Knowledge-processing system model for power outage detection and control. DACU = data acquisition and control unit.

The decision-making process occurs at the UKPS, which connects several KPS networks. In spite of all this, one notes that there is some delay in the DACU collecting the data and sending them to the KPS servers, where the data are processed and forwarded to the UKPS for a final decision after it has analyzed the processed data from the other KPS. The processed data could be a partial decision made by the local KPS, or it might be that no decision is taken by the local KPS or that it suggests a list of remedies to the problem, one over which the UKPS would be the final decision maker. The decision made by the UKPS could be over-ruled in the manual mode by the operator or operators monitoring the power centers. In the auto mode, the decision would be made by the UKPS and the control signals sent to the DACU for the appropriate action.

Tsunami Early Warning System There are so many variables and uncertainty to consider in the detection of a natural disaster like a tsunami. In some cases, we might have little or no information about the situation; in others, the available information is vague or incomplete. In almost all these cases, the system has to operate under severe time constraints, with little or no time to make a critical decision and sound an alarm about the catastrophe that is likely to occur. The variability and inevitability that result from complexity may be traced to the interaction of numerous independent actors. Functioning in an environment of uncertainty, complexity, and variability requires sound judgment, creativity, and initiative—all of which the UKPS should be able to handle.

The tsunami early warning system consists of two stages: the detection stage and the dissemination stage. As part of the detection process, the objective of the KPS is to detect, locate, and determine the magnitude of potentially tsunamigenic earthquakes occurring in any part of the sea floor throughout the world. Earthquake information is provided by seismic stations operating in various nations. If the location and magnitude of an earthquake meet the known criteria for the generation of a tsunami, a warning is issued to advise of an imminent hazard. The warning includes predicted tsunami arrival times at selected coastal communities within the geographic area defined by the maximum distance the tsunami could travel in a few hours.

A tsunami watch with additional predicted tsunami arrival times is issued for a geographic area defined by the distance the tsunami could travel in a subsequent time period. If a significant tsunami is detected by sea-level monitoring instrumentation, the warning is extended to other countries and regions. Sea-level (or tidal) information is provided by monitoring networks and other participating nations of the tsunami warning system (TWS). This effort encourages the most effective data collection, data analysis, tsunami impact assessment, and warning dissemination to all TWS participants. The dissemination process consists of sending bulletins and warnings to concerned government and emergency officials and the general public of participating countries and even those nations that do not officially participate but are likely to be hit by the tsunami. A variety of communications methods are used in disseminating the tsunami warning.

The system consists of several tsunameter mooring systems (TMS) positioned along the coastal line of various countries. The TMS consist of transducers, RF modems, and a bottom-pressure recording device that detect the changes in pressure caused by the tsunami and transit them to the surface buoy via an acoustic link that the transducers pick up and send to the satellite by means of the RF modem, as shown in Figure 1.12.

The satellite that collects the data from these TMS sends them to processing centers where the collected data are processed and the likelihood of a tsunami occurring will be determined. In addition, the path and magnitude of the tsunami are determined, as well as which countries are likely targets of this disaster. The necessary action is then taken, with tsunami alerts disseminated to affected countries or regions. In the two applications discussed above, a clear picture of a chaotic environment filled with variables and unknowns emerges.

Here, possible configurations of universal knowledge-processing systems are presented and applications arising from the implementation of such a system discussed. The architectures and applications are extensive. Other complex problems can also be solved. Numerous complex problems arise during routine situations;

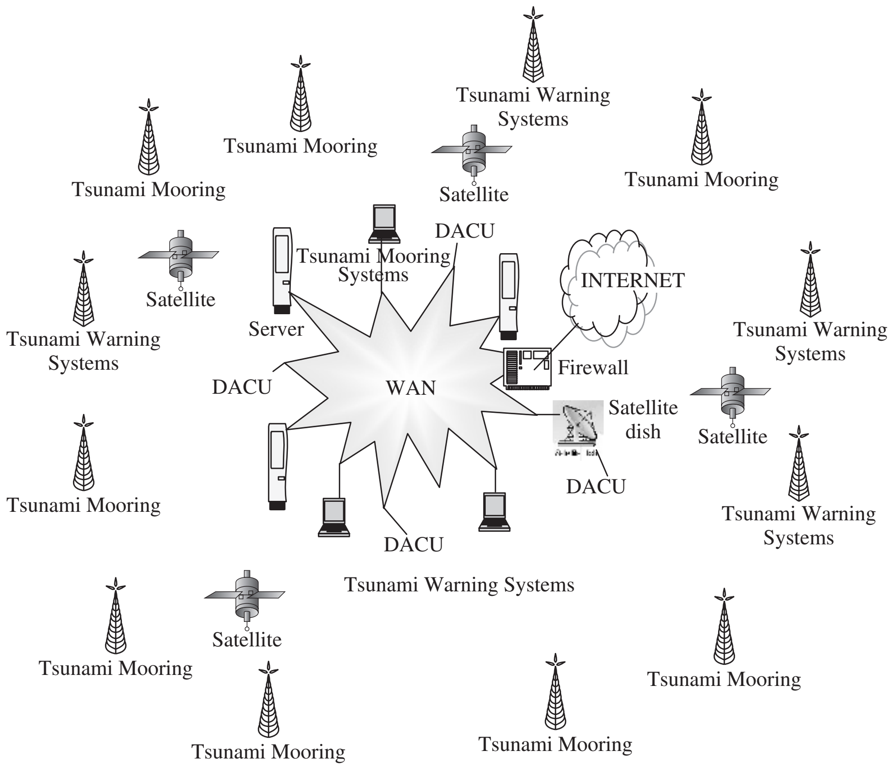

Figure 1.12 Universal Knowledge-Processing System–based tsunami early warning system. DACU = data acquisition and control unit.

they are frequently issues that cannot ordinarily be solved by the existing computing infrastructure. These problems require the knowledge-processing systems that lead to wisdom machines, those presented in this section, to make decisions that are time-critical in nature.

