Computers and Literacy: Redefining Each Other

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Executive Summary

The turmoil exhibited by the computer industry in the early 1990s suggests that it has been undergoing a major transition during which it is redefining both itself and the future social and business roles of its products. The purpose of this report is to provide context that can help stakeholders understand the changes underway and reach appropriate decisions on actions to take—or to avoid.

The analysis depends on two sets of concepts that describe the fundamentals of how information is developed and then organized for effective communication:

- The first set concerns symbols and patterns of symbols (such as words) that acquire specific meanings, and the instantiation of these symbols into "tokens" (such as ink marks on a substrate or magnetic domains placed on coated tape) that give these symbols the physical existence needed for their use and communication.

- The second set is devoted to the nature of information products and services. *All of these* require that the *substance* of information being communicated (in the form of input tokens) be delivered in a specific presentation *format* (such as ink on paper, in letter form, delivered by mail) that has been created, manipulated and transported to end-users by applying a series of *processes* that supply the necessary materials, energy and control operations.

The main linking elements between the two sets of concepts are the tokens and formats and the processes used to create and operate on them. Formats are critical to understanding what is happening, because dramatic changes in information products and services are commonly associated with the use of new kinds of formats. The path from new technologies to their impacts on processes, tokens, and formats, to changes in products and services, and to broad implications for stakeholders is therefore central to our purposes. This path is investigated by examining the historical evolution of new formats.

This report shows how formats can be defined *at their highest level of generality* in terms of the sequences of processes used to operate on the tokens that carry the substance. A particularly important feature of these tokens is whether they are transient or durable in nature—that is, short lived (like acoustic waves in air, which leave no lasting record of their existence) or possessed of a relatively permanent character (like acoustic waves recorded on magnetic tape):

- only tokens of low durability—and only some types of these—are well suited to easy, rapid, and economical manipulation and movement *over distances*, while

- high token durability is a requirement for safe, accurate, and reliable storage and later accessibility of information *over time*.

Contents

Much of the history of information technology has been concerned with creating new classes of tokens and processes that exploit different types of physical phenomena (e.g., mechanical, chemical, electric, electromagnetic, etc.) to control durability features as desired.

A sample of current and older formats were sequenced, using a set of twenty-one generic processes. The results suggest that by the early 1990s the older and more familiar formats no longer could sustain a strong growth role, while the newer ones were still in too early a stage of development to replace them in that role. At a more detailed level, the sequences show how the newer types of formats exhibit some striking differences from the earlier ones:

• They frequently are very action-oriented, helping people to "do things," rather than simply absorb or enjoy an information product.

• They provide for more user control over events, so the user can gain both convenience in use and ability to manipulate information to meet individual needs.

• They can be very fluid and open-ended in structure, with the outputs of one sequence of processes the starting point for another series.

• The fluid structure extends to the input phase, and to authorship; formats that permit very high levels of participation become easy to provide.

• The fluidity also permits great presentation variety; the new formats offer enormous freedom of choice, so that the mode and structure of presentation can be matched to the functional purposes of a product.

These benefits are not without costs; the users of the new formats are burdened with requirements to obtain considerable equipment, to acquire software and "rights" to access desired on-line information, to develop and maintain a variety of skills, and to accept responsibility for the personal management and control of almost all of their deliberate uses of information. These needs can amount to requiring a new form of user literacy. Society as a whole will have related costs, just as it did (and still does) to support the means whereby most of the population can be helped to an acceptable level of traditional literacy.

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Chapter One

Introduction

1.1 The Crisis

The computer industry, tumultuous even in its calmest times, showed signs in the early 1990s of being at an evolutionary watershed. The symptoms of structural death and structural birth seemed to be swirling in a melée of stark contrasts. There were disasters in the traditional mainframe and minicomputer markets, price wars in personal computer (PC) hardware and software, and grim declines in the fortunes of some once-strong industry participants; but there also was strong continuing growth and profitability on the part of other (often newer) competitors!

What was going on? Some considered the situation simply the downside of a cycle in industry fortunes, amplified by a general world recession. Others suggested that it derived mainly from growing industry maturity. The view presented in this report is that, although other factors contributed, the primary source of the turmoil has been a major transition that only recently got underway and is moving us in new directions for the sources of future growth and toward new paradigms for the future roles of computers. In the process, the transition will redefine not just computing but also the nature of future literacy—and what it will mean to be, and take to become, literate in a meaningful way.

Computers have already redefined themselves many times, and, as they did, they redefined many of the ways people work with information and even work in general. But there is a critical difference this time: the coming of age of digital electro-optical technologies.[1] Devices based on these technologies are most openly exemplified by PCs, but they also are actively used, or quietly embedded, in *every significant type of communications and information product and service*. With the ever greater performance digital devices can provide, one after another of the older limits on what can be done is being broken, and applications that could never have existed within the old confines are on their way to becoming commonplace. So the redefinition of the early 1990s covers *far more in its scope*

[1]The term "digital electro-optical" is used here to refer generally to advanced digital electronics, including hardware elements (such as optical disks) that also rely on the use of some attribute of light.

than just computers and, simultaneously, goes *more deeply than earlier redefinitions into the nature* of the business and personal information activities that can be affected.

Some of the capabilities that will characterize the new types of computer uses began receiving attention long before the technologies were ready to support practical applications. There is nothing new about concepts for software intended to offer or make use of high levels of user interactivity and communicability. Or for tools to help collective work. Or means to find and use information more effectively, such as through programs that can help search for, filter, prioritize and link materials. Or for integrating multiple types of media in a single computer product for work, education, or pleasure.

By the early 1990s, many simple variants and precursors of such applications were available on the market. Some had been conceived and worked on for a decade or more; others, like bulletin board systems, had grown up almost by accident, as users began to experiment in efforts to solve personal work problems. But these are just the tip of the iceberg of what is possible. Meanwhile, as these individual products were being worked on, very little overall context was developed to help gain perspective on the full extent of the changes to be expected and how the various pieces might fit together.

The purpose of this report is to provide a context for interpreting the changes underway which can help the many stakeholders (authors, actors, producers and publishers, distributors, regulators, users, etc.) to:

- understand events better, as they unfold;
- recognize opportunities and threats more quickly and the presence (or absence) of critical factors on which they depend; and
- reach planning and other decisions with more explicit recognition of the various risks and assumptions involved, including social and political factors as well as economic and technical ones.

1.2 Developing Context

The starting point for building the desired context is two sets of concepts that describe the fundamentals of how information is developed and then organized for effective communication:

(*i*) The first set concerns symbols and patterns of symbols (such as words) that acquire or are given specific meanings, and the instantiation of these symbols into "tokens" (such as ink marks on a substrate or magnetic domains placed on coated tape) that give the symbols the kind of physical existence needed for their communication (to oneself as well as to others).

(*ii*) The second set is devoted to the nature of communications products and services. *All of these* require that the *substance* of information communicated (in the form of input tokens) be presented in a specific delivery *format* (such as ink on paper in letter form, delivered by mail) that has been created, manipulated, moved, and made available to end users by applying a series of *processes* that supply the necessary materials, energy, and control operations.[2]

The main linking elements between the two sets of concepts are tokens and formats and, indirectly, the processes used to create and operate on them. *Formats are critical* to understanding what is happening, because dramatic changes in information products and services are commonly associated with the use of new kinds of formats. But new formats normally arise from the use of new processes, often applied to creating new types of tokens or manipulating existing ones in new ways. Sometimes, as in the case of radio and television, whole families of new formats evolve from the application of new types of tokens. In other situations, the influences were more subtle. To illustrate, the introduction of printing made it possible to produce books with exactly similar content, and thus with consistent pagination. Before then, the contents of individual pages (for the same total document content) differed from one scribe or copy to another, making pagination relatively futile. With effective pagination, tables of contents, indices, references, cross references, and other positional information could be used, changing the nature of scholarship. The combination of consistency of content and positional information greatly aided books in their competition with scroll formats.

The new process capabilities, in turn, may rely on new kinds of physical materials or new sources or ways to employ energy; changes in these areas often are the entry points for new technical applications in the information industries. The path from technologies and processes to tokens and formats to changes in products and services to broad implications for

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[2]The terminology used here has been used in previous Program publications (such as Martin L. Ernst et al., *Mastering the Changing Information World* [Norwood, N.J.: Ablex Publishing Corporation, 1993]); much of it was developed some decades ago in connection with philosophical analyses of the nature of communications.

stakeholders is, therefore, central to our purposes. This path can be investigated by examining the historical evolution of new formats.

Although the success of new formats is powerfully influenced by economic and social factors, their very existence and potential practicality usually will be established by the availability of suitable (and often new) processes. This dependence suggests that formats can be defined *at their highest level* of generality in terms of the sequences of processes on which they are based. At that level, for example, traditional correspondence by letter depends on only two generic processes: application of a pen or typewriter to paper followed by a form of "mechanical" delivery, such as by the United States Postal Service. Most formats are more complicated, and the generic processes can be extremely complex; at the detailed level they can have arbitrarily large numbers of subprocesses. Nevertheless, using members from a set of twenty-one generic processors, a very wide range of formats can be defined in a way that meets the needs of this report.

The processors mentioned above belong to five general categories of devices or activities: input devices, delivery mechanisms, terminals, presentation devices, and enhancers. When the processors are employed, they operate on streams of tokens—creating, organizing, changing, storing or moving them, or outputting them in a form that a user[3] can absorb. A particularly critical feature of these tokens concerns whether they are transient or durable in nature—that is, short-lived (like acoustic waves in air that leave no lasting record of their existence) or having a relatively permanent character (like acoustic waves recorded on magnetic tape). This importance arises because:

- only tokens of low durability—and only some types of these—happen to be well suited for easy, rapid and economical manipulation and movement *over distances*, while

- high durability is a requirement for the safe, accurate, and reliable storage and later accessibility of information *over time*.

