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Information, Information Society and Some Marxian Propositions

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Information, Information Society, and Some Marxian Propositions

Klaus Krippendorff

The following is an attempt to place information theory into the larger context of society, particularly into the context of a society that has been called postcapitalist (Dahrendorf, 1957) and postindustrial (Bell, 1973) and is now increasingly referred to by the term information society. The idea of identifying current global structural changes, particularly in the United States and Japan, with a shift in the predominant mode of production has not been very popular in the West. Yet it seems to promise to bring into focus, to an extent still unclear, some of the ongoing information-technological developments.

The idea of explaining structural changes in terms of changes in the mode of production goes back to Karl Marx, of course, who developed this analytical perspective a century ago and from experiences with what he knew best, a society at the beginning of industrialization. Having taken a path not predicted by Marx, the West thought his system to be dead, full of ideology and void of social reality. Surprisingly, the new information technologies, enriched by advanced knowledge of computation, communication theory, systems theory and above all cybernetics, force us back to reconsider Marx's level of analysis and its sociopolitical implications.

The scope of this paper is large compared with the space available here. This favors a style of presentation that is schematic, definitional, and propositional leaving many details undeveloped. Perhaps

further discussion and subsequent work will bridge the gap that will remain open.

I will start with a notion of information that has the dynamic qualities required for understanding structural changes, define it, place it into alternative paradigms, and elaborate some of its properties. The notion of information society will be sketched in terms of employment, in terms of the development of information technology and in terms of modern corporate forms of organization. In this analysis, information turns out to be a meta-economic currency. This leads to several propositions that I believe extend Marxian ideas so that they may be applicable to the social dynamics presumably underlying the emergent information society.

Information

Definition

Elsewhere, I identified information with the organizational work a message enables its receiver to perform.

By organizational work I mean arranging things, imposing a particular pattern on a situation or constructing something new from otherwise organized parts. Information connotes the dual meaning of "bringing something into form" and of "forming something from within." Both are intended in our definition. Both imply a process. In Shannon and Weaver's (1949) original formulation, information is seen as the difference between two states of uncertainty, the uncertainty before or without knowledge of a message and the uncertainty after receipt or with knowledge of that message. The reduction of uncertainty is but a simple kind of "organizational work" that takes place in the mind of a receiver. Their theory turns out to be not powerful enough to explain the kind of information processes ongoing in society, even so, "making a difference" is the minimal evidence for organizational work.

Accordingly, a computer program informs a general purpose computer by "wiring" it to perform a desired task. A blueprint informs a group of diverse construction workers to get organized such that a building is assembled from available materials. A command informs a military unit by directing its deployment. And genetic material informs the embryonic form of an organism by specifying that organism's growth.

These examples show that the term receiver must be understood quite generally. It applies not only to a single human being but also to a machine,

a social group, or a biological organism. Similarly, the term, "message" is intended to denote any arrangement of physical markers in a medium, whether these are holes punched into a Hollerith card, characters printed on paper, waves of sound or chemical compositions of DNA. To perform organizational work a message must be put into a context (a receiver) consisting of rearrangeable parts or building blocks and the arrangement that emerges must not be explainable without reference to the pattern (message) initiating the process. It is also important that the energy required to perform the organizational work is not supplied with the physical markers initiating the process. Reading a message neither "empties its content" nor destroys its "container" and this container metaphor is not only inappropriate but also distracts from the generality of the notion of information.

Defined in terms of organizational work, information displays some analogy to energy which is the classical measure of work in physics. In both cases, we must distinguish between its *potential* and its *actual use*. A gallon of gasoline has potential energy that is consumed in the mechanical work of driving a car. A book has potential information that may become empirically manifest when it yields practical results (from changing someone's mind to restructuring a portion of social reality). A library is a storehouse of potential information. Both concepts are also defined in context. The measure of potential energy is expressed relative to a level of entropy in the surroundings of the object measured. As this level increases, potential energy erodes. Similarly does information become powerless as the organizational work it specifies is already performed. Ignoring psychology, saying something twice is simply redundant. In the absence of the material entities that a certain message could help rearranging or transforming, the potential information cannot be utilized.

The important difference between information and energy lies in their level of description. Information is *a property of pattern*, arrangement, structure, and so on, *not of matter*. The possibility of coding information, for example, from my voice to the electrical impulses generated in a microphone to the mechanical movements of a stylus in the grooves of a record, makes different media carry the same kind of information. Although information unquestionably requires some material form to be transmitted, stored, or used, this *materiality is irrelevant* to the organizational work it is capable of. Energy, on the other hand, is *a property of matter*. The modulations of the flow of energy, the arrangement of physical markers carried by a medium, all of which have the potential of carrying information, do not enter the measure of energy but may enter the measure of information. When we say that a tank of hot water has the same potential energy as a wax candle, we compare two material forms. When

we say that one message can carry the same information as another message, we compare two patterns regardless of their material forms. *The organizational work information is capable of is one level removed from the mechanical work energy is capable of.*

There are several common confusions I wish to prevent here. First is the confusion of information with *data*. Data, a collection of facts, recorded observations for instance, may or may not convey information depending on whether they are or are not capable of reorganizing the context in which they are placed. Many data never pass the stage of a check mark on a piece of paper. It is only when they start to support a theory, change a course of action, or lead to policy recommendations that they can be said to convey information. Otherwise they are just collections of markers manifesting patterns, perhaps, but without organizational consequences.

Second is the confusion of information with *knowledge*. Knowledge is partly derived from interpreting observational data and partly created in the mind of an observer or by communicating within a community of observers. All three parts make knowledge indigenous to and a construction by an observing system. Knowledge can become information if it is communicated, written down, expressed. The library stores only potential information and makes it available to a community of interested readers. It will become used information only when it does something, when it is applied at least to a reader's mind but more particularly when it organizes something outside that reader, when an idea is put to work whether it helps designing a machine, changing a practice, organizing a group or making better management decisions. The kind of knowledge that is purely appreciative, self-satisfying, a value in itself—which has been part of Western liberal ideology since the period of the Enlightenment, however important it may be individually—this kind of knowledge does not support any work and is not to be equated with information. The closest characterization of information in terms of knowledge is that it is "*know-how*" not "*know-what*," not "*know-why*" and not "*know-what-for*."

Third is the confusion of information with *neg-entropy*. Neg-entropy makes reference to the second law of thermodynamics according to which entropy always increases, patterns found in nature generally degrade and orderliness necessarily diminishes in the world. In contrast, the whole evolutionary history on earth depicts living organisms as increasing their own complexity, creating pattern in their environment where there were none before and thus increasing orderliness in the world. The increasing sophistication in agriculture, technology, and government is cited as evidence of man's counterentropic intelligence. This observational fact has lead a good many thinkers to jump to the biocentric conclusion that

life contradicts the entropy law with information being the agent that reverses the natural trend toward increasing entropy. Since Prigogine (1980) we know that all of these supposedly counterentropic tendencies are natural and not in violation of the entropy laws. Since Maturana (1970) and von Foerster (1981) we know the increasing orderliness to be a property of the cognition by an observer or by a community of observers who impose their construction of the world onto their environment including onto themselves. Information measures this organizational effort but is not necessarily directed against nature. To take a complex system into parts may take as much organizational skills as assembling it. Both rearrange something and use information.

Fourth is the confusion of information with *symbolism*. To be sure, anything placed in a context may acquire meaning by interacting with it, and defining the context for a given message delineates how this message is to be interpreted, what it means. Information could be said to bestow a particular meaning to a message that focuses attention not on a static and socially constructed relationship between signs and their referents but on its dynamic consequences, on the behavior it sets in motion. Symbols may convey information because of this vicarious and largely conventional relationship but their information value is contextually bound. The information conveyed by symbols wears out by repetition (satiation), becomes redundant after they have done their "work" or remains mere potential when the surrounding conditions are insufficient to support the organizational work possible. The information content of symbols is different from the semantic relationship that gave rise to it.