1.6.5 Educational Networks

Educational networks are becoming universal. From an economic perspective, educational networks are more desirable for the routine and mundane tasks of teaching students the basic (and low-level) skills in any particular subject. The system is able to interpret independently and in conceptual rhythm with the learner, and yet provide comprehensive, dialogue type answers to queries on almost any subject. Web-based learning offers unique advantages for students, and faculty and economic rewards to administrators. This capability is achieved by incorporating the dynamic growth of high-speed networks already integrated in most existing telecommunications networks. Language to interpret a query, artificial intelligence to comprehend the global context of that query and student capabilities, and knowledge processing to uniquely construct a reply make educational networks [13] as desirable as MIS facilities [27] in monitoring most corporate functions.

The basic configuration of a single- or multicampus educational network is shown in Figure 1.13. Campus networks (CNs) may be classified by a numbering system akin to the Dewey Decimal System (DDS) or based on the Library of Congress (LoC) classification. Multinumeral campus network addresses with combined DDS and IP addressing will substantially facilitate the access of any knowledge base internally or on the Web.

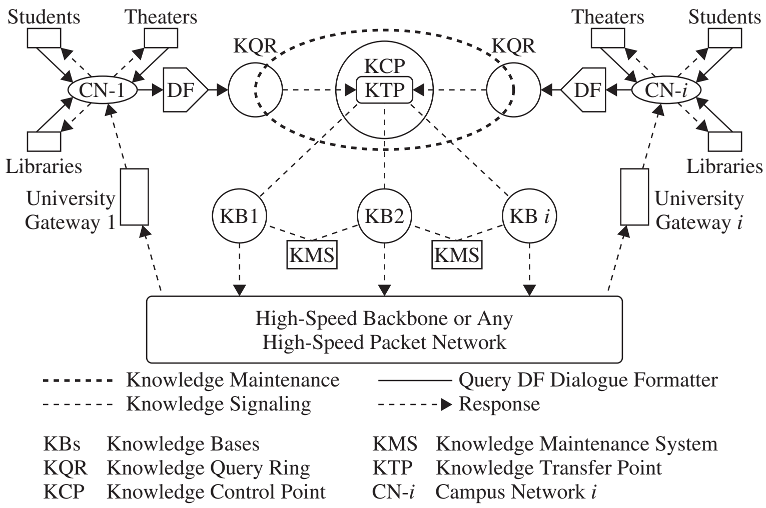

Figure 1.13 Configuration of a basic multicampus educational network.

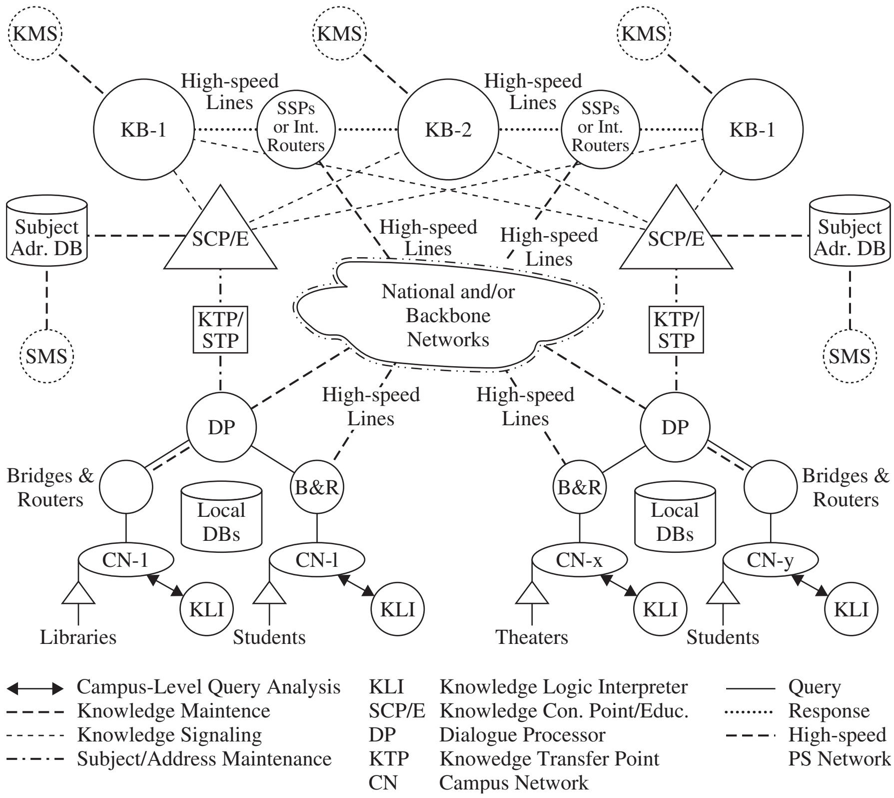

Figure 1.14 Configuration of an educational network for a developing nation.

A slightly modified educational network for a national university is shown in Figure 1.14. This particular network deploys the national, WAN, or MAN backbone network for access to and from distant cities or campuses. The typical service switching points (SSPs) of an intelligent network architecture may also be replaced by intelligent routers that can switch the ATM cells of a high-speed packet-switched network. Specific intelligent routers based on DDS classification have not been developed for educational networks.

Query structure and analysis are performed by dialogue formatters (DF) that interface the campus queries and also signal the KTP/STPs for services from the knowledge control points to obtain the appropriate response from the knowledge bases (KBs). The response time of such a network should not exceed the typical response times of intelligent networks. Simulation and design studies of such well-designed, intelligent network-based, educational network responses have been reported in considerable detail [28]. Extensive simulations indicate that such massive educational systems can be implemented with typical high-speed campus and backbone networks in most developed nations.