Much of the history of information technology has been concerned with creating new classes of tokens that exploit different types of physical phenomena (e.g., mechanical, chemical, electric, electromagnetic, etc.) to achieve desirable durability features, and with building

[3]For convenience, the term "user" is employed quite frequently in this report, with the understanding that the concept can cover all types of recipients and active intermediaries as well as individual initiators or manipulators of information.

associated tools to create these tokens, and to move them and change them to tokens of a different class and/or durability.When the high-level process sequences from a sample of current and older formats are examined, a number of trends can be noted that, overall, support the view expressed earlier that we currently are undergoing a major sea change, a transformation still in an early stage of development. In essence, we are in a period when older formats can no longer sustain strong growth rates while newer ones are not yet able to replace them as growth drivers. To illustrate, there is a limit to what can be done with a printed periodical, a traditional movie, or a noninteractive TV show, and this limit has largely been reached. But new types of formats, such as interactive multimedia, are still at a "market-testing" stage, where the attributes and structures needed for success are being identified. Until these factors are better understood, the newer formats cannot serve as major growth drivers.

At a more detailed level, the sequences show clearly how the newer types of formats exhibit some striking differences from earlier ones:

• They frequently are very action-oriented, helping people to "do things," rather than simply to absorb or enjoy an information product.

  - There are many examples of this action orientation in both recreational and work-like activities: contrast video adventure games with passive TV watching, or maintaining records in personally designed databases with keeping them as ink-on-paper lists on pre-printed forms.

• They provide for more user control over events, so the user can gain convenience in use and ability to manipulate and process information to meet individual needs. In some formats, the manipulation capability even extends to user operations within remote, provider-maintained files.

  - An example here is the difference between conducting an electronic database search from home and searching through a card catalog at a library.

• They can be very fluid and open-ended in structure, with the outputs of one sequence of processes becoming (sometimes almost immediately) the starting point for another series. Important opportunities are created by this flexibility; for example, new types of publishing can evolve, in which a "product" is never completed in even a briefly stable form but has a life-like aspect as it keeps incorporating changes, adding new elements, and casting off obsolescent ones.

  - Compare newsletter print publishing with what could develop from the evolution of electronic bulletin boards devoted to the same subjects.

• The fluid structure extends to the creation phase and to authorship; formats that permit very high levels of participation are easy for the new technologies to handle. Eventually, these capabilities may provide the first ever systems for effective and low-cost many-to-one and many-to-many communications that *do not* depend on physical presence of all participants.

– A mixture of electronic mail systems and bulletin boards can offer a full spectrum of choices between privacy and openness of communications and between contact with restricted and with very wide audiences; the contrast to conventional systems alternatives is great.

• Another area where fluidity offers great advantages is in presentation variety; here the new formats can become capable of offering creators and end-users enormous freedom of choice regarding desired modes and structures of presentation output. Most commonly discussed under the rubric of multimedia, the balancing of the use of each type of medium for just those functional purposes for which it is likely to be most effective may turn out to be one of the strongest long-term benefits to be derived from the new formats. The impacts of these techniques on education may finally bring to fruition some of the old, but unmet promises of computer-based learning, especially for those seeking (or having to seek) self-education that involves few or no ongoing links to any traditional academic institution.

• These benefits are not without costs; the users of the new formats are burdened with requirements to obtain considerable equipment, to acquire the financial and other software and "rights" to access desired on-line information, to develop and maintain a variety of skills, and to accept responsibility for the personal management and control of almost all of their deliberate uses of information. Society, more broadly, will have related costs to carry, as it does now, to support the means whereby most of the population can be helped to an acceptable level of literacy.

The remaining chapters of this report will follow the path described above, adding detail, examples, and analyses. Many social, economic, and political trends and events will contribute to shaping how future new formats are identified and evolve; and many advances in a wide range of technical areas will be critical to the pace of progress. The benefits of the new formats are sufficiently large and widespread that strong and continuing growth in their development and use is a reasonable planning assumption for all those potentially subject to their consequences.

Chapter Two

Communications and Information

2.1 Talking and Writing

A prior report[1] made the point that when users operate a PC, they are engaged essentially in a special form of self-communication, with the computer acting as intermediary, advisor, slave, and (occasionally) tormentor. This can serve as a useful starting point for examining how uses of personal computers have grown in the past and what possibilities may emerge in the future.What are the fundamentals of how we communicate information? As mentioned in the Introduction, two sets of concepts are important to addressing this question. The first concerns the basic components of "languages" of all types, and the second covers the elements required for building a "bundle" that contains an information output in communicable form. Both sets of concepts have been discussed in prior reports published by the Program on Information Resources Policy (PIRP)[2] and will be examined again here, but in the specific context of contributing to an examination of the past and potential roles of personal computers in information activities.

The origins of human communications, in their most primitive form, are uncertain, but the end effect was that, over time, limited sets of sounds and body motions acquired or intentionally were given specific meanings. They became symbols of real objects, threats, actions, feelings, and so on, enabling them to become the basic elements from which working languages evolved. In addition, simple analog sketches, paintings, and statues began to be used in ways that suggest they too had acquired the status of meaningful symbols, but probably not with a "vocabulary" large enough to justify considering them also as constituting significant languages. In time, individual basic sounds (phonemes) began to be employed in a variety of standard combinations or "patterns," increasing greatly the potential sizes of the "vocabularies" of emerging languages. In similar fashion, gradual acceptance of specific practices for relating the order of use of combinations of sounds (e.g., words) to the detailed

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[1]Martin L. Ernst, *Users and Personal Computers: Languages and Literacy, Costs and Benefits* (Cambridge, Mass.: Harvard University Program on Information Resources Policy, January 1993, P-93-1).

[2]See, for example, Anthony G. Oettinger, "Building Blocks and Bursting Bundles" and "The Abundant and Versatile Digital Way," in Ernst et al., *Mastering the Changing Information World*.

meanings of a collection of such combinations (phrases and sentences) started the evolution of local grammars. Gradually, very sophisticated oral languages arose and spread

2.1.1 Patterns

Much more significant to computers was the development of written versions of languages. These required two steps: the creation of sets of symbols and patterns that could be used to express the oral languages and the creation of "tokens" that could instantiate the patterned symbols in an appropriate physical form. Two general approaches (with many minor variants) were used to solve the pattern problem, one based on phonetic representations, the other (initially) on the use of ideograms.

The *phonetic approach* leads to digital systems that encode alphabets, whose letters (alone or in combinations) amount to symbols of particular sounds.[3] Ideally, each letter in an alphabet would represent a specific phoneme (or, perhaps, a very commonly used combination of phonemes), but this never has been practical. Over time, pronunciations keep changing and local dialects keep arising, making earlier letter-phoneme relationships obsolete. Although spelling also will change over time, for many reasons its rate of change is slower than that of pronunciation.

The first patterning step, therefore, involves establishing an accepted set of letters, presented in a specific order, as symbolizing a given oral word (itself the symbol of an object, feeling, etc.), regardless of current or potential pronunciation. Thus, "weight" and "wait" have quite different meanings, even though (currently) they have the same sound; and local dialects offer a wealth of examples of different sounds being applied to the same set of letters.

Additional patterning is used to deal with setting the appropriate order of a series of words and with a variety of other features (use of capitals, punctuation marks, specific font types and sizes, etc.) to establish the family of accepted patterns for the written portrayal of combinations of words in a given oral language. These patterning operations can improve the appearance of text, help establish context, and indicate emphasis that would be provided by intonation and voice strength during oral delivery of material.

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[3]There are numerous non-alphabetic, non-oral, digital languages, but these are ignored here. Typically they are based on codes, with one or a few symbols standing for a whole word, phrase, or sentence; this tends to limit their use to specialized purposes that require only limited vocabularies. Examples are Navy flag signals and, presumably, American Indian smoke signals.

Table 2-1 summarizes the symbol and pattern features of oral and alphabetic languages. It also illustrates the recursive, or "nesting," characteristics commonly encountered in the study of the nature of information (the example here being entries that are symbols of symbols).

The *ideographic approach* derived from analog systems in which simple symbolic images were created and combined. The original images probably were simple pictographs formalized and used, singly or in combination, to represent objects or concepts that correspond to specific spoken words. Again, patterning was needed to relate specific combinations of ideographs to particular words, especially words concerned with emotions and abstractions, and to establish acceptable orders of presentation and other features for effectively communicating a desired item of information substance. During this evolution, some or all of the analog attributes will be abandoned, and the ideographs will increasingly become arbitrary symbols. Eventually, the ideographic language becomes what amounts to a special form of digital language, but one based more on a "vocabulary" than on an alphabet.

An important feature of the information revolution is the flexibility offered by modern electro-optical technologies. These enable rapid and (to the user) easy conversions between digital and analog symbols, so that the two approaches can be combined in ways that exploit the virtues of each.

2.1.2 Analog, Digital, and In-Between

The phonetic approach, as noted above (section **2.1.1**) leads to a digital form of communications, while the ideographic version will usually retain important aspects of its analog origins. Each form has advantages, relative to the other, in some circumstances. The analog approach is relatively independent of the oral language being employed as has been demonstrated (in China, for example) by its use across major dialect differences that effectively amount to different languages. The alphabetic approach, in contrast, depends critically on the particular oral language associated with it; but digitally based writing is far easier to learn than writing that involves ideograms, and digital structures have inherently a type of flexibility well matched to the capabilities of modern electro-optical technology. In practice, most languages employ at least some elements borrowed from the alternative approach: ideographic languages tend to employ digital Arabic numerical notation, while

Table 2-1

Symbols and Patterns: Structure and Nesting

LEVEL	SYMBOL OF	EXAMPLE	FEATURES OF THE PATTERN INVOLVED	FOLLOWING PATTERN
A. AUDIO DELIVERY				
A sound	Usually nothing until combined with other sounds	"Duh" as in "dog"	Usually no significant pattern involved	Spoken words—that is, combinations of sounds that have specific accepted meanings
A sound signal	Specific warning or action	Fog horn, bugle call	"Local" and specialized coding	Sometimes an identity indicator
A spoken word	Object, action, attribute, feeling, concept, etc.	Spoken "dog"	Pitch, loudness, speed, intonation, inflection, and similar characteristics	Spoken phrases, sentences, paragraphs, etc.
B. ALPHABETIC SYSTEM DELIVERY				
Letter of a phonetic alphabet	A sound	"d" being the symbol for the sound "duh"	Fonts, sizes, styles, and similar attributes	Written words—that is, combinations of letters that represent a specific spoken word
Written word	An oral word—that is, an object, action, attribute, etc.	"Dog"	Upper case or lower case; font or font features; presented in Morse code, Braille, etc.	Accepted combinations of words to form phrases, sentences, etc.
Written phrase or sentence	Object, etc., in a particular context	"The barking 'dog' ran toward the car."	Particular words chosen to establish context, the order of word presentation (chosen from a set a acceptable possibilities), and suitable punctuation	Higher orders of coverage and organization

alphabetic languages use pictographs for many specialized purposes, such as highway signs and various hazard warnings.