Finally, there is the somewhat less problematic confusion between information and communication. (Note Shannon and Weaver's now-called "information theory" was published in 1949 as *The Mathematical Theory of Communication*!) Processes that involve a mere one-to-one relationship between signals sent and signals received, telephone communication and Xerographic duplication, for example, reproduce an original pattern at a distant location and thus retain the potential information in the original. The channel accomplishing this is actually immune to, unaffected by and ignorant of the sequentially coded and transformed patterns and might be said to transmit signals. The full power of the idea of communication as transmission of information becomes apparent when organizational work (yielding patterns, structure) in one system causes or influences the organizational work done in another system. Such a "channel" may have to "understand" some of the information involved and may require human beings or intelligent mechanisms of vastly different complexity than displayed by a telephone line.

Although I will say more about information, the fact that the concept is

not tied to a particular materiality does not make it subjective, idealistic, or void of reality. As a measure of organizational work, it describes an important intellectual activity in the real world which, I contend, has considerable social implications.

Diverging Paradigms for Information

Information has not always been defined so generally. For example, by emphasizing "facts," "news value," and "social responsibility," journalism links information to some concept of truth and to a professional ethic about which consensus must exist, at least in that profession. What is not always recognized is that this consensus is not an isolated phenomenon. It is regulated by stable institutional configurations and supported by a much larger paradigm that prescribes a particular ontology (what exists), a logic (an appropriate pattern of reasoning), a notion of causality, and so on, all of which are tied to the concept of a particular society and to the role of the individual within it. Information is just one part of it and it is useful to sketch some of the basic paradigms to see what information does within them.

Maruyama (1974) describes four alternative paradigms, each of which subsumes and distinguishes among a good many approaches to theory and practice. Paradigms of this kind serve to highlight conceptual differences and to accentuate what goes together. The reality we live in might not make such sharp distinctions. In table 23.1, I am using Maruyama's terms rather liberally, primarily to compare different notions of information with. For lack of space, I will "read" and comment only on the left column and the last row hoping that the remainder of the table is self-explanatory.

Accordingly, the journalistic conception of information might belong to his *hierarchical* type which has its roots, as the name suggests, in hierarchical forms of organizations whose overriding purpose is superior to or outside the reach of its members. In the extreme, this paradigm incorporates notions of a linear causality that is ultimately traceable to a prime mover, a god, an unquestioned authority, or a universal principle to which everyone is subjected to. In this paradigm, the dominant philosophy is absolutism, universalism, holism, organicism, or various forms thereof. It favors deductive axiomatic and theological patterns of reasoning, deriving true statements from axioms or particular purposes from general goals or from universal principles. Truth must be sought. Information is *absolute* and works unidirectionally to narrow the gap between ignorance and (a typically single) truth. The extreme form of such an organization is found in the Catholic church but it is also present in most rational forms of

TABLE 23.1
Four Paradigms for Information

	Hierarchical	Isolationistic	Homeostatic	Morphogenetic
Ontology of organization	Parts are subordinate to the whole. Stable hierarchical organization of categories.	Whole is fictional or subordinate to its parts. Aggregation.	Existing parts interact. Behavior converges towards an equilibrium and a stable pattern of relationships.	Parts interactively define their own organization, co-produce other parts including those producing them.
Causality	Linear causality ultimately traceable to a prime mover.	Non-causal. Synchronicity.	Circular causality. Negative feedback = deviation counteracting and converging. (Positive feedback is destructive and undesirable).	Self-referential (circular) dependencies and interactions creative of new forms (positive feedback) but also of closed realities.
Logic Pattern of reasoning	Deductive, axiomatic, theological.	Distributive, statistical.	Teleological, operational	Circular, computational.
Philosophy Individual values	Absolutism, holism. Fulfilling overall objectives, duty.	Pluralism Achieving individuality, self-realization, independence.	Equilibrium Systems Achieving equilibrium, balance, harmony in interaction with others.	Constructivist epistemology Maintaining local autonomy while creatively participating through interaction in other autonomous organizations.
Primary stimulus of social development	Deviations from principles. Obstacles to reaching goal. Problems.	Similarity or uniformity of individuals. Social entropy.	Inequalities in power, preferences and access to material resources. Social differences.	Multi-lectical (including dialectical) contradictions, conflicts, paradoxes.
Information = ability to perform intellectual-organizational work	Narrows the gap between ignorance and the (single) truth. Solves problems. Is absolute.	Achieves individuality, distinction, differentiation. Is subjective.	Reduces uncertainty, exhausts uncommitted variety, achieves (mutual) control and stability. Is contextual.	Increases organizational diversity while synthesizing higher forms of organizational closure. Is in-formative.

organization; for example, advertising agencies, which measure information by the degree to which it yields desired results.

In an *isolationist* paradigm, information is *subjective*. Individuals interpret messages in their own way and as there is complete tolerance for individual differences, a communication problem hardly arises. Such individuals use information to achieve individuality, self-realization, distinction, and individual differentiation.

Within a *homeostatic* paradigm, whose dominant feature is the interaction among existing components, information is at once contextual and constraining. It is *contextual* in the sense that messages are interpreted in the context of other messages and in the context of communicative exchanges and it is *constraining* in the sense that the receipt of such messages has the effect of reducing uncertainty (e.g., in the mind of a receiver), eliminating alternatives (e.g., in decision-making situations), exhausting uncommitted variety (e.g., in a social group that is instructed to perform a certain task), control (e.g., making someone do something he would not otherwise do) and coordinates (e.g., correlating otherwise uncorrelated or independent parts of a system). Shannon and Weaver's (1949) information theory formalizes this interpretation. Naturally, the theory is unable to consider what is alien to this paradigm: (a) the production of new components, the creation of new information, the invention of more powerful alternatives, the synthesis of dialectical opposites; and (b) the unequal significance associated with information (in Shannon's sense). It measures the extent to which a message enables its receiver to achieve an equilibrium, balance, or harmony, sometimes even if he does not desire it.

Although circular causality is common to the homeostatic and to the *morphogenetic* paradigm, the morphogenetic paradigm is able to see positive or deviation-amplifying feedback as a creative process that accounts for increasing organizational diversity. It is able to account for the interaction among components that produce other components (allopoiesis) and that enter the process that produced them (autopoiesis) (Varela, 1979). It is able to account for the resolution or synthesis of paradoxes, of contradictions and of higher-order conflicts (in the sense of involving many parties) which I call multilectical processes of transcending higher-order interactions. The paradigm moreover places the observer into the context of his own observations and accounts for the emergence of cognitive constructions of reality. In this paradigm, information emerges largely *from within* and may therefore be called *in-formation* (Varela, 1979). Positive feedback increases organizational variety, negative feedback achieves organizational closure, both are organization-formative processes.

In proposing these four kinds of paradigms, Maruyama also suggests a historical development, the hierarchical being the oldest of the four, the morphogenetic the most recent one. The homeostatic paradigm relies heavily on an ontology provided by systems theory, game theory, information theory (of the Shannon type) and control theory, all of which are subsumed by the cybernetics of observed systems (first-order cybernetics) whereas the morphogenetic paradigm has largely transcended the homeostatic one and heavily relies on an epistemology of systems that includes their observers as constituent parts. It particularly recognizes the important role of self-referential constructions that the largely Western philosophy has exorcised (Krippendorff, 1982). This paradigm is being developed in the name of a cybernetics of observing systems (second-order cybernetics) (von Foerster, 1974).

Properties of Information

Probably the most outstanding failure of economics is that it has been nearly unable to account for information and, because contemporary society has become increasingly involved in processing information within itself, economic predictions have increasingly been failures. The reason lies squarely and simply in certain properties of information that distinguish it from those traditionally accounted for by economic analysis.

Much of economic analysis rests on the invariance of value. Marx's observation that capitalists become fewer and richer as they buy each other out and extract more and more profit from the working poor is an example of this reasoning. Another is the notion of a commodity as something that is exchanged for its value. However, this invariance is rooted in the properties of matter and energy to which economic values ultimately refer. Odum & Odum (1976) have shown that the flow of matter and energy in society is correlated with the flow of money. It proceeds along the same paths but in the opposite direction and regulates them in the social domain. Similar to capital, according to the first law of thermodynamics, matter and energy can be transformed and redistributed but neither created nor destroyed. This law makes material processes easily accountable, and economics thrives on the invariance underlying it.

In contrast, information can be *created* like artistic productions, technological inventions, and the development of plans for socioeconomic institutions. Information *can be mass-produced* at very little cost by sequentially repetitive processes, such as in printing, copying, or by disseminating numerous replicas of one original, as is done by radio and television. Information *can also be destroyed* as is true for much of human history that may never become known to the full level desirable. Destruc-

tion of information was attempted but failed (owing to its wide distribution) in the Watergate case. Quantities of information are thus not subject to the same laws governing quantities of energy and the related economic quantities of value.