A well-designed infrastructure for packet-switched and ATM networks for developing nations will pave the way toward an informed and educated public. World-wide trans-oceanic fiber-optic-based information highways [13] are already providing access to global knowledge bases. The enhancement of any national education infrastructure for global universities requires the careful design of switching centers, link capacities, and the distribution of knowledge centers around the nation. Quality of service (QoS) considerations become crucial in the early design of networks.

1.6.6 Medical Networks

Intelligent medical network (IMN) configurations and designs were initiated at the City University of New York as far back as 1990 by Krol [29]. Numerous other researchers such as Mollah [30], Lueng [31], and Waraporn [32] have extended this methodology over the last decade. In an attempt to blend wisdom machines architecture into IMNs, we present two configurations that utilize intelligent Internet architectures and national medical expert teams that constantly scan the activities in hospitals and medical centers in order to filter out routine activity and identify unusual circumstances to add to medical knowledge bases around the country or the world.

Medical networks can range from small hospital networks to multinational global specialty-based networks for special condtions and rare diseases. In the current environment, search engines provide access to information but lack the human consultative platform for interactive sessions between experts. The financial and economic aspects of transactions could not be handled by former search engines. The development of medical service providers (see Figure 1.15) that do maintain extensive information electronically, ranging from patient ailments to medical insurance coverage and prescribed medications, will result in the online existence of the treatment program for each of their customers, in much the some way that credit card companies can track the financial activities of their clients.

General patient databases, physician access point units, patient access point units, and service facilities are connected to medical data banks and processors via several buses. In an alternative integrated medical computer system, numerous processors are included, each with their own memories and modules, and linked together to establish a processor net unit. This system can be used in a campus environment, where several buildings make up the hospital or several hospitals are interlinked over local-area networks. One such configuration is shown in Figure 1.16. The nature of components and their capacities are matched to the variety of services provided, and the sizes of links and routers are matched to the expected client base served by the medical facilities.

Large groups of independent hospital networks may be integrated (and programmed) to coexist within one larger medical network as independent intelligent networks sharing a network infrastructure. Functionality may also mean performing as a group of localized medical networks [33] for a particular hospital rather than as one massive medical network for a region or country. The role of

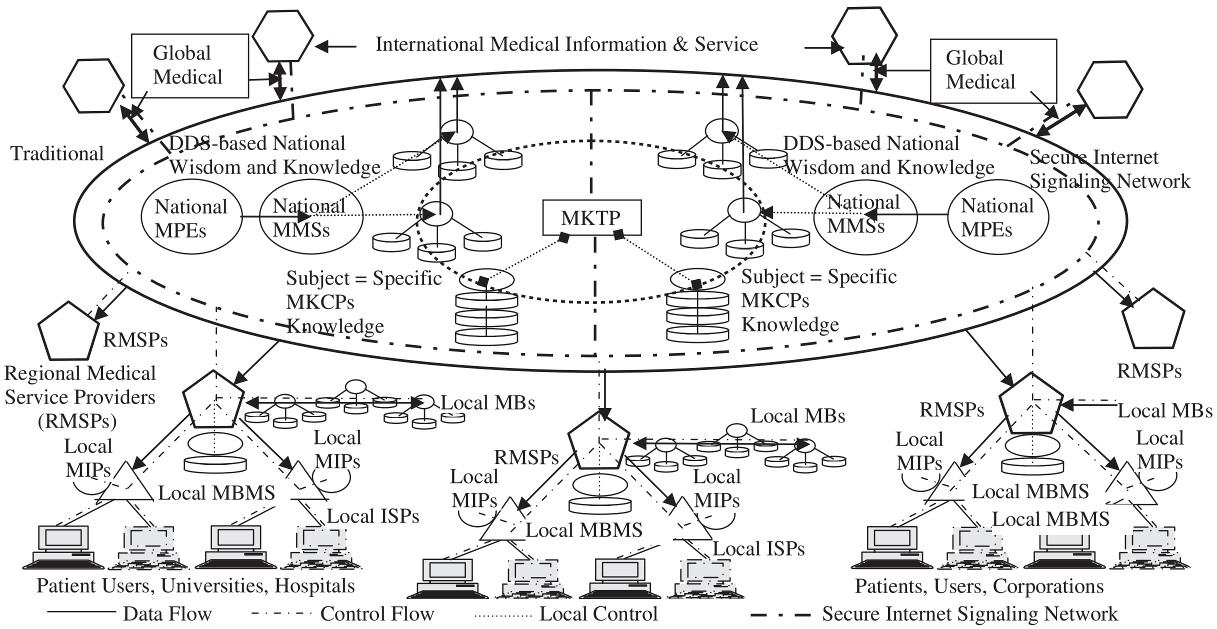

Figure 1.15 Framework of an Internet-based intelligent medical network with traditional intelligent network components. MSPs = medical service providers; MIP = medical intelligent peripheral attached to ISP local network; RMSPs = regional medical service providers; MBs = medical knowledge bases; MBMSs = MB management systems; MPEs = medical services provisioning environments; MKCP = medical knowledge control point; MKTP = medical knowledge transfer point; MMS = medical information management system; MPE = medical services provisioning environment; DDS = Dewey Decimal System/Library of Congress classification system bases.