So far, only what might be termed "general purpose, everyday" languages have been considered. The digital-analog characteristics of language are far more sharply illustrated by turning to what might be called "special purpose languages." Some of these merely involve specialized vocabularies used in many professions (law, accounting, medicine, etc.), both to meet real needs and to preserve a professional mystique. Others require a mix of digital and analog elements to portray the desired information content efficiently.

Among the older mixed representations are those used for maps and for recording architectural and engineering plans and musical scores. Maps and plans are primarily analog drawings, but the most useful of them almost always include some digital elements (place names, dimensions, materials specifications, etc.). Musical scores are in many respects digital, but their appearances have powerful analog aspects that can provide a strong sense of how the music will sound even to those who cannot "read" the score. Tables of business and government organizations, political cartoons, electric and electronic schematic diagrams, and mathematical equations and plots all have both vocabularies and grammars (specific accepted symbols and conventions and structures for their use), and all these forms of presentation employ a varied mix of digital and analog elements.

Even more interesting are some of the newer specialized languages, such as those used in biogenetics and protein chemistry. Information on the composition of specific proteins can be provided completely and with perfect accuracy in digital form, in long listings of alphabetic letters and numbers that describe the quantities of different elements present in specific protein molecules. For many purposes, however, effective use of information presented in this purely digital form is impossible; in those situations, the same information acquires a great deal more significance when inserted into a complicated analog diagram that indicates the geometrical structure(s) assumed by the particular combination of elements. The most effective diagram is a three-dimensional one which the viewer can rotate—a possibility that, for most purposes, did not exist until computers with considerable power became available.[4]

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[4]Solid models could be used for research and engineering purposes and in museum displays, but their level of use was very limited.

An even more widespread example of the mixed type of language is the computer graphical user interface (GUI), developed at the Xerox Palo Alto Research Center and brought to widespread public attention when used in the Apple Macintosh. This highly successful interface features a system of analog icons, which can be selected among using a tool such as a mouse. The icon analog approach is backed up by a set of digital keyboard codes for many of the same commands. For the beginner, the intuitively appealing icons are very much the preferred means to control the computer while, among the more experienced, the digital keyboard often provides a faster and more efficient alternative. In this example, therefore, the use of a mixed language structure enables users to take advantage of the best features of each type!

The importance of mixed analog-digital forms for portraying information, and of families of related ways for showing the same information with different analog-digital mixes, appears to be growing. Computers are particularly well suited to this area and have the potential to make important contributions.

2.1.3 Tokens

All communications depend on the use of some type of physical representation of the patterns that constitute the substance carried by a message. We call these instantiations "tokens." While they are physical, they need not be tangible; and, even if tangible, they may not be durable. Patterned modulations of high-frequency electromagnetic waves furnish an example of nondurable, intangible tokens: air pressure waves that carry sounds to human ears are tangible tokens (since they can be felt) but they are not durable. Written languages have achieved most of their value from using tokens that are both tangible (they can be directly seen) and durable.

An enormous variety of types of tokens have been employed for "written" communications—carvings on rock, scratches in wax or clay, knots on a piece of rope, raised bumps on paper, among many others. The dominant mode in recent history has been ink (delivered by pen, typewriter, or printing machines of one kind or another) on a surface of papyrus, parchment, or paper. Only in recent years has competition to print arisen, in the form of computer-driven electronic displays.[5] One competitive disadvantage of these displays

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[5]See Martin L. Ernst, *Electronic-Print Competition: Determinants of the Potential for Major Change* (Cambridge, Mass.: Harvard University Program on Information Resources Policy, 1989, P-89-4).

is that the information tokens they use directly are not durable. A result of this deficiency is that electronic displays have tended to be employed mainly in situations (such as in air traffic control) where relevant information must be used immediately, or under conditions where durable back-up versions exist (or the user can cause to exist) on paper, magnetic tape or disk, micro-fiche, or the equivalent.

In spite of being the dominant durable token set during most of recorded history, the level of use of ink-on-substrate tokens in the general population was not high until the mid-nineteenth century. Many factors were involved, principally the high costs of production and distribution; this problem was strongly amplified by contemporary societal values and by inhibiting regulatory and tax structures established to reflect those values. Technology (most directly through lowering production and delivery costs) played a part in changing that situation; the emphasis on technology in this report, however, should not blind us to the many other forces that contribute to success and failure.[6]

2.2 How to Make Information Useable

2.2.1 Substance, Format, and Process

Information and communications are tightly intertwined; an information item that has not been communicated (to oneself or to others) has no more significance than a sound no one has heard. This intertwining implies that the content of information cannot form an information product by itself; there must be other ingredients that give this content a suitable degree of communicability. A broadly useful way to incorporate the needed ingredients is to define information products or services in terms of three different elements or "building blocks":

- *Substance* (the informational content) to be transmitted or received, in the form of a set of patterns (and associated tokens) created by oneself or by another,

- *Format*, which provides the detailed definition, arrangements, and organization for presenting the set of substance patterns created and then transmitted or moved to the desired destination, using appropriate types of tokens and suitable intermediate formats for each step of the creation, movement, and presentation activities,[7] and

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[6]Some societal factors that can have important impacts are well documented in Richard D. Altick, *The English Common Reader: A Social History of the Mass Reading Public 1800-1900* (Chicago: University of Chicago Press, 1957) and M.T. Clanchy, *From Memory to Written Record* (Cambridge, Mass.: Harvard University Press, 1979).

[7]Note that this definition, with its inclusion of intermediate formats, is broader than the usual interpretation of "format"; normally this term is associated only with the final presentation format.

• *Processes*, which provide materials, tools, and energies to instantiate patterns as token sequences, to change one type of token to another when required, and to manipulate and "move" the various tokens as needed for delivery and presentation at the desired user location.

Using these definitions, an information product or service is created by developing a "bundle" that comprises one of each type of building block: a body of *substance*, a *format* judged appropriate for communicating that substance, and a set of *processes* (each using specific materials, tools, and energy inputs) expected to meet the requirements for production and distribution effectively in the selected format.

Table 2-2 presents some simple examples of application of these definitions. The top part of the table shows a number of the common, current substance-format combinations in use, as a function of the nature of the substance being communicated. The bottom portion lists a number of the processes that may be involved in bundles that provide ink-on-paper products and services. In the table, only some of the formats and processes that could be included are shown. At a more detailed level, there are a lot of relevant but unmentioned formats (such as TV delivered by cable, satellite or video cassettes) and intermediate processes (each with a possible requirement for changes in token types, or arrangements that amount to temporary "hidden" format changes). This highlights the fact that, while the application of the bundling structure is quite simple in concept, it can be made very complex in practice by going into greater and greater detail concerning the final outputs and the various intermediate operations used for producing them.

Although considerable detail may be needed when planning individual new products, or product lines, the main value of the bundling concept arises when broader perspectives are important. As noted elsewhere:

> Information resources in turn are made up of information products and services. These products and services are bundles of substance, format, and process. Substance, format, and process are building blocks; they can be used alone or in an infinite number of combinations, which can be taken apart and put together again. The way the blocks are combined or used depends on convention, namely, on the fairy tales dominant at the moment. Thinking in terms of these building blocks helps avoid entrapment by conventions that were appropriate to some moment in history but whose time has long since gone. When needed, untying the basic building blocks sets free once

Table 2-2

Information Bundles

A. Substance-Format Combinations

Substance	Common Formats
Personal News	Ink-on-paper letter, or sound waves via telephone
World News	Phosphor-on-glass CRT for broadcast TV, or sound waves from broadcast radio speaker, or print-on-paper newspaper
Airline Reservation	Travel agent electronic message and magnetic disk record on computer-computer link to airline
History of Computers	Ink-on-paper book
Adventure Story	Ink-on-paper book, or phosphor-on-glass CRT for broadcast TV, or photographic grain on celluloid movie

B. Processes for Information Products Using Ink-on-Paper Formats
(The list covers many Format variants; no single one of them is likely to use all the Processes shown)

Create and Prepare
- Observe
- Collect
- Analyze and organize
- Write or tabulate
- Edit
- Lay out
- Index

Produce
- Pen paper
- Type paper
- Word process paper
- Prepare plates
- Print
- Collate
- Fold
- Bind
- Cover
- Pack

Distribute
- Address
- Bundle
- Originator pick-up
- Transport
- Destination drop-off
- Unbundle and sort
- Deliver

Manage
- Acquire:
  - personnel
  - finances
  - equipment
  - supplies
  - manuscripts
  - subscriptions
  - advertising
- Market:
  - promote
  - advertise

> again the creative and discretionary possibilities in their multiple potential combinations. . . .
>
> As needs and tastes for substance change and as new formats and processes come to hand, bundles of an earlier time come undone. Familiar products and services come apart. New ones come and go through trial, error, more trials, and more errors until stabler mixes settle in once again.[8]

It is in the roles of helping to establish perspective and understand better the sources of change that the bundling concept can contribute to the current work.

2.2.2 Changing Bundles, Building New Ones

The potential for making changes to existing information bundles can arise from many sources acting through influences on any one of the building blocks or on a combination of them. The initiating sources have their roots in a mix of technical, demographic, socio-cultural, economic, business, and governmental factors (with national defense sometimes an important contributor). At any given time, some of these factors are likely to be acting to create specific opportunities or pressures for changes, while others may be acting to inhibit or veto possibilities. Most changes are incremental, but occasionally a series of closely related changes will together produce impacts of a size and speed provoking (but not necessarily deserving) the term "revolutionary." The changes following the invention (or, more accurately, reinvention in Europe) of movable type, the development of steam-powered rotary presses, and the widespread introduction of computers are examples of types of events that attract such terminology.