Many economists in the West have responded to the unquestionable economic importance of information in terms of number of jobs available, level of investment, and volume of transactions, by regarding information as a commodity, paralleling such traditional categories as steel, chemicals, automobiles, social services, and so on. This seems entirely inadequate. A commodity is a product of humans or of nature that is exchanged for the value either of its consumption like food, clothes, automobiles, or of its use in the production of other commodities, as with tools, machines or production facilities that are subject to slower wear and decay. Because information is cheaply reproducible and may not lose its value when used repeatedly, *information does not have the property of a commodity* and cannot be accounted as such without total disregard for its organizational role. That part of information processing that consumes raw material and energy, that is, the production of the physical carriers of information and the maintenance of the media of communication, all of which are accountable economically, is relatively insignificant if not irrelevant to the structural changes these media are able to cause by the information they provide.

Information may be purchased either in the form of *access rights* or the *privilege of use*. In both cases, institutional structures mediate between the economic transactions and the information flows within a society, moving information outside the traditional realm of economics. For example, in buying a newspaper, what changes hands is not information alone but also several pages of newsprint. Reading the newspaper neither destroys its material form nor consumes its content. It does not even prevent others from reading it later. Not knowing exactly what the newspaper contains, the first reader pays for having physical access to a known category of content. After reading what he wants, the newspaper has lost its value for him but not necessarily for secondary readers to whom he can pass it on without appreciable loss to himself. This can surely not be said for consumer goods and for the means of production. The subscription to a newspaper, the acquisition of a television set, the registration for a course of study at the university, and so on, purchases *access rights to a category of information*. Industrial espionage aims at acquiring a category of information without paying for the access rights. On the other hand, when one commissions research on the optimal reorganization of a plant, when one acquires instructions to produce a pharmaceutical product or when one buys a plan to assemble a microcomputer, the purchaser knows

quite specifically what the information will do when he has obtained it. And the implication of the economic transaction is that he will have *the privilege to use the information* obtained by him. The money paid may compensate the seller for his physical effort but it is the privilege of use that the buyer acquires. Granting or depriving someone of this privilege of use is independent of the possession of the information. For example, the knowledge of a plan to rob a bank does not imply the privilege of its use.

Relative to the production, exchange, and consumption of commodities, information assumes a *superordinate position* and an economic analysis of the information processes involved ought to take this extraordinary position into account. In the input-output table for an economy in which exchanges between and transformations within industries (categories of industries, sectors of an economy, or geographical regions) are entered, information participates in the process by changing the table. It may change the transition function within one cell (e.g., when information is geared toward a more efficient organization of the process), it may change the interaction between cells otherwise considered independent (e.g., when industries, etc., become more informed about each other and coordinate their production and consumption) or it may add new cells, rows, or columns. (e.g., when information introduces new technologies, communication technology for example, that cause structural changes in the economy). In such an analysis information is seen to be about or superordinate to the economy. It guides, controls, and rearranges the economic activities and has, hence, the characteristic of a *meta-economic quantity* that cannot easily be built into a system of analysis that is essentially flat and provides no opportunity for self-reference.

Information Society

In this section I will sketch what might be the three most important indicators of the transition to a form of society in which information seems to be the predominant feature. These are the changing patterns of employment, the widespread adoption of a new technology and the emergence of modern corporate structures.

Changes in Employment Pattern

Probably the first serious recognition of the role of information in society came with Price's (1961) work showing how the development of science, as an institution and measured in terms of number of scientists, correlated with, and in fact predicted, economic development. At the same time Machlup (1962) collected a wealth of data on *The Production and Distri-*

bution of Knowledge in the United States and came to the startling conclusion that in 1958 about 29 percent of the existing GNP was spent for knowledge. The figure was rightly criticized as too broad. It included under education, for example, not only schools and universities but also education at home, on the job, in church. It also counted entertainment, the mass media in particular, as a knowledge industry.

Subsequently, Porat (1977) analysed some 440 occupational categories and 201 industries. He separated those concerned with information from those related to the production of goods and found that in the year 1967, 25.1 percent of the U.S. GNP was due to that part of the economy which creates, processes, and distributes information. Included in this category are education, advertising, accounting, the mass media, printing, telecommunications, and computer manufacturing, as well as parts of the finance and insurance business. He called this the *primary information sector* and proceeded to estimate the contribution made by information-related jobs within industries that are not part of the primary information sector and found an additional 21.1 percent of the GNP coming from information activities in this so-called *secondary information sector* or 46 percent in total and 53 percent of all income earned. This increase in economic activity devoted entirely to information processing is further demonstrated in a recent study at MIT which found that of the 19 million new jobs created in the United States in the 1970s, only 5 percent were in manufacturing, 6 percent in services, both in the goods producing sector, and 89 percent were outside the goods producing sector.

There is no doubt that information is necessary in the functioning of any society. Formal education has been with us for several centuries and if one includes socialization—the slow integration of individuals into the working of society—intergenerational transmission of information is a functional prerequisite. There is also no doubt that farmers, craftsmen, and industrial workers always required considerable amounts of information to be productive. But what is different here is that there are now many more jobs and many more employment categories, not just teachers, that specialize in the creation, production, and dissemination of information without using it themselves. Information processing, which had before been the unalienable domain of the human mind, is now becoming professionalized and has entered the public and corporate domain, involving human beings as mere mediators of an unfolding process of societal organization.

One can quibble over the validity of the occupational categories or demand a finer differentiation between kinds of information produced by them, but all these figures support the staggering growth in the economic significance of information in contemporary society. Following the above discussion on the properties of information, I suggest that these figures

might be indicative more of the *production of the material vehicles* for information processes to take place than of the amount of information that is potentially available or actually used. The latter would be manifest in an acceleration of structural changes about which we may not have objective measures but sufficient anecdotal evidence.

Information Technology

One mark of the coming information society is the above shift in the pattern of employment. Another is the widespread use of electronic computers, a new technology that may underlie this shift and the likely cause of social changes of a magnitude not yet fully imaginable. I will sketch the development of this technology, not so much because of its obvious importance but because its history sheds light on how technology might develop generally and what role information plays in a society in transition. This sketch could also be considered a demonstration of what a morphogenetic theory of information might entail and serve as a general scheme for accounting for the kind of large-scale societal changes of ultimate interest.

I am suggesting that all technological developments, and by generalization, all interactively growing social features, go through four stages: embryonic, opportunistic, self-assertive growth, and systemic maturity or institutionalization.

Embryonic. Information enters a context of material entities it is capable of organizing into a new form. In the 1940s mechanical calculators were common. The telephone with its elaborate switching technology was in place. Radio communication, which relied on the mass production of receivers including relays then in the form of vacuum tubes, was available. Owing to the large scale planning effort at the beginning of World War II, the 1940s were also marred by logistical problems, making financial resources readily available to find practical solutions. The idea of a robot, a human-made replica of humans that would do what it is told to do was an idea well-established in literary fantasies. In this environment, which provided all the parts needed to build electronic computers (and, for that matter, a lot of other things too) the idea of a computing machine was realized at the University of Pennsylvania where two professors worked for years to wire a room full of vacuum tubes and switches into a functioning whole. It was a change from a collection of independently available components to an organized whole, a change from quantity to quality, guided by the information then available to the inventors. To be sure this information was available elsewhere too (Ledger, 1955) and could have been applied at other places with similar results but it did not come

to fruition there, the question of why being a separate issue. The embryonic stage of a technology, which might last for a long time, terminates with the social recognition that something new has been found, invented, realized, named and thereby considered organizationally-structurally distinct from what was known before.