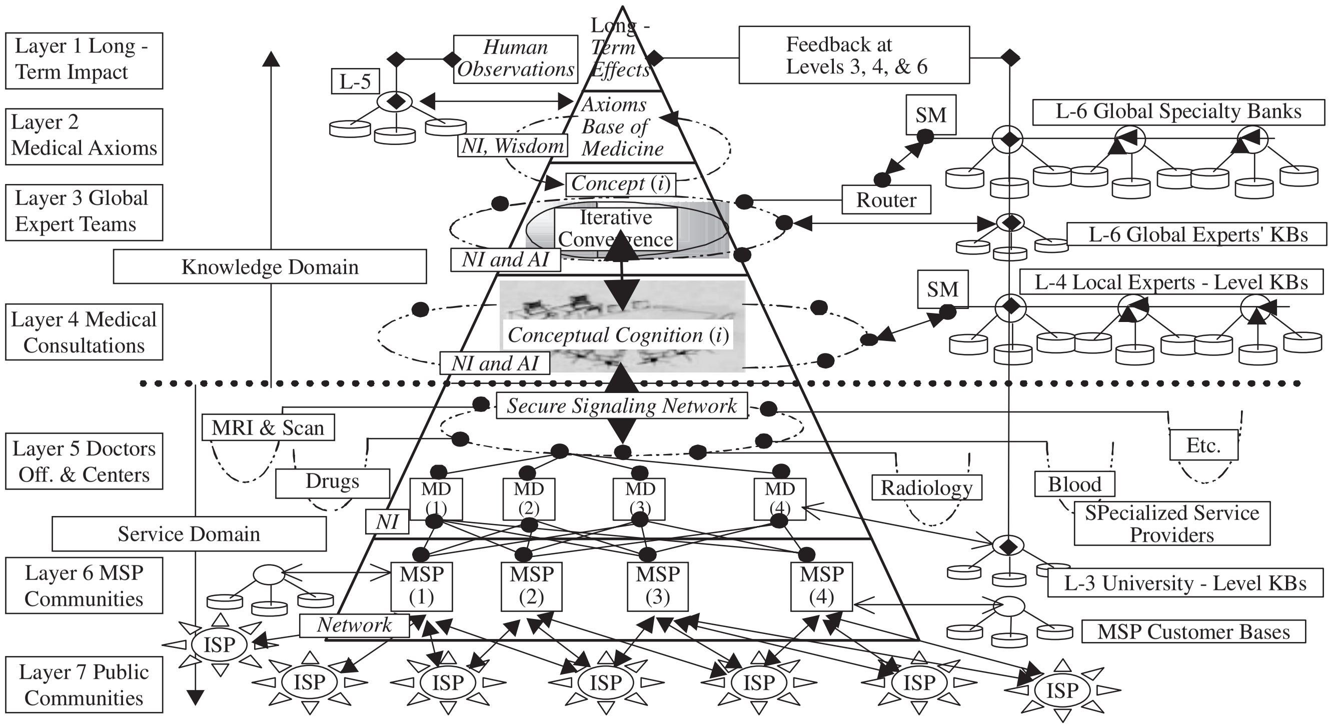

Figure 1.16 A seven-level intelligent hospital environment. This arrangement serves public medical needs via Web access (level 7) to the hospital. Routine physician–patient transactions are handled at the lower levels (5–7). Facilities at the higher levels (1–4) provide venues for physicians and hospital staff to consult with local medical communities and interact with subject matter specialists around the globe. Network security is provided at all seven levels. SM = switching module; MSP = medical service providers; MD = doctors.

numerous medical service providers (MSPs) will thus be confined to local-area services and information access. The main advantage of having a large number of smaller and localized MSPs is that the cost and complexity are much lower than those incurred by a large MSP. The new competition in terms of localized MSP services will reduce medical expenses and overall customer costs.

More local MSPs and businesses can offer medical information and services such as discounted prescription drugs, hospital and nursing services, or physical therapy. Such an increase on the supply side of medical information will help the medical field become more competitive and thus contain medical costs in the long run.

1.6.7 Antiterrorism Networks

An IT platform for an antiterrorism (AT) office within a country is shown in Figure 1.17. The blueprint can be customized to suit any office reporting to a prime minister or executive body. The numbering system provides for organization, document tracking, and continuity among the functions in the different branches of government.

The special PM-AT network AT1000 facilitates linkage with a centralized command facility. This segment can be designed to be physically or logically independent of other networks. Security and network connectivity under fault conditions become important considerations designing this network. The EG computer and network configuration are thus fundamental in monitoring the policy, goals, and project completion in any branch of the government.

The architectures presented in this section offer added benefits to the knowledge community by interleaving computer-based antiterrorist methodologies with the quick response of high-speed networks that serve the Internet and Intranet industries. When artificial intelligence (AI) techniques are used to detect and possibly predict emergency conditions in a country, a network-based sensing and monitoring environment can be integrated with its high-speed backbone networks.

The execution of the policies set forth by the leader(s), and the roles of the minister(s) and the staff, are scanned and documented accurately by the filing system built into the EG infrastructure. Typically, the traditional concepts of planning, organization, staffing, implementation, and control can be achieved efficiently and optimally in any country. The network for the entire EG is depicted in Figure 1.18. The configuration can be customized, and its numbering system makes the possible organization, document tracking, and continuity among the functions in the different branches of government.

Configuration of the routers and links is also shown in Figure 1.8. When the numerous levels of ministerial offices are dispersed throughout the country, the dependability of the backbone network becomes an issue. Secure and trustworthy connections via independent or leased public domain channels sometimes provide intra-office capability.