As these examples suggest, most periods of rapid change tend to be identified with a particular new technology. This certainly is partly justified, although the nature and rate of penetration of applications of the new technology—and even the timing of discovery or invention of the technology—are often dominated by the non-technical factors described earlier in this section. Regardless of such considerations, there is no doubt that the ability of technology to be a critical enabling force justifies a somewhat closer look at how it operates. The development and spread of new technologies is itself, a major subject of study, so the

[8]Oettinger, "Building Blocks and Bursting Bundles," 17-18.

examination here of the enabling role of technology must be quite limited and will be confined to experience in the information industries.[9]

While there are some major exceptions, the early uses of a new or improved technology within the information industries most commonly will be in the process area. From there, the impacts will permeate substance and format, involving other new technologies (including some in the substance and format areas) as the influences spread. In general, changes in process appear in the form of better and/or cheaper:

- *Materials*, to be used in final products or presentation devices, or for support of intermediate products or operations,

- *Tools and procedures*, for collecting, recording, fabricating, transporting, and disseminating information-related items,

- *Energy types and sources*, and ways to make more effective or convenient use of energy,

- *Procedures and mechanisms* (some of them made very important by the improvements just cited) for management and general support of the overall operation, and

- *Combinations* of the above.

There are countless everyday examples of all the kinds of technological influences listed above. A feel for the variety of possibilities is given by the entries in **Figure 2-1**, described shortly.

The uses of new information technologies can create changes that gradually affect all of society. These changes operate broadly in two ways: by reducing costs of existing information products and services and by enabling new types to be brought to market. The cost-reducing impacts can build markets both by making existing products more affordable and by making economically feasible the production of new types of products (e.g., new substance-format-process combinations) that were already technically feasible but only at costs too great to build a viable market. The product-enabling impacts allow the creation of entirely new types

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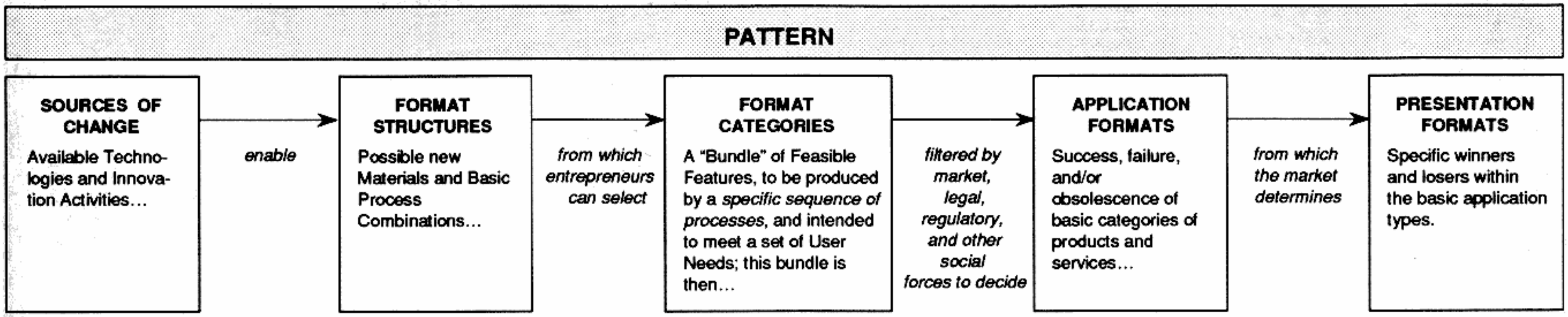
[9]Examples of literature on technology development and spread include: George Basalla, *The Evolution of Technology* (New York: Cambridge University Press, 1989), Henry Petroski, *The Pencil: A History of Design and Circumstances* (New York: Knopf, 1990) and *The Evolution of Useful Things* (New York: Knopf, 1992), and Ruth Schwartz Cowan, *More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave* (New York: Basic Books, 1983).

of products that simply could not be built or, in some cases, even conceived in any way that had a practical basis—before the new technology became available. In many situations, the most important sources of change arise in intermediate materials, assemblies, or products (such as improved liquid crystal molecules or microprocessor chips), rather than directly in the final products.

Figure 2-1 summarizes this view of how formats are enabled, conceived, and tested to determine their social and economic acceptability. It contains examples of how formats become more completely defined as successive steps are taken through the pattern. The ways used in the examples to split format definitions at one step into those for the next step are entirely arbitrary; many alternatives are available. As discussed in more detail in **Chapter Three,** there is no standard taxonomy for describing formats.

Whether arising from incremental growth or springing full blown from a technical breakthrough, the most important impacts of new technologies have been the new format possibilities they create. Except when near-analogies already exist, new formats will be the component of new information bundles most different and unfamiliar to both producers and end-users. Considerable experimentation in what may be a small and ill-defined market may be needed to identify and then implement favorable versions of the new product. Whenever a new format is being provided, some user training—or, at least, some acclimatization of a user segment—may be required to prepare the groundwork for effective market growth. The introductions of new formats often will be relatively high-cost, high-risk operations. Fortunately, the new formats also can offer very high rewards to individuals and societies.

The above characteristics give the format component a rather special position in the evolution of information products and services. To provide more background, the next chapter presents a careful look at the *sequences of processes* needed to deliver information substance in a variety of specific old and new formats. These process sequences are effective descriptors of many characteristics of formats; and they provide a link between technical capabilities and the "feasibility envelope" of possible and practical new formats of the future.



EXAMPLES

STRUCTURE	Ink-on-paper by printing	Two-way voice by electronic means	Sound/music by electro-mechanical means	Alpha-numeric material by electronic means
CATEGORIES	By output physical package: 1 - [Scroll] 2 - Single page 3 - Folded sheets 4 - Minimally bound pages 5 - Well-bound pages	By user mobility situation: 1 - Stationary 2 - Mobile	By storage medium employed: 1 - None—real-time delivery 2 - Mechanical 3 - Magnetic 4 - Electro-optical	By presentation device: 1 - Printed-on-paper 2 - CRT screen 3 - Flat panel screen
APPLICATIONS	1 - None currently significant 2 - Short letter, Notice 3 - Newspaper, Flyers 4 - Short Reports and Periodicals 5 - Books	1 - [Point-to-point telephone], networked telephone 2 - Radio telephone, cellular telephone, mobile radio/CB radio	1 - Loudspeakers, radio, TV, telephone 2 - [Paper rolls], [records] 3 - Magnetic tapes/cassettes, digital audio tapes 4 - Audio CD's	1 - [Ticker tapes], [telegraph/ telex], facsimile, computer printer 2 - On-line databases, videotex , electronic mail, CD ROM 3 - As for (2) above

Notes:
1. Examples shown in brackets [......] have become, or are becoming, obsolete.
2. APPLICATION entries apply to CATEGORY entries in the same column that have the same numbers.

Figure 2-1

The Evolution of Formats

Chapter Three

The Structure of Formats

3.1 Formats High and Low

Like a number of other words in the vocabulary of the information world, the term "format" is overstretched and underdefined. Format was described (in section **2.2**) as concerned with "the detailed arrangement and organization for presenting the set of substance patterns. . . ." While that sounds simple, many difficulties arise in use of the word because of the range of levels over which the term must be applicable. At the highest level, format is concerned with the fundamental, almost strategic, character of presentation arrangements, such as "print on paper delivered by mail" or "video via broadcast TV." After playing a comparable role as a descriptor of the materials, processes, and organizations involved in what can be a long series of intermediate levels, at the lowest level the same word is still in use, this time in its most common meaning, which covers quite fine details like fonts and font sizes, page layouts, use of columns and graphics, size and type of paper, and similar matters.

In general, at the top format tends to be a creature of techno-economics, because the fundamental format possibilities derive largely from the available technologies. Toward the bottom, format is increasingly influenced by pragmatic aesthetics—balancing costs against the value of including specific features and quality elements that will likely appeal to a particular market segment. At this level much of the "brand identity" of a product-line can be established, a matter of major importance in many media areas.

There is no generally accepted classification system, or hierarchy, for describing the various format levels or the features that characterize each level. An organizing principle, particularly at the highest level, could be valuable for understanding better how formats have changed over time and what the prospects are for different format possibilities in the future. Accordingly, a trial organizing approach is described below, based on two elements: (*i*) the types and sequence of processes that must be employed if information is to be presented in a particular high-level format,[1] and (*ii*) a specific attribute with special importance to all types

[1]This approach implies that formats can be viewed as patterns of processes, somewhat parallel to the way substance can be regarded as patterns of symbols.

of information products: the durability of the input and output tokens used in the series of processes.

There are many reasons why token durability is an appealing characteristic to employ when differentiating among broad groups of formats. First, much of the early history of information technology was concerned with finding better means for making durable substance tokens and lowering their costs; more recent developments have followed a path that emphasizes quite different and more varied token features. As a result, durability is a good divider of all high-level formats—both in historical terms (between older and newer groups of formats) and in regard to the nature of the information materials involved (for example, fixed text and images or dynamic forms like audio or video). Another reason durability is important is that local accessibility of durable tokens means that at least some degree of user-recipient control capabilities are available. For example, if durable tokens are used to present information (as in a magazine or book) or as inputs to drive the presentation of information (as on an audio tape or a computer disk), the user will have "convenience control." That is, the user will be able to handle an interruption of use of the materials by setting them aside temporarily, without having to miss anything, or paying for unused access time, or having to quit a task and restart it at the beginning. An even stronger form of control is "manipulation control," which is available when locally stored (or, in some cases, remotely stored but user-accessible) tokens are durable but easily converted to a manipulable form through use of equipment such as a PC. The key factor underlying this type of user control is an ability to change back and forth easily between durable and more volatile types of tokens. Easy conversion capability provides great flexibility in the movement and storage of information materials and enables a wide range of technologies to contribute to processing and communication activities. The types of tokens that can be subjected to fast and economical manipulation and movement are all of low durability. In contrast, high token durability is a requirement for the safe, accurate, and reliable storage and accessibility of information over time.