Opportunistic. The new technology is narrowly categorized, cast into traditional terms and applied where it causes the least changes in the adopting institutions, primarily substituting for existing functions. It is noteworthy that the machines of this new technology were called "electronic calculators," signifying that they were seen as calculating devices that used numbers as inputs and outputs and served the function previously performed by applied mathematicians. The first applications, say between 1945 and 1970, were largely for national-scale projects such as national defense, space exploration and in support of scientific research involving a great deal of computation such as in physics and statistical work. The computers of this period were largely sequential machines that centralized computational work into a single unit. Concurrent to the growth of big computers three embryonic developments must be mentioned: (1) the use of computers in toys and games, now a major industry, which again posed no threat; (2) the application of computers in business and the accompanying recognition that computers actually process information not just numerical data; and (3) the continuing research at American universities, developing theories of computation, of programming languages and of systems design, creating new academic disciplines, computer sciences, artificial intelligence, computational linguistics, for example, and producing a considerable number of highly trained and motivated computer buffs who could realize their dreams in niches not yet explored and work outside traditional domains of institutional controls, starting corporations of their own. This development largely took place beneath the surface of conventional applications.

Self-assertive growth. The technology now expands and finds unanticipated applications that no longer replace older forms but create new needs and new variates to satisfy them. These tend to challenge existing institutional structures. Self-assertive growth characterizes today's use of computers in the United States and in Japan. One technological innovation making this expansion possible is the development of microcomputers, that is, computers that are nearly as capable as the larger ones of ten years ago but portable and comparatively inexpensive. A second is the combination of microcomputers with telephone networks, rendering centralized information processing obsolete and introducing a kind of parallel processing on a large scale. The third is the shift in emphasis in development from hardware to software, which is the kind of information that organises

computation. This shift enormously increases the adaptability of computers to emergent situations. In the course of this growth, computers are making inroads into education, not replacing teachers as had been feared, but creating individualized learning experiences, making more information faster available to students than teachers could provide and producing a generation of people familiar with and capable of handling information processing tasks. Under the name of "word processors" computers are replacing typewriters, a variety of financial accounting tasks, and modifying office communication by offering electronic mail services, computer conferencing, networks for accessing data banks stored elsewhere and also making optimum management decisions. Computers are scheduling a great many complex activities from civilian air travel to inventory control which the ordinary person barely experiences when buying a ticket or paying at the cash register of a supermarket. Computers are naturally taking over banking and one speaks of electronic money that no longer exists in the form of coins but in the memory of a computer to which owners have limited access. Programmable robots are solidly in place in industry, replacing workers in mass production from automobiles to computers themselves. Software is created for a great many applications for running hospitals and for crime control. The knowledge of experts such as in medical diagnosis and in geology has reached the state of computerization at which it can be marketed through and accessed by telephone lines (Feigenbaum & McCorduck, 1983). Japan has adopted a national policy of computerization (Masuda, 1981). The United States lets these self-stimulating developments grow within the context of the market place. A challenge of traditions is inevitable in either case.

Systemic maturity or institutionalization. Having superseded all obstacles in its way to become dominant within a given ecological niche, the technology develops stable relations with other technologies and supports the institutional arrangements it helped in part to create, it has become a "cultural complex" no longer a "dynamic technology". We cannot be certain at this point what computers will ultimately do and which institutions they will favor in a mature information society. Since we have no experiences with such a society we can only speculate. We know the automobile is in this phase, having surrounded itself by an automobile industry, an oil industry, a system of roads and car services, legislation, safety control, even folklore, not to speak of the population of drivers who consider this complex most "natural." The industrial mode of production had reached a similar state of maturity when it was successfully challenged by the emergence of bureaucratic practices and now by the advent of information technology. Information technology is not likely to replace any of the older existing technologically motivated cultural complexes but

it may overcome their dominance and leaving enough room for initially unnoticed innovations to emerge that may become dominant in the future.

I am convinced though that information technology is of a kind qualitatively different from older technologies, whose institutionalization we have seen, for it does not primarily process matter and energy but organizational work in the social domain that is so much more connected with man's intellect than any other technology in the path of history.

Modern Corporate Structures

The church and the army are classical forms of large-scale organizations. Industrialization added the enterprise and later the state to the repertoire. But the twentieth century created the corporation.

A corporation is a self-governing entity whose life span is independent of that of its members. Members enter a corporation by contractual agreements that stipulate functional responsibilities, obligations, and benefits and such agreements may be terminated by mutual consent. This voluntary membership gives a corporation considerable flexibility in responding to emergent opportunities. Corporations have generally fewer levels of organization and grant its components a greater independence. Interaction among corporate components is regulated by something like an "internal market" and a corporate policy, both of which are overseen by a board of directors. Corporations also have assets, but the ownership of these assets is typically functionally distributed and rarely in the hands of specific people. For this reason corporations have sometimes been called "legal fictions." Although the functional rationality of corporations may make them transparent internally, their self-government makes it often difficult to penetrate them from the outside or to apply effective governmental control. This may be one reason for their recent growth in numbers as well as in political power.

Big business corporations like AT&T, General Motors, Standard Oil, and IBM date all back to the 1920s and were created by skillful organizers, neither by managers nor by owners, who had the wisdom to economize by decentralizing corporate decisions and by making the "internal market" to define the link between corporate components. This internal market is similar to but more efficient than the external market in which corporations compete, thus thriving on this difference with a minimum of expense for governance. For example, at General Motors, the producer of batteries sells his products to the car manufacturing unit at a certain percentage above production costs. Efficiency is further enhanced by the sharing of information and the internal compensation of profits and losses. Because there is otherwise no systemic difference between the internal manufacture

of a product and its purchase from the outside, the corporation remains competitive as a whole as well as in each of its parts.

Corporate forms of organization have been widely applied even to nonprofit organizations, such as American universities. At the University of Pennsylvania, for example, each school functions to some extent as an independent company with a separate accounting mechanism. Through a complete breakdown of the costs and services provided, the university administration can check on the efficiency of each school and make appropriate decisions on the allocation of resources. The financial assets of the university are formally owned by its board of trustees, which oversees the operation of the university as a whole. Faculty, students, and administration probably are the university's most important assets, but they are not ownable except through the mechanism of loyalty and are nearly exclusively informational. Faculty, students, and administration also participate in the university's self-government through such organs as the faculty senate, the student assembly, and the president of the university. Thus the informational assets check on, if not dominate, decisions regarding the allocation of the formally owned financial assets. With the increased role of information, it seems that modern corporations are becoming more university-like.

The use of information technology certainly made traditional forms of organization, the military, the state bureaucracy and the industrial enterprise, more efficient. But it has significantly elaborated the structure of corporations. The first and most noticeable impact on corporate structures is probably due to telecommunications, telephone, teletype and data transmission. Its effects are two-fold. First, it allows organizationally decentralized corporate components to disperse geographically and geographically separate companies to become newly recruited parts of existing corporations. Second, it allows for a more efficient balancing of budgets and instant accounting for larger numbers of corporate components. The result is the emergence of increasingly powerful "invisible empires," invisible in the sense that it is difficult to locate corporate entities. The traditionally "solid" organizations that represented themselves by moving into a complex of adjacent buildings, including the production facilities, is being dissolved into a communication network of interacting components. Space is no longer a delimiter of growth, multinational corporations being the most outstanding examples.

A corollary of the efficient use of telecommunications is superior access to information about changes in labor markets, costs of raw material, local tax structures, political stabilities, and so on. Coupled with the inherent corporate flexibility, this leads to the relocation of production facilities into more cost-effective areas, often into developing countries that are

eager for industrial development. Fearing widespread unemployment, labor unions in the United States have tried to prevent such relocations and are now forced to make concessions on wages and benefits and to participate in economizing production. They become thus absorbed into corporate processes rather than fight them. The large-scale effect is that a significant portion of U.S. industrial production becomes either fully automated or is slowly moving to foreign countries, yielding increasingly significant corporate earnings from abroad. The term "de-industrialization" quite appropriately characterizes what increasingly happens to the United States.

Probably the most significant impact on modern corporate structures results from the use of information technologies, electronic computers and computer networks in particular, for data processing and for corporate decision making. Owing to the need to coordinate the increasingly many loosely connected corporate units, corporations pioneered the business use of computers before traditional forms of organizations caught up with them and they used this technology not to automate subordinate processes of production (industrial robots and automated offices) but to process, correlate, and condense vast quantities of data about their internal and external corporate environments and to thereby prepare decisions that are better informed than those made without the availability of this technology. Generally, better-informed decisions made at corporate headquarters and at negligible costs can generate or save much more capital than can be obtained by painstaking improvements in production at the periphery of a corporation. The increasing truth of this condition clearly favors investments in the information processing facilities of a corporation over investments into its means of production. Consequently many modern corporations divest themselves of their production facilities (provided that separate operation and ownership poses no threat to the corporation), become increasingly involved in information processing, create information jobs, and invest in such information resources as experts, data banks and computer networks to connect them. By not recognizing that ownership of means of production means little when the production facilities exist primarily in conjunction with the policies of larger corporations, the current tendency of foreign governments to restrict U.S. ownership of foreign factories only speeds up the process of the increasing alliance of corporate structures with information processing technology. American know-how, advanced communication technology and information processors might not be appreciated in some corners of the world, but they become increasingly indispensable in making production and society work everywhere.