An intelligent decision support system can be ported in the network environment by appropriately arranging the functions of the three switching systems

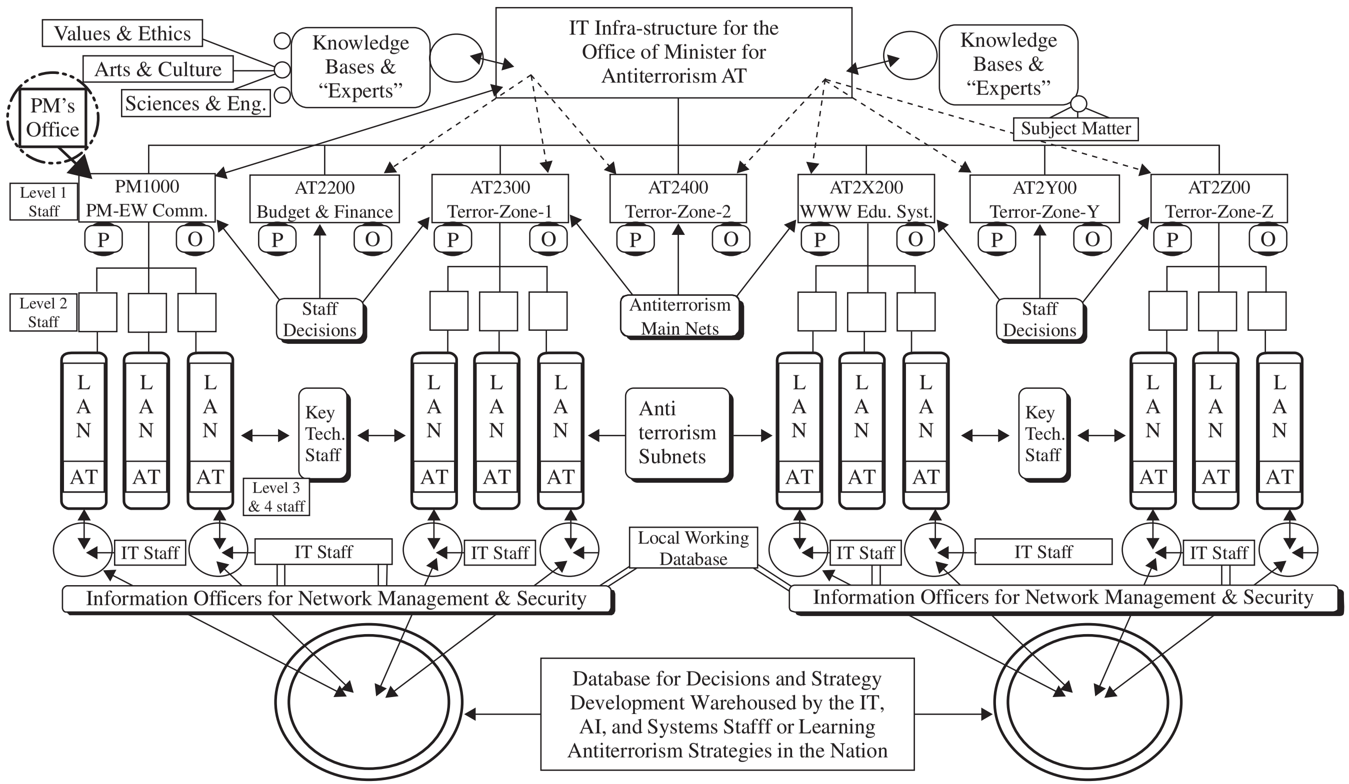

Figure 1.17 Integrated antiterrorist platform for terrorism-related information processing and management. The platform allows the police and antiterrorist special units to learn and teach specific strategies.

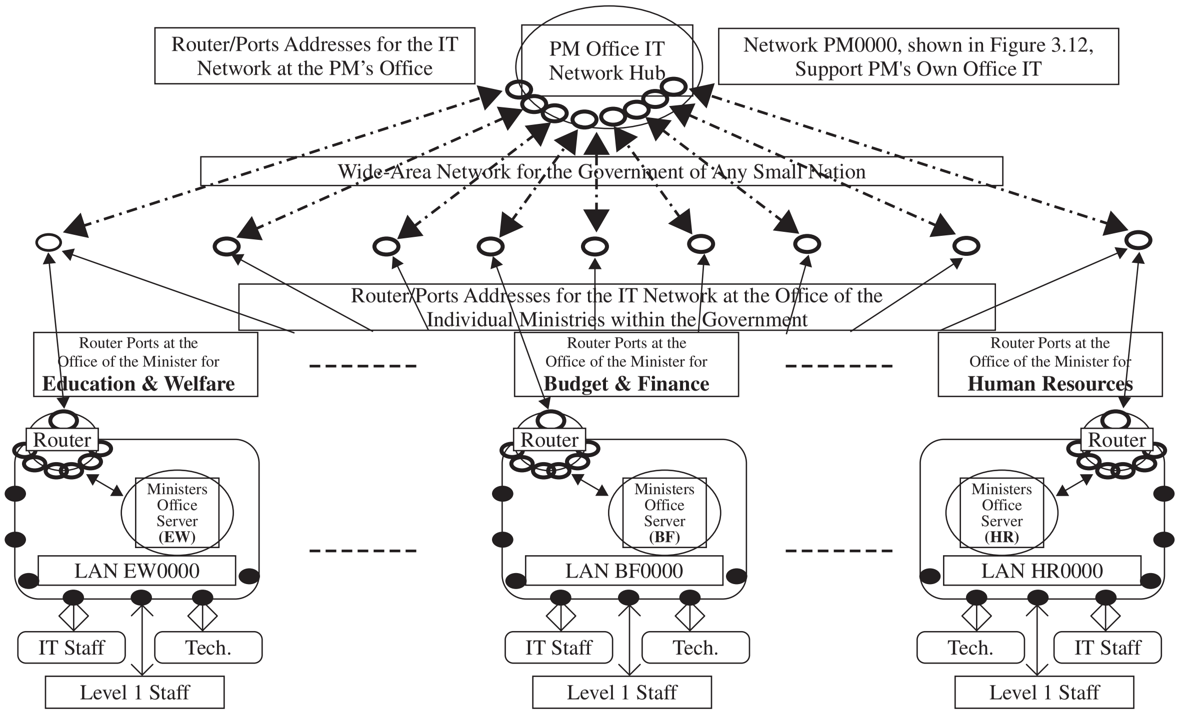

Figure 1.18 A layout of routers and the network incorporating the electronic government backbone network and the functioning of the police, defense, and antiterrorist staff members to develop a unified and coordinated strategy for responding to emergency situations.