The descriptive classification system presented below relies on tracing the flow of tokens through a series of generic processing steps, each of which receives tokens in a given durability state (durable or transient[2]) and has an output with either the same or the alternative durability state. At this highest format level, only limited detail on the processes will be required; each process can be treated almost as a "black box" performing a specific set of functions. The intent here has been to keep the number of processes to the minimum needed to provide a clear description of process flows for a suitable test sample of information packages.

3.2 Processes for Describing High-Level Formats

3.2.1 Processor Groups

A variety of different kinds of information activities can be described in terms of processes conducted with equipment (and associated human skills) drawn from one or more of five processor groups:

- **Input Devices**, which convert external audio and/or visual signals and/or measurements, or user created mechanical inputs, into tokens suitable for further action steps,

- **Delivery Systems**, which move sets of tokens to where users, or their intermediaries, can have access to them,

- **Terminal Devices**, which receive tokens sets and process them to a form suitable for additional processing or for presentation to the user,

- **Presentation Devices**, which convert received tokens into audio and/or visual signals directly available to user senses, and

- **Enhancers**, which increase the utility and value of the processed information and expand the information's coverage of users and its availability geographically and over time.

A given information package may not require a member of each of the groups; in fact, the oldest (pre-writing) packages required only an input device. Most recently developed packages depend on processes of all the types; to a considerable extent, they are based on combining a number of common sequences (almost modules) of processes.

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[2] "Durable" should be interpreted as implying survival without noticeable change for at least days and, normally, for years or decades; for "non-durable," survival for minutes or less is expected. There is no entirely suitable single word for describing this characteristic; for convenience, "transient," or occasionally "volatile," will be used here.

Table 3-1

List of Major Processors and Eras of Their Development and Growth

INPUT DEVICES		TERMINAL DEVICES		ENHANCERS	
Instruments	Era 1	Developer	Era 4	Arranger	Era 3 (all eras)
Pen–Typewriter	Eras 2, 4	Player	Eras 4, 5, 6	Storer	Eras 2, 4
Camera	Era 4	Receiver	Era 5	Duplicator	Eras 3, 4
Keyboard–Mouse	Eras 4,6			Recorder	Eras 4, 5, 6
Scanner	Eras 4, 6			Manipulator	Era 6
Pick-Up	Eras 4, 5, 6				
DELIVERY MECHANISMS		**PRESENTATION DEVICES**			
Mechanical Delivery	Eras 2, 4	Projector	Era 4		
Switch Systems	Eras 4, 5	Speaker	Era 4		
Transmission Systems	Era 5	Printer	Era 5		
		Display	Era 5		

Notes:

Era 1 = Pre-writing; oral tradition societies
Era 2 = Writing or equivalent; all manual methods
Era 3 = Early print
Era 4 = Later print; mass media, early electric systems, photography
Era 5 = Electronic systems
Era 6 = Digital electro-optical systems

When more than one number is shown, the later numbers indicate periods when new needs or new technologies led to large improvements in an existing Processor and to great increases in its applications and markets.

3.2.2 Major Processors and Their Functions

Table 3-1 lists twenty-one major processors. As indicated by the "Era" associated with each process, they are crudely ordered within each group in terms of historical development (even though their current technologies and markets may bear little resemblance to those that existed when they were first put to use). **Table 3-2** presents descriptions of the processors, in terms of the functions they conduct, along with common examples of equipment or activities representative of each of them. Additional details are given in the **Appendix**.

Table 3-2

Descriptions of Major Processor Functions

NAME	DESCRIPTION
	A. INPUT DEVICES
INSTRUMENTS	Manually operated mechanical, electro-mechanical, or optical devices for creating transient visual or audio tokens. ***Examples:*** *trumpets, drums, bells, whistles, signal flags, light signals*
PEN–TYPEWRITER	Manually operated mechanical or electro-mechanical devices for marking or inscribing tokens on a base material. ***Examples:*** *stylus, pen, pencil, brush, knife, chisel, typewriter*
CAMERA	Opti-mechanical devices for capturing visual and/or audio tokens on photographic emulsion. ***Examples:*** *still and motion photography*
KEYBOARD-MOUSE	Electro-mechanical devices for manually creating (ab initio or from existing materials) sets of electric, electronic, or digital electro-optical tokens. ***Examples:*** *Computer keyboard, cursor, mouse, joy stick, touch screen system*
SCANNER	Devices for automatically converting static visual materials, and some types of coded magnetic data, into electronic or electro-optical tokens. (For recognition of patterns or of characters from multiple character sets, SCANNER must be accompanied by MANIPULATOR.) ***Examples:*** *facsimile scanners, product code (optical) scanners, credit card (magnetic) scanners*
PICK-UP	Electronic and electro-optical devices for converting audio and/or visual tokens into electronic tokens. ***Examples:*** *microphone, telephone hand set pick-up, video cameras, photo-electric devices and arrays, transducers of various kinds*
	B. DELIVERY MECHANISMS
MECHANICAL DELIVERY	Mechanical movement over distance of token-carrying materials to end users, through delivery services, merchandising systems, or other means. ***Examples:*** *book stores, newsstands, paper carriers, messengers, subscription services, U.S. Postal Service, United Parcel Service, courier services*
SWITCH SYSTEMS	Delivery over distance of electronic tokens through switched systems that directly connect the specific parties involved or through intermediaries serving them. ***Examples:*** *inter-office, local and long distance telephone services, mobile and cellular telephones, telex, LANs and WANs*
TRANSMITTER SYSTEMS	Simultaneous delivery over distance of electronic or electro-magnetic tokens by broadcasting to equipped and authorized recipients, normally without any specific addressing activity. ***Examples:*** *radio and television services, cable systems, satellite broadcast systems, some government and military systems (such as weather broadcasts)*

Table 3-2, continued

NAME	DESCRIPTION
	C. TERMINAL DEVICES
DEVELOPER	Converter of fragile, imperceptible chemical tokens on emulsions to more durable, visible forms. ***Examples:*** *photographic processing of exposed film to negatives, prints, and enlargements*
PLAYER	Converter of durable but imperceptible mechanical, electronic, magnetic or optical tokens into electronic forms that are suitable inputs for other processes, including PRESENTATION devices that can produce perceptible visual and/or audio tokens. ***Examples:*** *record player, audio tape cassette and disk players, video cassette and disk players, computer disk and tape storage "read" systems*
RECEIVER	Processors (and amplifiers) of switched or transmitted streams of electronic and electro-magnetic tokens into forms suitable for feeding other processors, especially PRESENTATION devices. ***Examples:*** *radio and TV tuner-receivers, computer and facsimile modem-receiver components*
	D. PRESENTATION DEVICES
PROJECTOR	Enlarger of both static and moving optical materials, especially (but not exclusively) those stored on film, for more detailed examination or for presentation to large audiences. ***Examples:*** *slide projectors, movie projectors, projection TV and VDT displays*
PRINTER	Converter of volatile electric/electronic tokens of static visual information to durable "marked on base material" versions of the same information. ***Examples:*** *telegraph/telex printers, computer printers, facsimile printers*
SPEAKER	Converter of received patterns of electric/electronic tokens into audio tokens. ***Examples:*** *radio and TV speakers, loudspeakers, telephone hand-set speakers*
DISPLAY	Direct presenter of visual and audio-visual materials that have been received and organized as patterned sets of electronic tokens. ***Examples:*** *television displays, video display terminals (CRT or flat panel), instrument and clock digital displays*
	E. ENHANCERS
ARRANGER	Arrange and manage the selection, acquisition, organization, editing, composition, production/manufacture, and distribution of informational materials of all types of media. ***Examples:*** *organizing, conducting, and supervising essentially all editorial, professional and production functions associated with media intended for more than very limited audiences. These amount to most of the "Create and*

Table 3-2, continued

NAME	DESCRIPTION
	Prepare" and "Manage" functions of Table 2.2. In this report, ARRANGER is discussed but not explicitly used in any process sequence.
DUPLICATOR	Devices for making multiple durable copies of a single set of tokens (of any durable token type), either directly or through use of intermediate processes. ***Examples**: all types of multiple-copy printing or copying operations, record production, "loaded" audio and video cassette and disk production*
STORER	Means and devices for placing materials in storage, under carefully controlled conditions that allow convenient later access by authorized users. The critical duration of storage may be short (as for current stock prices) or extended (for public archival materials). In general, STORER is used in this report only when the operation is critical to the purposes of a product or service; RECORDER is used for more personal or local forms of storage. ***Examples**: library and database service storage operations*
RECORDER	Devices to capture volatile electronic tokens, convert them into a durable physical, magnetic, or electro-optical form, and place them in an accessible storage device. ***Examples**: computer "write" and storage system components, VCR and audio tape deck "write" and store systems*
MANIPULATOR	Device that performs digital manipulations of all types on electronic and electro-optical signals. ***Examples**: some kind of manipulation capability has become embedded in almost all types of information format processes. Explicit use of MANIPULATOR here is limited to situations where absence of the capability would make operations impractical or uneconomic, or would defeat the purpose of the product or service being offered. Examples include applications such as: character and speech recognition, information compression and decompression, and processes where manipulation is critical to meeting specific end-user needs (as with database search systems or for personal VCR and electronic mail operations)*

Because the words used as names for many processors do not fully reflect their characteristics, the reader is urged to examine the descriptions in **Table 3-2**. There are a number of limits and ambiguities with regard to some of the processes that should be recognized:

• The table does not include what might be called the "Natural" processors, the body parts that produce human voice and movements, even though these are the main processors used for many common formats, such as conversations, lectures, debates, theater, and song. These processors, all of which produce transient tokens, are implicitly present as the suppliers of form and energy to most of the listed **Input Devices**.

• Two important processors, Arranger and Manipulator, are very widely employed but often in ways that amount to bundling them with other processors. Both are discussed but only Manipulator is listed in formal format process sequences, and then only in the special situations mentioned in **Table 3-2**.

• The durability of the tokens entering the Developer process (exposed photo emulsions) is ambiguous. The tokens are not directly observable, and they are quite fragile until they have been developed; nevertheless, they can have a considerable life before they must be developed. Because they are "incomplete" and cannot be used directly, they are treated as Transient.