In the emerging information society, corporations are amassing so much

capacity to display intelligence (in the sense of their ability to make informed decisions concerning the very societal organization of which they are a part), that the social use of this capacity increasingly dominates older forms of organization including those traditionally charged with the responsibility of government. The volume of information corporations can produce to further their interests can easily exceed a government's capacity to process it (see the volume of documents AT&T produced in its divestment case that required an army of lawyers to read them). Corporations employ the most well-informed lobby in the U.S. congress. Members of corporations occupy top level positions in the U.S. government. Although the new technology has produced a large number of very small corporations that can respond faster than large corporations can, their markets often exist as the result of larger corporations' decisions and they easily accept their model and guidance.

Although corporations are clearly kept alive by employing real people, it is the information that is processed in corporate structures, not people, that govern the contemporary economy. The corporate use of information processing technology has made corporations the "social brain" of the emerging information society.

Some Marxian Propositions

In turning the idealist Hegel "upside down," the materialist Marx had a thorough disrespect for mental constructs, ideas, and knowledge. He might have even included the modern conception of information in this list of "epiphenomena." I believe this proved fatal for his theories but not necessarily for his constructions in which I find several modern ideas. Let me elaborate some of them from a morphogenetic perspective.

System Change: Succession vs. Supercession

Marx saw social history as a history of class struggles, creating a *succession* of social systems. So the ancient slave system was replaced by the feudal system, the feudal system was replaced by the capitalist system which Marx believed would cease with the emergence of socialism. Having built his conception of society on an economic base, including the prevailing material conditions, the physical means of processing these, and the workers required in production, Marx saw the way this economic base was operated, the relations of production, ownership in particular, as coming into necessary conflict with the forces of production and thereby nourishing the seed of its own destruction. With the help of revolutionary forces

that come into being as the result of such necessary conflicts, a new social system emerges from "the ashes of the old."

However, history does not support the contention that social systems are mutually exclusive, antagonistic, or in necessary opposition to each other and that they succeed each other in a chainlike progression. The ancient slaves did not erect the feudal state nor did the journeymen and servants of the feudal landlords engineer the capitalist system. Capitalism was not preceded by a class struggle between the serfs and nobles or between the journeymen and their exploiting guild masters. The capitalist economy and the society of the bourgeoisie responsible for it grew up as an independent structure within feudalism. In fact the patriarchal organization of the guild and the freewheeling merchant associations probably constituted an embryonic state of capitalism while the feudal system flourished with their help. Although there were drastic cases in which functionally superfluous feudal lords were forcefully evicted from power, this was merely symbolic because the capitalist system already in force had made the old ruling elite dispensable. It did not simply eradicate the old organizational forms and values but absorbed them into their own. Emerging systems were all structurally more powerful, could exist on a higher level of organization, and were particularly capable of resolving conflicts the older systems could not master within their own powers.

Socialism, which according to Marx should have come about in highly industrialized societies, England, France, Germany and the United States, for example, succeeded primarily in industrially less advanced countries, Russia and China, for example, largely in the aftermath of a war and because the revolutionary leadership was convinced of Marx's ideas. This speaks against the strict economic determinism Marx advocated and in favor of the role of information in social development. Marx's theories demonstrated their potential of doing organizational work.

History speaks forcefully in favor of the contention that social systems do not succeed by replacing each other. They may coexist, often for a long time and without a struggle. New systems tend to emerge in ecologically insignificant niches where the controls by the prevailing system are marginal or ineffective. One system may *supersede* another if the latter proves to be structurally more capable of coping with problems the other is unable to master.

In the true spirit of Marx's dialectic, the new system often represents a synthesis that need not be "built on the ashes of the old" but may well integrate the old system into a more complex, adaptively more successful, and, as far as its ability to control society and its material environment is concerned, more powerful organizational form. We have ample evidence

for supercession (not succession) in the social development of the industrialized countries.

Currencies: Capital → Authority → Information

Marx saw capital as the principal currency of social development within the capitalist system of production. Curiously, his definition very much conforms to the underlying structure of the definition of energy on the one side, information on the other side, and authority in between. For Marx, capital is neither money nor property owned but putting both *to work*. The distinction is crucial and applies also to the distinction between potential energy (the energy in a tank of gasoline) and the energy consumed by performing a mechanical task (driving a car from one place to another), between potential information (a plan for a factory) and actual information (organizational work expended when building the factory). Authority too has this duality. It need not be exercised in the form of rewards and punishments but is effective by perceiving the potential of their enactment.

I would say that capital, authority, and information are three currencies among several minor ones operating simultaneously in interacting parts of a social system. The materialist Marx had no conception of information as a measure of intellectual work about which we have become aware only recently and he underplayed the significance of authority by favoring a one-dimensional framework of analysis that permits only a single all-penetrating currency: the capital. His differentiation of people into two classes, the capitalist class, which controls the capital by owning means of production and by letting it work for them, and the working class, which does not possess any capital to control, nearly exhausted the distinctions he saw as important. He observed near the end of his life the emergence of the banking system that mediated among capitalists, and he was very much concerned with the role of the state in the capitalist system which assumed a somewhat similar mediating role, he grouped the people employed in these institutions, next to two other groups to be mentioned later, into a third category, so-called "*dritte personen*" of whom those who "command in the name of capitalism" include merchants, middlemen, speculators, commercial laborers (white-collar employees), managers, foremen, and so on.

It was the category of people who "command in the name of capitalism" that developed bureaucratic administrations whose dominant currency was not ownership but authority. Authority developed within such administrations as a semiautonomous currency. Authority could not be purchased. For example, the emerging concept of "corruption" indicated the bureaucratic effort to control its own currency against the intrusion of money.

Apparently without developing a class consciousness by itself, this group introduced legislation and enacted practices that institutionalized the conflicts arising between the owners of the means of production and their workers (Dahrendorf, 1959), making ownership more of a responsibility than a way of getting rich. The banking system, insurance companies, the stock market, the labor unions, and democratic governments all cooperated, albeit implicitly, in the wider distribution of economic benefits without eliminating the capitalist class and without destroying the capitalist mode of production by absorbing both into a new and more encompassing system of bureaucratic control. (Interestingly, bureaucratic systems have also taken over the management of noncapitalist countries, such as the Soviet Union, creating there what some writers have called a "New Class" (Djilas, 1958). This transition occurred without revolution.

In the emerging information society, the ancient wisdom that knowledge can erode authority seems to have been put into large scale social practice. Interestingly, Marx's second category of *dritte personen*—by his definition those who live in the capitalist system but do not participate in it, priests, lawyers, professors, artists, teachers, physicians—having existed in an embryonic phase for a very long time now appears to come into the forefront of this latest social development. These are the creators and communicators of information. These are the experts consulting government and industry on how to do what they cannot do within their own limitations. These are the inventors and early users of computer systems and communication networks which process and distribute data at quantities never before known in history. These are also the designers of algorithms for automatic control of production processes and for the monitoring of the environment, from the weather to military movements, for making administrative and managerial decisions, for accounting for the flow of money, merchandise and people, and for governing parts of the economy without human interference, often without an understanding by those affected by these semiautomated systems.

Even so nobody doubts that information is one of the most significant currencies in the technologically advanced countries of the West, traditional methods of controlling its flow, of tracing its organizational consequences and of directing its morphogenesis have largely been failures. As already mentioned, entering information into an economic input-output table accounts only for the material characteristics of information, not for the organizational work it does. Legislation concerning copyrights of computer software, concerning the control of flexible and geographically dispersed corporate structures which are fundamentally based on information technology, concerning privacy of information, etc., are far behind and largely ineffective in the face of the speed of actual developments.

Morphogenetic theories of information are in their infancy. It is therefore no surprise that the information technology has grown exponentially and increasingly becomes a force that dominates authority, capital and other currencies and directs socioeconomic development.