or switching the modules of any of those systems. One can simulate all the functions of a national economy, a corporation, a society, or any midsized social entity by distributing "sensors" in the environment and then regulating the "climate" of the entity with intelligence modules distributed throughout the network. One can program the response to each sensed scenario as a quantitative measure of the attributes of a set of programmable objects. One can separate the three basic components of any intelligent MIS (the dialogue processor, analytical/simulation module, and data manager) into three interdependent machine clusters.

1.7 KNOWLEDGE NETWORKS

Knowledge bases and networks are becoming increasingly common in the Internet environment. Knowledge processing to monitor and maintain the specific information that resides in such knowledge bases becomes necessary to be able to provide knowledge, news, and information-specific services to satisfy the public needs.

In this section, we present an architecture in which knowledge-based storage functions are compatible with processing, management, and knowledge services. Intelligent network (IN) environments where customized service provision is common in both second-generation IN (IN/2) and advanced intelligent network (AIN) environments provide a basis for the design of knowledge services provision. Whereas service logic programs offer specific service functions that can be executed in traditional computer environments, knowledge logic programs need very specific architectures to perform knowledge functions. The overall architecture of generic knowledge machines is presented in this section. Such machines perform programmable functions and execute application programs that entail knowledge-based micro- and macrofunctions.

1.7.1 Evolution of Knowledge Networks

In an extremely rudimentary sense, computer networks can minimally serve as knowledge networks. These networks perform knowledge functions such as processing, management, storage, and retrieval of critical objects that constitute the key elements within any body of knowledge, such as an article, a paper, a book, etc. The parsing of knowledge to uncover the crucial objects that play a decisive role in shaping any body of knowledge is akin to parsing for symbols within the compliers of higher-level languages (HLLs). In essence, knowledge implies objects, around which webs of relationships accumulate. The systematic study, analysis, and implication of these relationships give rise to incremental or derived knowledge, which in turn becomes a part of mainstream knowledge. Even though this definition appears to be self-perpetuating, it contributes to the explosion of knowledge on an ever-expanding scale. It also leads to the discovery and invention of new objects and concepts that are added to the dictionary in an unending process.

The nature of objects and the relationships between them (such as the keywords of a paper, or chapter, or an index in a book) constitute a segment or body of knowledge. These objects and their interrelationships become disoriented during knowledge processing. Only when there is consistency in the processing of all the objects that are implied in a body of knowledge is the overall processing of knowledge logical, coherent, consistent, and legitimate. Knowledge environments vary in their adaptation and intelligence. Service intelligence in communications systems has been successfully deployed since the 1980s [34, 35]. In the knowledge domain, the three basic categories of intelligence are feasible. They facilitate (1) connectivity to high-speed backbone networks and the Internet, (2) address and service update capability via the service control point database (SCP) of the intelligent networks (IN), and (3) knowledge-based intelligence (KI) look-up capability via the Dewey Decimal System (DDS) or Library of Congress (LoC) classification system [36, 37].

1.7.2 Knowledge Network Configuration

In Figure 1.19, when the adjunct knowledge service processor (AKSP) detects a request from the ISP user, a trigger condition invokes the participation of the appropriate knowledge service provider (KSP-*i*), The knowledge control point (KCP) unit of the KSP will start the attribute search for KBs around the world and does an initial match. Second-level matching takes place based on the client's attributes. After the raw information for the digital libraries and KBs is processed, the knowledge is again processed to obtain the exact information required by the Internet service provider (ISP) client, and it is dispatched from the KSP (for additional processing knowledge) over the global, national, or local backbone networks.

The limited access, high level of security, and logical separation from other Internet traffic will ensure the high quality of the information, knowledge, concept, or wisdom that the return KSPs to the ISP client. If we look back at the early telecommunications industry, in-band signaling systems were a cause of serious concern in the mid-1980s and early 1990s. The common channel inter-office signaling system (CCISS) and ITU-based standards for international signaling networks (or the CCISS network for local signaling) have evolved with a distinct and standard protocol to alleviate the inband signaling issues.

As the Internet starts to permeate every branch (medical, educational, commercial, business, financial, etc.) and phase of activities, the need for a distinct knowledge-signaling network and the participation of knowledge-processing systems and providers is foreseen. We give an example of such next-generation systems, one that appears to be financially viable and technologically feasible, in Figure 1.19.