• The dividing line between Switch and Transmission Systems is that the former requires delivery to specific people (or households or institutions) at specific (geographical or other) addresses, while the latter is available to all in range that have suitable equipment and have acquired any necessary codes or other authorizations. The difference is clear between telephone and TV broadcasting, even though both these means can employ wires, radio waves, or a combination in making delivery. Ambiguity can arise for some uses of electronic mail, voice mail, cable TV, and pay-per-view TV. For the present, the last two of these are considered as delivered by Transmission Systems (the cable box or "pay" being the "authorizations") and the first two by Switch Systems.

• Other dividing-line situations may not be obvious. Pen-Typewriter output is in the form of durable tokens; most devices that meet this requirement are mechanical in nature, although sometimes electrically aided. Keyboard–Mouse is concerned with similar general purposes, but its output tokens are transient and the electro-mechanical devices used are coupled to electric, electronic, or electro-optical elements. Electric typewriters are in the first category, electronic typewriters, in the second. Another example is that Printer is reserved for situations requiring only single (or very few) copies, such as PC outputs or facsimile operations, while Duplicator covers all types of larger printing systems (as well as equipment for production of audio records, "loaded" audio and video tapes and disks, office copying machines, and similar devices). Finally, Storer is used only when this operation is central to the functions of an activity and its customers; Recorder is assumed to provide the means to store information for other situations of interest.

The processors of **Table 3-2** were tested for their ability to describe a sample of thirty-one telecommunications and computer products and services, ranging in complexity from very simple, primitive mechanisms (many of which are still in active use[3]) to computer-based products just beginning to emerge on the market. In general, the sequences of processes worked quite well as descriptors, although the availability of different reasonable choices regarding the level of detail to employ obviously can lead to differences in the exact process sequences chosen to describe a particular format. Further details on this work are in the **Appendix**; the balance of this report presents selected results and implications.

3.2.3 Process Features and Capabilities

We start by examining the characteristics of the tokens associated with each of the processes of **Table 3-2**. Some of these are presented in **Table 3-3**, which shows the physical natures of the inputs and outputs of each process, the durability (Durable or Transient) of the associated input and output tokens, and the main sources of the energy driving the processes. To provide a sense of trends over time, the processes are ranked in order of their Eras of initial use.

Much of the material in this table could be described as "anticipatible." During the early eras advances were largely related to finding and improving systems to create durable tokens, which were needed to enable information both to survive over time and to withstand the rigors of slow, and frequently rough, physical movement. The inputs to the early processes were mostly human mechanical actions, and the primary supporting energy sources also were mechanical. All these processes are still in widespread use, but now they incorporate many high-technology features and materials that give them enormously greater flexibility, speed, and economy of use than in their original form.

For more recent periods, the emphasis has been almost entirely on processes that are highly effective and economical at moving and manipulating transient tokens, and on developing different means for easily converting tokens from one level of durability to the other. These capabilities provide many of the newer systems with a feature of great practical importance: they make the linking of processes—with the output of one becoming the input

[3]Although no further attention will be paid to the more primitive means of communications, their current importance should not be underestimated. For example, it would be extremely difficult to operate our transportation system without the mass of signs, signal and warning lights, bells, horns, whistles, sirens, signal flags, markers, etc., that we employ and whose meaning we normally comprehend without conscious thought or delay.

Table 3-3

Characteristics of Processors

ERA OF FIRST USE	PROCESSOR	NATURE OF TOKENS EMPLOYED IN PROCESSES:		DURABILITIES:			MAIN ENERGY SOURCES USED IN PROCESSES
		INPUTS	OUTPUTS	IN	OUT	CHANGE?	
1	Instruments	Mechanical motions	Mechanical effect	T	T	No	Mechanical, light
2	Pen–Typewriter	Mechanical motions	Mechanical patterns	T	D	Yes	Mechanical, electrical
2	Mechanical Delivery	Physical product	Physical product	D	D	No	Mechanical, many others
2	Storer	Mechanical, electro-magnetic or digital electro-optical patterns	Mechanical, electromag-netic or digital electro-optical patterns	D	D	No	Mechanical, electrical
3	Duplicator	Mechanical patterns	Mechanical patterns	D	D	No	Mechanical, electrical
4	Keyboard–Mouse	Mechanical motions	Electric, electronic, or Digital electro-optical patterns	T	T	No	Mechanical, electrical
4	Camera	Fixed or moving images	Sensitized chemicals	T	T	No	Light
4	Developer	Sensitized chemicals	Stable chemicals	T	D	Yes	Chemical
4	Projector	Stable chemical patterns	Fixed or moving images	D	T	Yes	Electrical
4	Scanner	Physical product	Digital electro-optical patterns	D	T	Yes	Electrical
4	Switch Systems	Electronic patterns	Electronic patterns	T	T	No	Electrical
4	Pick-up	Acoustic waves, video images	Electronic patterns	T	T	No	Acoustic, light, electrical
4	Player	Mechanical, electronic, magnetic, or electro-optical patterns	Electronic or electro-optical patterns	D	T	Yes	Mechanical, electrical
4	Recorder	Electronic or electro-optical patterns	Physical, magnetic, or Digital electro-optical patterns	T	D	Yes	Mechanical, electrical
4	Speaker	Electronic patterns	Acoustic waves	T	T	No	Electrical
5	Printer	Electronic patterns	Mechanical patterns	T	D	Yes	Mechanical, electrical, chemical
5	Receiver	Electronic or electro-magnetic patterns	Electronic patterns	T	T	No	Electrical
5	Transmission System	Electronic patterns	Electronic or electro-magnetic patterns	T	T	No	Electrical
5	Display	Electronic patterns	Video images and acoustic waves	T	T	No	Electrical, chemical
6	Manipulator	Digital electro-optical patterns	Digital electro-optical patterns	T	T	No	Electrical
—	Arranger	Various	Various	Mix	Mix	—	—

for another—far easier and cheaper. This pattern shows up in many of the most recent process sequences discussed in this chapter and has important implications for future formats.

These distinctions are shown in **Table 3-4**, where the output tokens of the processes (excluding Presentation Device outputs, for the reason given in the table) are divided into three groups: Durable; Transient but not directly manipulable; and Transient and directly manipulable. The first group of processes enables or assists the storage and physical movement of tangible information materials; the third is dominated by means for acquiring and moving intangible information patterns, which can be manipulated easily and for many different purposes, and then can be converted to durable state when desired.

Table 3-5 summarizes current process and token capabilities. Many of the older processes have been left out (Instruments, Pen–Typewriter, and the photographic series of Camera, Developer, and film-related uses of Projector) so that attention can be focussed on the main areas of current activity and progress—digital electronics and electro-optics. **Table 3-5** is essentially a list of the general tools now available to enhance old formats and develop new ones. The importance of the items listed is only partly covered by the material shown in this and previous tables, since the value of the tools lies not only in their availability—versions of most of them having been around for quite some time—but also in that they all are rapidly *getting better and cheaper*. It is not unreasonable to claim that, by the early 1990s, means for conducting all the operations shown in **Table 3-4** either were already available as *consumer products or services*—affordable by most middle-income households—or were rapidly becoming so. Numerous responses to these new techno-economics already have arisen, and many more are on the way.

3.3 Format Process Sequences

The evolution of formats can be reviewed most easily in terms of the technologies underlying their principal processes. For this purpose, we use four families of technologies: mechanical, photographic, electric/electronic, and digital electronic/electro-optical. As we move through these families, there is a trend toward increasing complexity of format sequences requiring use of a more detailed notation if the critical features of these formats are to be expressed fully. The notation is summarized in **Table 3-6**, and, in addition, individual

Table 3-4

Characteristics of Process Output Tokens

ERA OF USE	THE OUTPUT TOKENS OF THE PROCESSES ARE:		
	DURABLE	TRANSIENT BUT NOT DIRECTLY MANIPULABLE	TRANSIENT AND DIRECTLY MANIPULABLE
1		Instruments	
2, 4	Pen–Typewriter		
2, 4	Mechanical Delivery		
2, 4	Store		
3, 4	Duplicator		
4	Developer	Camera	
4, 5			Switch Systems
4, 5, 6	Recorder		Pick-Up
4, 5, 6			Player
4, 6			Keyboard–Mouse
4, 6			Scanner
5			Receiver
5			Transmission Systems
6			Manipulator

Note: All Presentation Devices are omitted; by definition, their outputs are final and not subject to further processing.

Table 3-5

Processor Devices Available for Conducting Digital Electronic/ Electro-Optical Operations

	ACTIONS	FOR TOKENS CONCERNED WITH: TEXT AND DRAWINGS	STILL IMAGES	SPEECH AND SOUND	MOVING IMAGES
ACQUIRE	CAPTURE TOKENS ab Initio				
	as Durable Tokens	—	—	—	—
	as Transient Tokens	Keyboard–Mouse	Pick-Up	Pick-Up	Pick-Up
	CONVERT TOKENS from:				
	Transient to Durable	Recorder, Printer	Recorder, Printer	Recorder	Recorder
	Durable to Transient	Scanner, Player	Scanner, Player	Player	Player
TRANSPORT	MOVE TOKENS OVER SPACE when:				
	Tokens are Transient	Switch, Transmission	Switch, Transmission	Switch, Transmission	Switch, Transmission
	Tokens are Durable	Mechanical Delivery	Mechanical Delivery	Mechanical Delivery	Mechanical Delivery
	ACCEPT MOVED TOKENS when:				
	Tokens are Transient	Receiver	Receiver	Receiver	Receiver
	Tokens are Durable	Mechanical Delivery	Mechanical Delivery	Mechanical Delivery	Mechanical Delivery
MAINTAIN	SAVE TOKENS OVER TIME when:				
	Tokens are Transient	Recorder	Recorder	Recorder	Recorder
	Tokens are Durable	Store	Store	Store	Store
	ACCESS SAVED TOKENS when:				
	Tokens are Transient	—	—	—	—
	Tokens are Durable	Mechanical Delivery, Player	Mechanical Delivery, Player	Mechanical Delivery, Player	Mechanical Delivery, Player
AMPLIFY	INCREASE AVAILABILITY OF OUTPUT TOKENS when:				
	Tokens are Transient	Recorder plus Duplicator	Recorder plus Duplicator	Recorder plus Duplicator, Speaker	Recorder plus Duplicator, Projector
	Tokens are Durable	Duplicator, Projector	Duplicator, Projector	Duplicator, Projector	Duplicator, Projector