Dynamics: Dialectical → Hierarchical → Multi-lectical

The original ideal of a dialectical process is very much rooted in the use of language, the Greek *dialektikos* denoting a method of intellectual investigation by dialogue. Reasoning in these terms seems to be trapped in the linguistic preference for binary opposites. One cannot easily imagine a negation, an opposite or a distance between more than two things. Although dialectical processes involve three entities, it is the pairwise interaction between thesis and antithesis (the first binary relation) that the synthesis of the two is to overcome (the second binary relation). Accordingly, Marx forced nearly all his observations into the binary scheme of a conflict between oppressors and oppressed. I already mentioned this so-called *dritte personen* who did not fit into the scheme and were considered inessential by him. Similarly, agricultural production which was initially noncapitalist in organization was not considered a third part to the conflict but a mode of production that would eventually end up being capitalist and therefore required no specialized conception. Marx made many other binary distinctions, such as the distinction between an economic base and the superstructure of a society, the distinction between forces of production and relations of production, or the distinction between use value and exchange value; all are binary.

The first blow to this binary way of thinking came, I believe, with the emergence of mediating institutions, the already mentioned banking system and state government, both of which had to simultaneously juggle with various parts of the capitalist economy. Marx was aware of the role of the state but quickly characterized it as an instrument of the ruling class, the capitalists, and thus managed to maintain the basic distinction between two antagonistic forces.

However, the increasing numbers of industrial managers not only mediated between the capitalists and the workers (if this was the primary conflict in the society Marx experienced) but they also developed independent bureaucratic forms of organization that institutionalized these conflicts. Being based on a currency that had little to do with the ownership of capital, as elaborated above, the bureaucracies had some autonomy in themselves. Authority can either arise with the emergence of individuals who are noticeably outstanding in commonly agreed upon characteristics, for example, experts, geniuses, leaders, or be assigned by virtue of the

office held, the position maintained, the work done, for example, foremen, priests, presidents, policemen. It is the latter kind of authority that brought about and was in turn instituted by the bureaucratic forms of administration that overcame ruthless capitalism. The use of this kind of authority within bureaucracies made them clearly *hierarchical* forms of organization in which each level was on the one hand responsible to and on the other hand obtained its authority from the next higher level. The top of this hierarchy was, for whatever reasons, not occupied by the owners of the means of production but by those who either rose through the ranks of the bureaucracy, were elected to the office, or were legitimized by formal procedures.

The crucial point to be made here is that hierarchical forms of organization are fundamentally different from a free market of products, money, and services and require a logic of description more powerful than the one capable of describing social change in terms of conflicts, contradictions, or oppositions between just two, or primarily two, entities. I believe the laws of bureaucracy escape Marx's original categories and the dynamics of the information society is even further removed from these categories.

I would argue, both with and against Marx, that if the idea of a dialectic has some reality beyond its ability to account for the social dynamics of early capitalism, then it should be applicable to itself and be generalized or transcended to account for the failures of earlier accounts. I am suggesting that Marx's dialectical thesis encountered its first major antithesis in the no-longer binary antagonism motivating the reality of hierarchically organized bureaucracies. The logic appropriate to account for this new reality is as much a synthesis of initially incompatible forms as the system it describes is more powerful in the sense of encompassing initially conflicting elements.

Just as in Marx's conceptions, all organizational hierarchies are based on a simple unidirectional causality, but unlike in Marx, it is a top-down causality, not necessarily directed forward in time. This top-down determinism, from a position of higher authority to a position of lower authority, coordinates individual activities and assumes that overall purposes are served on each level of the hierarchy. Each such level is constituted by (in the sense of defined within itself and in terms of) an organizational synthesis of cooperating and competing elements, whether these are holders of offices or departments (having hierarchies of their own), that are forced to interact with each other and jointly report to the level above. Each level is a synthesis of a higher ordinality than the elements contained in it. Thus a hierarchical bureaucratic system may be described as the coexistence of several levels of synthesis, each referring to or including

elements that are syntheses of elements subordinate to them. Koestler (1967) created the term "holon" to denote an entity that both consists of an arrangement of parts and participates in (higher-order) arrangements of parts. Thus a bureaucratic system is both a natural synthesis of the tension within a marketlike system, such as in early capitalism, and a natural co-growth of authority, a new currency that is largely unaffected by money flows. The synthesis arising out of binary oppositions is just a specialized (two-level, two-part) case of a hierarchy (multilevel, many-part system). There are also numerous laws of bureaucratic organizations, the most popular being Parkinson's Law and The Peter Principle, the former explaining the growth of hierarchical control, the latter the movement of individuals up the hierarchy—but I am not concerned with these here.

This hierarchical thesis is in direct conflict with the realities of an information society and it appears that the synthesis between the two is now emerging within cybernetics, the discipline most closely associated with the morphogenetic properties of systems. These morphogenetic properties are particularly prevalent in the emerging information society. This synthesis offered by cybernetics (a) recognizes and advances systems for describing the *interaction* among many entities, people, corporate units, or machines. Interaction among many entities clearly generalizes the "interaction" (conflict, opposition, contradiction) between two. It (b) recognizes and is increasingly capable of describing *unities* as formed on the basis of the interaction among parts. This explanation of the emergence of unities is wholly consistent with the intentions of Marx's dialectic but a generalization of the notion of level in a hierarchy which is there static and nominal, whereas in cybernetics it is dynamic and self-defining. Finally, and probably the most important contribution of cybernetics is the ability to describe the process as embodied in (c) a *circular form of organization*, forming unities from parts with the unities possibly becoming parts of themselves, that is, being self-referential. This overcomes the paradigmatic unidirectional causality implicit in hierarchical forms of organization and in Marx's historical determinism. It removes the ultimate authority from the top of a hierarchy, the prime mover as the unexplicable initiator of a process and the final destination, by entering the top of the hierarchy into its own bottom or by closing the circle of causality, this circle being its own best explanation. It also overcomes the binary logic implicit in Marx's class struggle, etc., which has little to say about the complex reality of contemporary society. It retains Marx's process-toward-higher-order-complexity notions. I have called this circular and multivariate process of systems development: *multilectical*.

Feedback and Closure

Marx clearly recognized how capital was put to work and, using time, extrapolated how this closed system would disequilibrate and eventually break up: the factory owner derives profit from selling his products above production costs. A portion of this profit is reinvested in production facilities which thereby continue to grow bringing him higher profits in return. The factory worker who has to ultimately pay for the ever-increasing profit becomes poorer the more he participates in trying to improve his own lot within the system of capitalist production. Finally, workers will recognize their own functional indispensability on the one side and comparative misery on the other and destroy the system of which they were a part.

Marx here described what is now known as feedback, more specifically positive feedback, which is a circular causal process that continuously amplifies an original inequality as the process goes around and around this cycle (Maruyama, 1963). In the capitalist system of production the result can be stated in a nutshell: "the rich become richer and the poor become poorer," the ideal of uniform equality being an unstable equilibrium. The fact that the system did not collapse in the industrialized West and grew instead is the result of counteracting forces or what is known as deviation-reducing, or negative feedback, which limited the apparent determinism before reaching a point of breakup. These forces were mobilized from outside the positive feedback cycle Marx described as closed.

It has been a thesis in this paper that the "counteracting forces" (a terminology derived from the homeostatic paradigm) are in fact created by the synthesis of more powerful systems, transcending those unstable forms and developing new "currencies of control." However, I would maintain that positive feedback is a feature in any societal growth, regardless of the system involved. In bureaucracies it is easily observed that people in positions of authority become more powerful by the very fact that they have easier access to the means of exerting power and amass authority at the expense of those who have little to begin with. The emergence of dictators and the growth of government bureaucracies are examples that suffice here. The same positive feedback can be observed in an information society, now checking the otherwise unlimited inequality regarding authority and capital.

To begin with, most of the traditional applications of information are rather unproblematic and have for this reason not been considered an important problem. A worker at an assembly line must have sufficient amount of information (through education, training, and experience) to do his job of putting things together. Even a manager who is to perform

leadership functions and to make responsible decisions must have acquired the appropriate skills to organize his environment optimally. Although feedback about the results of informed actions may increase success the next time around, the process is unproblematic in this context because the information involved is essentially located within the actor, not communicated to and applied by others, and the process is ultimately converging toward a stable equilibrium, defined by the optimum utilization of organizational skills and the limits of success. This feedback is negative.