1.8 CONCLUSIONS

This chapter introduces the current socioeconomic setting for the accelerating development of computer and communications systems that provide users with

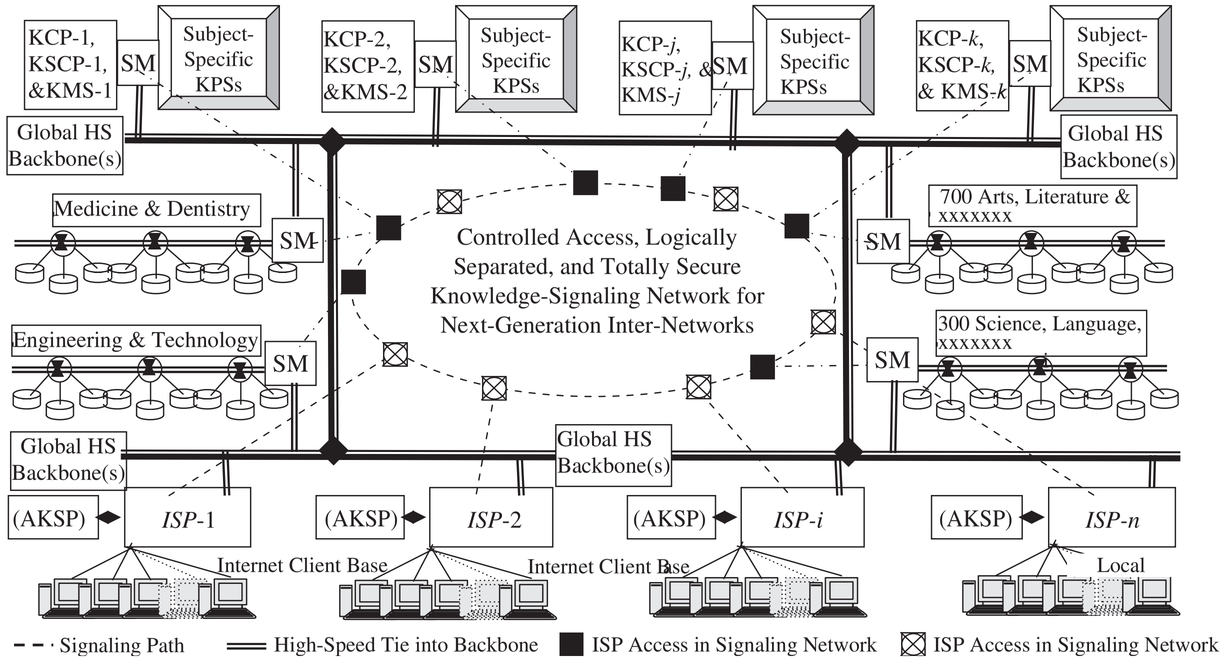

Figure 1.19 Network layouts for two-layer services of the next-generation Internet systems. Intelligent Internet and intelligent networks for building a peaceful and secure future. ISP = Internet service provider; AKSP = adjunct knowledge services processor; SM = switching module; KPS = knowledge service provider; KCP = knowledge control point; KSCP = knowledge services control point; KMS = knowledge management services.

precise and pertinent information. The machines preprocess the information furnished to an extent that the user can make sound and accurate decisions in solving a local problem. Such preprocessing is evident in the current Internet search programs when delivering search results. These current processes are rooted in basic logic rather than intelligence. The configurations presented are derived from the processing of objects contained in the information processed rather than the words used to generate that information. The processing capabilities and algorithms of the networks are readjusted to suit needs the user.

The architectures presented in this chapter cover a wide variety of applications, ranging from intelligent hospital environments to electronic governments for nations. The commonality in all the networks presented is their access to Web knowledge bases that validate and furnish global objects for comparison and inference. The intelligence embedded in such objects also interpreted by machines and processors makes the results returned to the user consistent with the explicit or implicit needs of the user. In a sense, the networks interpret user needs and the methodology to find solutions to such needs from the global and universal objects stored in the knowledge bases.

The machine configuration for most environments offers added benefits to the professional community. In most networks, such as medical or educational ones, the computer-based methodologies for the best solutions to specific situations in localized problems are customized by network intelligence in routing and by artificial intelligence in processing. In specialized networks such as tsunami warning, antiterrorist, or emergency response systems (ERS) networks, the methodologies with the quickest response are coupled with artificial intelligence (AI) techniques to detect and predict possible emergency conditions in the country and are deployed. These techniques can be deployed by any socioeconomic organization (such as a corporation or nation) to predict and monitor stability and continued survival. Machine response moderated by human intuition is generally quick, and the corrections are optimized to prevent oscillations and repeated corrections. A smooth and damped transition occurs from one stable operating condition to the next.

A network-based sensing and monitoring environment can be integrated with the high-speed backbone networks of the country. An intelligent decision support system can be ported in the network environment by appropriately arranging the functions of the three switching systems or switching the modules of any of those systems.

REFERENCES

1. Bell Telephone Laboratories, *Engineering and Operations in the Bell System*. Western Electric Co., Winston-Salem, NC, 1982.
2. S. V. Ahamed and V. B. Lawrence, *Design and Engineering of Intelligent Communication Systems*, Kluwer Academic Publishers, Boston, 1997.