Table 3-6

Notation for Format Sequence

NOTATION	EXPLANATION
[ ]	All sequences or sub-sequences are enclosed in square brackets (except for the situation covered in the next to last entry)
>	Processor operations within a sequence or sub-sequence are separated by a "greater than" symbol
[ ] > [ ]	Sub-sequences may be used to indicate changes in ownership and control of the processing equipment being employed. In these cases, if the overall operation is generally continuous, the "greater than" symbol is used as the sub-sequence separator
[ ] :: [ ]	Sub-sequences also may be used to indicate either a planned time separation between groups of operations or a situation with multiple operations of a later sub-sequence per instance of the earlier one(s), or both. In these cases, a double colon sign is used as the separator
UNDERLINING	Underlining is used to mark processor equipment owned or controlled by recipient users (or by initiating users, but only if they also are recipients)
&	Two or more processors linked by an ampersand are "grouped"; this is done only when they operate essentially simultaneously, appear to users as though single processors, and commonly are packaged together as a single physical unit
{ }	Braces used to enclose a sub-sequence (rather than square brackets) indicate that, as a specific part of the format, the user can —and often must—exercise control over and (within limits) manipulate sub-sequence processor equipment owned or managed by the provider or the provider's agents
MANIPULATE	MANIPULATE normally is grouped with other processors, the order of the grouping specifying whether the manipulation is provided by the user (MANIPULATE first) or bundled into the equipment (MANIPULATE last). Ordinary parentheses are used and ordinary algebraic rules followed to avoid ambiguity when more than two processors are involved

elements of it are explained in footnotes, as requirements for use of each element (and, thus, for examples of use) arise.

3.3.1 Mechanical Formats

Formats based on mechanical processes employ durable, tangible tokens, and have simple and direct structures. Examples of the earliest mechanical formats include: inscriptions on public buildings, public notices and decrees, on-site agreements, lists and business records, and, most important in the long run, letters and instructions. The structure for the simpler ones involved only primitive versions of a single **Table 3-2** process:

[PEN–TYPEWRITER];

and the most complex (letters) needed only two processes:

[PEN–TYPEWRITER > MECHANICAL DELIVERY][4]

The introduction of printing added a new process that had tremendous impact on the creation and use of information—the ability to economically duplicate materials in durable form. In due course, a large variety of print formats arose, many of them directed at mass audiences. The high-level structure of these publications, during most of their history, was simply:

[PEN–TYPEWRITER > DUPLICATOR > MECHANICAL DELIVERY]

Although excluded from the sequence for reasons mentioned in **Table 3-2**, two processors (ARRANGER and MANIPULATOR) assumed growing importance with the emergence of mass media format structures. Until duplication became an effective working process, information activities tended to be conducted by individual scribes or by fairly loosely organized groups of scribes. The introduction of printing made large-scale information businesses possible, bringing with them all the management, economic, editorial, and production interventions encompassed by ARRANGER and the early equivalents of MANIPULATOR. Requirements for skilled information management began to move far beyond the publications area, into almost all aspects of business and government operations.

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[4]All sequences are enclosed in square brackets. Within a sequence, individual processors are separated by a ">" symbol.

A simple illustration of this growth in information management operations is provided by public libraries, whose widespread development in the latter part of the nineteenth century was encouraged by the successes of the publishing industry. The format structure for the operations connected with an individual library holding, *as "viewed" by this holding*, is:

[PEN-TYPEWRITER > DUPLICATOR > MECHANICAL DELIVERY > STORE]
:: [MECHANICAL DELIVERY > (Used) > MECHANICAL DELIVERY]

where the processes within the first pair of square brackets comprise a set of producer processes and those in the second constitute one of many cycles of user activity.[5]

There is also an associated library set of processes not covered by the above, which involve extensive use of ARRANGER (to acquire and manage materials) and early forms of MANIPULATOR (to help organize and ensure availability of materials). The library format combination is an example of what might be called "Multi-View" formats (because they require more than a single perspective for full description of the needed processes). As illustrated by process sequences presented in sections **3.3.3 and 3.3.4**, these types of formats have acquired a growing presence with the introduction of advanced information technologies.

3.3.2 Photographic Formats

In the 1990s, photographic formats may become obsolescent for many of their traditional activities as electro-optical techniques replace chemical processes for recording fixed and dynamic images. The review here is confined to one photographic format, the production and presentation of theatrical movies. The process sequence for this format is:

[CAMERA > DEVELOPER > DUPLICATOR > MECHANICAL DELIVERY > PROJECTOR]

Movies furnish a good example of a dynamic format based on using complex technological production tools to convert durable tokens into transient ones at the point of consumption. The format is made dynamic by rapidly presenting successive static bodies of substance (stored on

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[5](*i*) This overall sequence has two sub-sequences. Multiple sub-sequences (each with its own set of brackets) are used to separate the sets of processor operations that different participants (most commonly providers or users) own and/or manage, control or operate. (*ii*) The sub-sequences here are separated by the symbol, "::". This indicates either a time separation between the first and second sub-sequences, or repeated operation of the second sub-sequence per instance of the first, or both. In the above case, both reasons apply. Alternatively, if neither of the above reasons applied, the " > " symbol used to separate processors would also be used to separate sub-sequences. (*iii*) The underlining indicates that processors so marked are owned and controlled by user-recipients, rather than by other participants.

film) that have numerous small changes from one body to the next. The pattern of the changes, not the individual elementary constituents by themselves, conveys the key substance features.

The change operation is the last step in creating the format, and the movie version of Projector, by providing the change capability, becomes a key format element as well as a Processing Device. The result is a combination of substance, process, and format reminiscent of much earlier types of dynamic (but very transient) formats such as debates, rituals, theatrical performances, songs, dance, and the like. However, the particular technology involved—that is, the Projector process of taking a collection of durable token sets and converting them into dynamic and transient form at the point of consumption—makes the movie format non-participatory by users. In contrast, many of the early formats just mentioned were designed to permit, or even to encourage, group participation. The general question of the level of user involvement available when employing a particular format becomes important with consideration of more advanced technologies and the new formats they can support.

3.3.3 Electric/Electronic Formats

The introduction of formats that rely on electric tokens started a series of major changes, with requirements for massive new infrastructures. For the first time, there was a need for terminal and presentation equipment in the hands of either end-users or, for some formats, intermediaries serving end-users. Most of the earlier electric/electronic formats continued to have relatively simple high-level structures, but, over time, newer formats were introduced and complexity grew.

Some sequences for typical electric/electronic formats include:

- For telegraph and telex, either:

[KEYBOARD > SWITCH SYSTEM] > <u>[RECEIVER & PRINTER]</u>[6] or

[KEYBOARD > SWITCH SYSTEM > RECEIVER & PRINTER > MECHANICAL DELIVERY]

[6]The use of two or more processors separated by an ampersand, "&", indicates that operation of the grouped processors normally occurs simultaneously, so that they act like a single processor and are often physically packaged together. When grouped like this, they can be considered a single processor.

with the top sequence applying to private-line situations (such as for a personal stock ticker-tape machine) and the bottom sequence for delivery to users from a central receiving and delivery office.

- Half-cycle of a two-way telephone conversation:

[PICK-UP] > [SWITCH SYSTEM] > [RECEIVER & SPEAKER]

where the second half-cycle is the inverse of the first (and where PICK-UP, RECEIVER and SPEAKER normally are packaged physically as integrated telephone handsets).

- Live radio or television:

[PICK-UP > TRANS. SYSTEM] > [RECEIVER & SPEAKER or & DISPLAY]

- Records, audio tapes and disks, video cassettes and disks:

[PICK-UP & RECORDER > DUPLICATOR > MECHANICAL DELIVERY] :: [PLAYER & SPEAKER or & DISPLAY]

- Facsimile (early analog version):

[SCANNER > SWITCH SYSTEM] > [RECEIVER & PRINTER]

Many variants of these and earlier formats continue to receive significant use. Three examples are: remote printing of text products, like newspapers, closer to their end-user populations; delayed studio broadcast of TV materials; and simple audio databases, such as for stock quotes or inquiries about utility bills.

- Remote printing:

[KEYBOARD & RECORDER > PLAYER & SWITCH SYSTEM > RECEIVER & RECORDER > PLAYER & DUPLICATOR > MECHANICAL DELIVERY]

- Delayed TV broadcast of material prepared earlier:

[PICK-UP & RECORDER] :: [PLAYER & TRANS. SYSTEM] > [RECEIVER & DISPLAY]

- Audio databases inquiry; as viewed by user:

[PICK-UP > SWITCH SYSTEM] > {RECEIVER & (MANIPULATOR &

PLAYER) > SWITCH SYSTEM} > [RECEIVER & SPEAKER][7]

For this last sequence, because manipulating the audio database is required of the user and is central to achieving the user's purposes, MANIPULATOR has been included as a specific process.[8] Audio database inquiry is a Multi-View format operation (with different sequences of processes applicable to the database operator, the users, and the data items), so it is not fully defined by the single (user view) sequence given above.

3.3.4 Digital Electronic/Electro-Optical Formats

Formats based on digital technologies are characterized by variety, flexibility, structural (but not necessarily operational) complexity, and a major expansion in user capabilities to control what they get and how. Examples of the structures of these formats are:

- User-delayed VCR playback of live TV program:

[PICK-UP > TRANS. SYSTEM] > [RECEIVER & RECORDER] :: [PLAYER & DISPLAY]

- Facsimile (using character recognition and data compression):

[SCANNER & MANIPULATOR > SWITCH SYSTEM] > [RECEIVER & (RECORDER & MANIPULATOR) > PLAYER & PRINTER]

- Voice mail; view of one-way message:

[PICK-UP > SWITCH SYSTEM] > {RECEIVER & (RECORDER & MANIPULATOR)} :: [MANIPULATOR & PLAYER & SPEAKER]

- Electronic mail; from view of material created and sent:

[KEYBOARD & RECORDER > PLAYER & SWITCH SYSTEM] > {RECEIVER & (RECORDER & MANIPULATOR)} :: [(MANIPULATOR & PLAYER) & DISPLAY or & PRINTER]

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[7]Some of the sub-sequences from here on are enclosed in braces, e.g., { . . .}, rather than square brackets. This signifies that, as a specific part of the format, the end user is able to—and often *must*—control and manipulate (within specified limits) equipment and resources owned by the provider or the provider's agents.