Information is subject to *positive feedback* if the information that is produced and communicated to others at least in part reenters and improves on the process that produced it. This is probably the most outstanding procedural feature underlying the emergence of an information society. On the level of the individual, this process has been described by Bateson (1972) as deuterio-learning or learning how to learn. On the level of society this process increases its ability to organize its own organization. Let me give a few examples of this positive feedback involving information rather than authority or capital with which we are familiar.

One obvious example is the use of computers in the computer industry. The design of computers requires a good many decisions regarding the most advantageous arrangement of components, the optimization of such interdependent variables as speed, storage capacity, and physical size, and the development of suitable software, not to speak of marketing considerations. Such decisions are quite common in the design of complex systems, but they are also usually made by highly trained engineers. Naturally, computer manufacturers had early access to computer technology, understood its capability better than others did and used it to make their own decisions. Current electronic computers are very good at enumerating and exploring vast numbers of alternatives, some hardly imaginable by human designers, and they can easily search for an optimum path provided algorithms are general enough to be applicable to a given situation and can be stated iteratively. What a computer can do best is very much related to its own makeup and design and the application of computers to its own design has greatly increased the speed of development towards increasingly capable, increasingly flexible, increasingly portable, and increasingly interfactable computers. The Hollerith cards I punched ten years ago are now uncommon and difficult to enter in a computer. Ten years ago only a few social science students had done something with a computer, now children are introduced to this technology in toy stores. With a history of at best forty years, Feigenbaum and McCorduck (1983) now speak of a fifth generation of computers. As it is, each generation of computers is designed with the help of the computers of the previous generation. For those able to compute computation, computational ability increases expo-

nentially relative to those merely able to compute other things. This positive feedback has magnified the discrepancy between the speed of development of computers relative to the speed of development of a technology that can not be applied onto itself, regardless of how socially important it may be.

Katzman (1974) explored the social use of communication and similarly finds, that, whenever a new medium of communication, a new kind of programming, or a new technology for accessing information is introduced, those individuals that are already rich informationally become informationally richer. This applies, for example, to educational television programs, such as Sesame Street, designed to improve learning skills and interest in basic education among children, especially among the poor and intellectually deprived part of the population. In developing countries it is also used to promote literacy. While the program is indeed successful in the sense of improving motivation and knowledge in the aggregate, however, those children who come from educationally higher levels of the population benefit more from it than those who do not start with the same level of information. The improvement in the aggregate does not narrow the informational differences in the population, rather it magnifies them. In developing countries, literary programs tend to be of greater benefits to those who already have a better chance to become literate to begin with. The same amplification of informational differences is observable in the individual use of communication technology. Those who know how to use it first become literate with it earlier and obtain more information about a lot of other things faster than those whose level of information does not prepare them as well for such involvement. Information breeds itself in the fertile ground of a population that provides the positive feedback for this process to take place.

I already mentioned the propensity of corporate structures to absorb information technology faster than other structures. Here too positive feedback loops magnify the differences initially existing among organizations. Those early adopters and heavy users of information processors become increasingly more brainlike vis-à-vis their environment, tend to produce more information than material products and move into positions of control commensurate with the role their information production plays in the social processes of which they are a part.

As repeatedly mentioned, Marx observed this deviation amplifying circular causality only in how capital was put to work. Presumably owing to the extremely slow growth of information processing capacity in Marx's time, which was then nearly entirely confined to the human brain, Marx neither recognized the generality of his proposition, nor did he consider the circular causality he did observe to be open to constraints arising side-

by-side with the increasing economic differences. The examples show positive feedback to be present in the work that information does well. In Marx's extrapolation, the continuous amplification of existing economic differences spells doom to the system that contains this circular causality. Experiences in the industrialized West show such differences to reach limits much before the complete breakdown of the system sustaining them. It is the knowledge of such feedback loops (including the capability of recognizing the system) that ultimately invalidated Marx's deterministic extrapolations. Information of this kind was at least important if not decisive in opening up and curbing the process Marx described as a closed and deterministic one.

Determinism → Creation of Potential

There is an inherent paradox in trying to predict the inevitable outcome of a process that involves people who have information about that process and about their involvement in it.

Marx saw the wheel of history rolling perhaps with variable speed but in a predetermined direction. In charting the inevitable progression from one system to the next, he had to assume as he did that people had no information about their system in the sense that they had nothing that would enable them to reorganize their own situation and thereby change history. Neither the capitalists nor the workers could escape their individual destinies. He considered ideas as epiphenomena of the basic (material-economic and hence deterministic) mechanism. Enlightened people could speed up this progression but neither reverse it nor deviate from it. Prediction must always assume an observer-independent determinism which excludes information about and within the system so described thus rendering the above stated effort untenable.

By definition, individuals who possess information about something can at least in principle engage in organizational work directed towards changing this something. There may be good reasons why people might not use the information they have access to. They may not wish as a matter of preference to realize what they could do. They may not have the resources to apply all they could. They may experience psychological, social, or moral constraints restricting the use of information available to them. It may also be the case that the material circumstances (the resources to which available information refers or that are required to engage in the organizational work specified, for example, time, financial resources, and material conditions) are insufficient, rendering available information inapplicable or irrelevant. Whatever the case may be, the possession of relevant information characterises the ability to change and the possibility to exert one's

will, thereby making the process affected by it to that extent unpredictable. Thus, when people do have information about a process involving them, the process can no longer be described in deterministic terms and is to some extent unpredictable. This renders the above stated effort unacceptable for reasons complementary to those preferred by Marx.

The paradox lies in the apparent impossibility of a system to be both predictable and in possession of information about itself. Only one or the other seems possible. The resolution of this paradox involves a change in the role of the observer from an outsider (a role Marx claimed for himself) to one that is part of the system he wishes to predict (or create, actually), that is, one that allows him to communicate with other observers in and of the system including with himself. This resolution is being developed under the name of second-order cybernetics (von Foerster 1974; Krippendorff, 1982). But it is also possible to remove oneself from the paradox without relinquishing the role of an outside observer. This means abandoning the predictability criterion of validity and describing a system with information about itself in terms of constraints on its potential. The criterion of validity implied here is a negative one in that a theory about such a system can not say what will happen but what cannot happen. Such a theory is valid if the observations fall within the range of those considered possible by the theory. Bateson (1972) considered this negative form of reasoning a characteristic of cybernetic explanations. I will briefly comment on how this pertains to understanding the role of information in society.

There is little doubt that all societies require some information to cope with environmental threats and to insure the continuance of the group. The organizational work required in primitive societies may have been more reactive than is now the case but even in modern society much of the information sought is intended to solve emerging problems. But there is also little doubt that modern problems are more human-made than natural, and that the technology creating these problems is to a large extent premediated, that is, guided by information in the form of creative ideas, inventions, and improvements. It is the availability of information that provides options for alternative paths of behavior. The emergence of an information society is therefore also the emergence of a new kind of determinism that provides more options than constraints.

Elsewhere (Krippendorff & Steier, 1979) we suggested that social systems, actually any kind of system including machines, may have three kinds of input: energy or matter, organization, and information. Organization refers to how the parts of the system interact and co-produce material entities or information. The form of this interaction may have historical, individual, or informational explanations with which we dealt briefly in the

foregoing. Together with energy and material input in the form of food, fuel, material resources, and so on, from an environment, they form the *ecosphere* of the system, which consists of the interaction among several populations of different species. Contemporary society particularly includes machines and social institutions that are species in their own right. As I said above, complete knowledge of the laws of interaction operating within the ecosphere would make the ecosphere predictable save for the occurrence of genuinely random events.

The information available within a system constitutes what Boulding (1978) calls the *noosphere*. It is constituted by the collection of plans, of representations, of procedures, of ideas for the construction of objects or of instructions to realize certain interaction patterns, including "the totality of the cognitive content (and) values, of all human nervous systems, plus the prosthetic devices by which this system is extended and integrated in the form of libraries, computers, telephones, post offices and so on" (Boulding, 1978, p. 122). The noosphere contains all the options available that members of a social system can draw from. To the extent courses of actions are chosen, the noosphere also contains all possible futures of that system. It is in the absence of a noosphere that the behavior of a system is deterministic in the sense that it is doomed to follow just one "plan." To describe a system's noosphere is to describe the system's *potential* to behave and to develop, that system's possible futures.