3. Rogier Noldus, CAMEL: *Intelligent Networks for the GSM, GRPS and UMTS Network*, John Wiley & Sons, Hoboken, NJ, 2006.
4. S. V. Ahamed, "The Architecture of a Wisdom Machine," *International Journal of Smart Engineering Systems Design*, London, 5(4), 2003: 537–549.
5. B. Stroustrup, *The C++ Programming Language*, 3rd ed., Addison Wesley, Boston, 2000.
6. P. Seibel, *Practical Common Lisp*, Apress, Berkeley, CA, 2005.
7. S. J. Russell and P. Norvig, *Artificial Intelligence*, Prentice-Hall, Upper Saddle River, NJ, 1995.
8. E. Castro, *HTML for the World Wide Web with XHTML and CSS: Visual QuickStart Guide*, Peachpit Press, Berkeley, CA, 2002.
9. C. P. Poole and H. A. Farach (Eds.), *Handbook of Electron Spin Resonance: Data Sources, Computer Technology, Relaxation, and Endor*, Springer-Verlag, New York, 1999.
10. L. Buckwalter, *Avionics Training: Systems, Installation, and Troubleshooting*, Avionics Communications, Inc., Leesburg, VA, 2005. (auto pilots for planes)
11. K. Williams, *Build Your Own Humanoid Robots: 6 Amazing and Affordable Projects*, McGraw-Hill/TAB Electronics, New York, 2004.
12. B. Yenne, *Attack of the Drones*, Zenith Press, 2004. Also see G. West, "Drones Ahead: Pilotless Planes Reduce Danger and Increase Efficiency," *Alaska Business Monthly* (HTML), April 1, 2007 (digital). Farmington Hills, MT.
13. S. V. Ahamed, *Intelligent Internet Knowledge Networks*, Wiley-Interscience, Hoboken, NJ, 2006.
14. J. M. Keynes, *The General Theory of Employment, Interest, and Money*, Prometheus Books, Buffalo, NY, 1997. Also see R. M. O'Donnell, *Philosophy, Economics, and Politics: The Philosophical Foundation of Keynes's Thought and Their Influence on His Economics*, Palgrave Macmillan, New York, 1989.
15. J. Neumann and O. Morgenstern, *Theory of Games and Economic Behavior*, Princeton University Press, Princeton, NJ, 2004.
16. J. R. Parker, *Algorithms for Image Processing and Computer Vision*, John Wiley & Sons, Hoboken, NJ, 1996.
17. R. Arena and M. Quere (Eds.), *The Economics of Alfred Marshall: Revisiting Marshall's Legacy*, Palgrave Macmillan, New York, 2003.
18. A. Smith, *The Wealth of Nations*, Prometheus Books, Buffalo, NY, 1991.
19. D. S. Byrne, *Complexity Theory and Social Sciences*, Routledge, New York, 1998.
20. E. Alpaydin, *Introduction to Machine Learning (Adaptive Computation and Machine Learning)*, MIT Press, Cambridge, MA, 2004.
21. J. Neumann and O. Morgenstern, *Theory of Games and Economic Behavior*, Princeton University Press, Princeton, NJ, 2004; see "Zero Sum and Non-Zero Sum Games." Also see A. R. Washburn, "Two-Person Zero Sum Games (Topics in Operations Research Series)," Military Applications Social Research, Elsevier Science & Technology, "Handbook in OR" Burlington MA., 2003.
22. E. G. Sable and H. W. Kettler, "Intelligent Network Directions," *AT&T Technical Journal*, Summer 1991: 2–9. Also see W. D. Ambrose, A. Maher, and B. Sasscer, *The Intelligent Network*, Springer-Verlag, New York, 1989.

23. J. O. Boese and R. B. Robrock, "Service Control Point: The Brains Behind the Intelligent Networks," *Bellcore Exchange*, Navesink, NJ, December 1987.
24. *SAP Solutions and eLearning*, SAP (UK) Limited, Feltham, Middlesex, England, 2002.
25. R. Rowley, *PeopleSoft v.8: A Look under the Hood of a Major Software Upgrade*, White Paper, PeopleSoft Knowledge Base, 2005. Also see R. Gillespie and J. Gillespie, *PeopleSoft Developer's Handbook*, McGraw Hill, New York, 1999.
26. S. V. Ahamed and V. B. Lawrence, "Evolving Network Architectures for Medicine, Education and Government Usage," Pacific Telecommunications Council, Hilton Hawaiian Village, January 14–18, 2002.
27. K. C. Laudon, *Management Information Systems*, Prentice-Hall, Englewood Cliffs, NJ, 2003.
28. M. S. Pinto, "Performance Modeling and Knowledge Processing in High-Speed Interconnected Intelligent Educational Networks," Ph.D. dissertation, May 2007.
29. M. Krol, "Intelligent Medical Network," Ph.D. dissertation, City University of New York, 1996. Also see M. Krol, and D. L. Reich, "Development of a Decision Support System to Assist Anesthesiologists in the Operating Room," *Journal of Medical Systems*, Springer Verlag, New York, NY, 24, 2000: 141–146.
30. N. Mollah, "Design and Simulation of International Intelligent Medical Networks," Ph.D. dissertation, City University of New York, 2005.
31. L. Leung, "Design and Simulation of International Intelligent Medical Networks," Ph.D. dissertation, City University of New York, 2005.
32. N. Waraporn and S. V. Ahamed, "Intelligent Medical Search Engine by Knowledge Machine," in *Proceedings of 3rd International Conference on Information Technology: New Generations*, IEEE Computer Society, Los Alamitos, CA, 2006. See also N. Waraporon, "Intelligent Medical Databases for Global Access," Ph.D. dissertation, City University of New York, 2006.
33. S. V. Ahamed et al., "Hospital-Based Integrated Medical Computer Systems for Processing Medical and Patient Information Using Specialized Functional Modules," U.S. Patent 6,272,481 B1, issued August 7, 2001.
34. W. D. Ambrose, A. Maher, and B. Sasscer, *The Intelligent Network*, Springer-Verlag, New York, 1989. Also see *IEEE Communications Magazine*, Special Edition on Intelligent Networks, February 1992. See also J. Meurling, "An Intelligent Network Perspective," *Bellcore Symposium on Intelligent Networks*, Brussels, Belgium, 1988.
35. S. V. Ahamed and V. B. Lawrence, *Intelligent Broadband Multimedia Networks*, Kluwer Academic Publishers, Boston, 1997.
36. M. Mortimer, *Learn Dewey Decimal Classification*, 21st ed., Scarecrow Press, Lanham, MD, 1999. Also see *Dewey Decimal Classification and Relative Index*, 22nd ed., OCLC, Dublin, OH, 2003; J. P. Comaroni, *Dewey Decimal Classification*, 18th ed., Forest Press, Albany, NY, 1976.
37. J. Ganendran, *Learn Library of Congress Subject Access*, Scarecrow Press, Lanham, MD, 2000. Also see U. S. Government, *Library of Congress Classification*, http://catalog.loc.gov.