In previous societies, the noosphere was more limited than it is today, not just by the properties of the inquiring mind and by its capacity to premeditate, to invent and to create new ideas, but particularly by the availability of storage facilities to preserve, and of communication media to transmit, the collectively created potential. It is this potential that information technology now transforms in ways unprecedented in human history. Information technology, which operates in the ecosphere as all technology does, draws from elements in the noosphere and feeds its products back into it, making the noosphere expand both in volume of options available as well as in the length of time governed by it. It is fair to say that an *information society essentially creates its own possible futures and is limited primarily by the futures it can compute* and only secondarily by its material history.

Boulding observes several processes that account in part for the unprecedented growth of the noosphere. There is the already mentioned *replication*, duplication or reproduction of information such as in printing, broadcasting and telecommunications. The power of replication gives a great deal of stability and coherence to a system in which information can decay or be selectively eliminated from circulation.

There is *recombination* or the organization of numerous existing pieces

of information into a new unit. This multilectical process is probably the one that is most unique to the noosphere. Unlike in biology where genes are combined bisexually, recombination in the noosphere is multisexual in the sense that a great many diverse things can be synthesized into a new form. For example the car was invented from knowledge of a four-wheeled carriage, of steering devices, of the need for a (mechanical) power source, and so on. A factory integrates many workers, production facilities, material and energy resources into a functional unit. The bisexual metaphor like the dialectical metaphor breaks down when it comes to recombination processes in the noosphere. Whereas bisexual recombination has great combinatorial advantages over monosexual replication, *multilectical processes are unimaginably more powerful than dialectical ones.*

There is *mutation*, the modification of existing pattern in the course of transmission, the adaptation of information to particular circumstances. Societies differ in the rate of mutation they permit and in which area of the noosphere they allow mutation to occur. When it is high, information is distorted, imitated, and elaborated. When it is low, efforts must usually be expended to counteract biases and decay.

There is *communication*, the reproduction of information at different geographical locations in society, and its complement, the *selective elimination* of information no longer "fit to survive" the competition for validity, relevance and purpose.

There is *realization* and *production*, the conversion of potential to actual organizational work, for example, the assembly of a piece of equipment, the scheduling of events or the execution of a plan. Just like the DNA is ultimately responsible for growing a particular organism, so may information bring complex processes into being. A particularly powerful form of realization, and one that operates on the noosphere itself, is the realization of information to organize other information, for example, the assemblage of computer programs into larger packages and in turn into larger systems of compatible packages, etc.

There is *description*, the complement of realization and the codification of actual organizational work into storable form, perhaps for subsequent analysis or replication of the process giving rise to it.

There is also *pollution*, the overloading of the noosphere by irrelevant information that occurs in the absence of criteria to determine its usability. The ability of computers to generate voluminous outputs from small numbers of insignificant data is a case in point. Unable to separate the wheat from the chaff, libraries are often overloaded with never-read books that nevertheless may contain some important information in the future.

There is also *cancerous growth*, the autonomous growth of a category of information at the expense of destroying information in another cate-

gory. Cancerous growth ranges from the domination of the noosphere by fads to large-scale destruction of information for the sake of an ideology or to support a social system unable to cope with the deviant information available, for example, Nazism and many modern authoritarian regimes restrict access to information that would challenge its roots.

In the emerging information society, the tremendous increase in the capacity for information storage, the phenomenal speed with which such information can be accessed, processed, and fed back into storage, the extraordinary density of communications from the telephone to the mass media which is now linked to computer processing and large data banks through powerful institutions like corporate structures, the growth of science in universities and associated with governments, all these increases in the ability to handle information, have expanded the noosphere of contemporary society to an extent still unimaginable. They also redirect social attention from tradition, from how things were done in the past and what was good about them, to the future, to what is conceivable or can be done. They also force us to reconsider the categories of sociopolitical analysis. The idea of historical determinism can certainly no longer be left unquestioned. The *creation of a society's potential* that comes with the development of a powerful noosphere including its sometimes self-generated properties will have to occupy our foremost attention.

Conclusion

We know that any system that produces, processes, and disseminates information and uses this information to continually realize and improve on this production magnifies its own systemic (specifically technological) biases, becomes organizationally closed, confining, and autonomous. We already know that the emerging information society is magnifying informational inequalities that could conceivably force another form of organization to overcome what we see happening now. While the notion of information as a form of work is, as I have tried to show, quite different from energy, capital, and authority, it is closer to the inquiring intellect and therefore of a radically different kind. What we do not yet know is whether the emerging information society with its tremendous increase in the human-societal potential to determine its future and its promise of liberation from the constraints of the past is indeed an expansion of the human mind, its ultimate trap or a mere transitional form. This paper merely suggests a framework for raising the question.

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References

- Bateson, G. (1972). *Steps toward an ecology of mind*. New York: Ballantine.
- Bell, D. (1973). *The coming of post-industrial society*. New York: Basic Books.
- Boulding, K. E. (1978). *Ecodynamics: A new theory of societal evolution*. Beverly Hills, CA: Sage.
- Dahrendorf, R. (1959). *Class and class conflict in industrial society*. Stanford, CA: Stanford University Press.
- Djilas, M. (1958). *Die neue Klasse; Eine Analyse des kommunistischen Systems*. Munich: Kindler.
- Feigenbaum, E. A., & McCorduck, P. (1983). *The fifth generation artificial intelligence and Japan's computer challenge to the world*. Reading, MA: Addison-Wesley.
- Koestler, A. (1967). *The ghost in the machine*. New York: Macmillan.
- Katzman, N. (1974). The impact of communication technology: Promises and prospects. *Journal of Communications*, 24 (4), 47-58.
- Krippendorff, K., & Steier, F. (1979). Cybernetics properties of helping: The organizational level. In Richard F. Ericson (Ed.), *Improving the human condition: Quality and stability in social systems* (pp. 89-94). Louisville, KY: Society for General Systems Research August.
- Krippendorff, K. (1984). An epistemological foundation for communication. *Journal of Communication* 34 (3): 21-36.
- Krippendorff, K. (1987). Paradigms for communication and development. In D. Lawrence Kincaid (Ed.), *Communication theory: Eastern and western perspectives*. New York: Academic Press.
- Ledger, M. (1981). The case of the E.N.I.A.C. *Pennsylvania Gazette*, 81 (October), 30-35. The E.N.I.A.C.'s Muddled History. *Pennsylvania Gazette* 81: 29-33, September.
- Machlup, F. (1962). *The Production and Distribution of Knowledge in the United States*. Princeton, NJ: Princeton University Press.
- Maruyama, M. (1963). The second cybernetics: Deviation-amplifying mutual causal processes. *American Scientists* 51, 164-79, 250-56.
- Maruyama, M. (1974). Paradigmatology and its Application to Cross-Disciplinary, Cross-professional and Cross-cultural Communication. *Cybernetica*, 17, 136-56, 237-81.
- Marx, K. (1932). *Capital*, Max Eastman (Ed.), New York: Modern Library.
- Masuda, Y. (1981). *The information society as post-industrial society*. Washington, DC: World Future Society.
- Maturana, H. R. (1970). *Biology of Cognition*. Urbana: Biological Computer Laboratory, University of Illinois.
- Odum, H. T., & Odum, E. C. (1976). *Energy basis for man and nature*. New York: McGraw Hill.
- Porat, M. U. (1977). *The information economy*. Washington, DC: Office of Telecommunications, U.S. Government Printing Office.
- Prince, D. (1961). *Science since Babylon*. New Haven, CT: Yale University Press.
- Prigogine, I. (1980). *From being to becoming. Time and complexity in the physical sciences*. San Francisco: Freeman.
- Shannon, C. E., & Weaver, W. (1947). *The mathematical theory of communications*. Urbana: University of Illinois Press.

- Varela, F. G. (1979). *Principles of biological autonomy*. New York: Norman Holland.
- Von Foerster, H. (1974). *Cybernetics of cybernetics or the control of control and the communication of communication*. Urbana: Biological Computer Laboratory, University of Illinois.
- Von Foerster, H. (1981). *Observing Systems*. Seaside, CA: Intersystems.

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