[8]To make somewhat more specific the type of manipulation involved: (*i*) If MANIPULATOR follows a process, it is embedded in the process (i.e., data compression in a communication device); (*ii*) if MANIPULATOR precedes a process, a human (provider or user) is managing the manipulation (such as by specifying storage or access and retrieval operations); and (*iii*) when more than two processes are grouped together, parentheses and algebraic rules are employed to clarify any ambiguity.

where it is assumed that the message originator stores the material as it is created and then sends it as a single transmission, rather than create the message while on-line.

- Database inquiry; user view of transaction:

[KEYBOARD > SWITCH SYSTEM] > {RECEIVER & (MANIPULATOR & PLAYER) > SWITCH SYSTEM} > [RECEIVER & RECORDER > PLAYER & DISPLAY or & PRINTER]

- Scan document into personal computer memory:

[SCANNER & MANIPULATOR > MANIPULATOR & RECORDER]

- Database downloading with later retrieval; user view:

[KEYBOARD > SWITCH SYSTEM] > {RECEIVER & (MANIPULATOR & PLAYER) > SWITCH SYSTEM} > [RECEIVER & (MANIPULATOR & RECORDER)] :: [(MANIPULATOR & PLAYER) & DISPLAY or & PRINT]

where the processes prior to the :: separator cover the downloading step, and those after the separator cover later local retrieval actions.

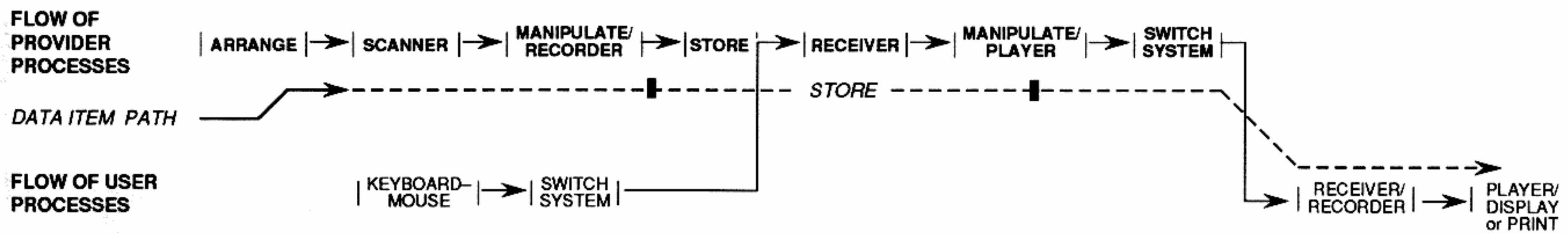
- PC personal records operations:

[KEYBOARD > MANIPULATOR & RECORDER] ::
[KEYBOARD > MANIPULATOR & PLAYER > MANIPULATOR > MANIPULATOR & RECORDER > PLAYER & PRINTER]

where the top brackets enclose an entry operation—presumably one of many made over time—and the bottom brackets enclose one of many possible application cycles (retrieval, processing and output).

Among these sequences, database inquiry provides a good opportunity to examine Multi-View systems in detail. **Figure 3-1** illustrates the flows and processes for each of three views in both diagrammatic and tabular form. The two active participants (provider and user) have coherent sets of processes to conduct, with some overlap and some independent operations. With both of these participants covered, the data item list of processes is redundant, but the list can help stakeholders to understand the full pattern of the operations and, by indicating the activities to which the information is exposed, can be useful for purposes such as quality control and security.

A – PROCESS FLOW DIAGRAM



B – SEQUENCE OF PROCESSES

	PROVIDER VIEW	DATA ITEM VIEW	USER VIEW
PREPARATION CYCLE	ARRANGE SCANNER/MANIPULATE MANIPULATE/RECORDER STORE	*ARRANGE* *SCANNER/MANIPULATE* *MANIPULATE/RECORDER* *STORE*	
USE CYCLE	RECEIVER MANIPULATE/PLAYER SWITCH SYSTEM	*PLAYER* *SWITCH SYSTEM* *RECEIVER/RECORDER* *PLAYER/DISPLAY or PRINTER*	KEYBOARD-MOUSE SWITCH SYSTEM RECEIVER MANIPULATE/PLAYER SWITCH SYSTEM RECEIVER/RECORDER PLAYER/DISPLAY or PRINTER

Figure 3-1

Database Operations: An Example of a Three-View System (Assumes Inputs to the System Are in Print Form)

It is apparent from the figure that database operations are close relatives of those conducted by libraries. Databases already provide a form of supplement to traditional libraries and have largely replaced them in a number of specialized subject areas. They may serve as an example of what a more general purpose electronic "successor" to libraries might look like—if or when computer-driven displays become widely accepted for extensive reading activities. There are, however, important differences between the systems. Some of the differences, like costs and other qualifications for access to information, have critical social implications. But these subjects require major studies of their own; they go far beyond the scope of this paper.

Another feature illustrated by the various sequences is the spread of user control in many information activities, as indicated by the high level of participation required by equipment owned and operated by users. Much of user equipment can provide only what was described earlier as convenience control, but the last few sequences (database operations, scanning documents into memory, and personal PC record-keeping) go much further than this.

The example of document scanning is important, because it closes a gap in individual user capabilities: it offers (and will offer more cheaply and more effectively by the mid-1990s) a simple means to move information available in print, but not in electronic form, into user computer files without the need for the user to transcribe the material. The scanning activity, again, raises a number of social and policy issues, because it has the potential to continue a strong trend, at the local level, of "democratizing" (or "socializing") the duplication process in a form that can easily degenerate to theft of intellectual property. Massive local duplication activity (some legal, some not) started earlier, with duplication of written materials on copying machines. Copying audio tapes and computer programs followed. Scanning devices feeding PCs simply open up a new area (e.g., converting text and images to an electronic format) in a flexible and convenient manner.[9]

The last two sequences (database downloading and personal records activities) are typical examples of common PC operation formats. The first emphasizes the communications abilities

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[9]See, for example, the following publications by Anne W. Branscomb, "Nurturing Creativity in a Competitive Global Economy: Intellectual Property and New Technologies," in Ernst et al., *Mastering the Changing Information World*, and *Technical Rips in the Seams of Intellectual Property Law* (Cambridge, Mass.: Harvard University Program on Information Resources Policy, April 1992, P-92-2).

of suitably equipped PCs, in this case for obtaining a body of information from a remote source and storing it for (potentially repeated) use later. The second concerns a more self-contained situation, where a mix of data storage and analysis of important personal information comprise the main objectives of the activity.

There are innumerable potential extensions and variants of these formats . Some can appear quite complex, though the complexity usually results from combining a number of individually simple modular loops. In all cases, two features are notable: first, that the user's range of control of operations has been greatly expanded (in large part because it is the user's equipment that is being employed); and, second, that many of the Arranger and Manipulator operations of the total process are now the user's responsibility.

The implications of these and other trends in processor and format developments are discussed in **Chapter Four**.

Chapter Four

Endings and Startings, Contrasts and Hopes

4.1 The Long Road to the Present

Before proceeding further, a brief review of the evolution of formats will provide useful background for considering how the future may develop.

The earliest formats relied on transient tokens and employed a minimum of processes—primarily human sounds and motions and, occasionally, simple mechanical devices. All these formats were dynamic in nature, with information communicated by a parade of tokens that vanished almost as soon as presented. Unless they made use of relay activities, most of the formats operated only at short ranges, especially those based on human sounds and gestures. The combination of dynamic character and short range encouraged highly participatory communications, with opportunities for extensive interactions, all of which tended to create a rather democratic environment. On the downside, the outputs were characterized by:

- limited temporal endurance, leading to loss of information or degradation of accuracy and reliability over time;

- short geographic range of coverage, which restricted the participatory benefits to local inhabitants;

- limited and fragmented total substance capacity, due to lack of storage devices other than human memory; and

- difficulties in dealing with subjects that involved complex scope or context; these difficulties derived from the storage deficiency and its inhibiting effects on the development of symbolic forms for representing complicated and subtle concepts.

The development of writing cured some of the weaknesses, but at the price of a loss of some of the virtues. Because writing systems produce durable output tokens the endurance of information could be extended, although weaknesses in copying processes left considerable room for errors (and bias) to creep into different versions of the same materials. Greater endurance also eased the capacity problem somewhat and encouraged numerous advances in creating symbolic representations for a broader range of subjects. Having durable tokens expanded the distance over which information could be distributed effectively and provided a set of working tools that could help create and teach an expanding base of concepts and structured knowledge. But the means by which token durability was achieved were incompatible with maintaining the dynamic and participatory character found in earlier formats; and to create or interpret the tokens, considerable training in difficult skills was required. In time, major areas of knowledge and communications ability arose in which direct social participation was limited.

The development of printing eliminated most of the "copying error" problems, and printing economics permitted much lower cost production of materials (although these costs still were high by modern standards). Lower costs, and the resulting larger supply of materials produced, increased the relative benefits of reading—even for readers who could not write. But special skills were still required to use print formats, and, for almost 350 years, social patterns and tax structures in most countries operated against widespread education in reading and writing.[1] Thus, the low-participation, generally undemocratic environment continued. It took until the middle of the nineteenth century before the pressures driving the industrial revolution forced changes in attitudes that led to universal education, public libraries, and twentieth century concepts about what it meant to be literate—and about how important it was for nations to have high levels of literacy.

Partly as a result of these changes and partly as a cause, the last half of the nineteenth century saw the rise of entire new families of information formats. Until these developments, there had been only the (transient token) oral tradition and primitive signal system formats and the (durable token) writing system formats, with the latter produced by one of two general methods—pen inscription or (relatively slow and expensive) printing processes. Then, within about fifty years, starting in the late 1830s, mass media, photography, telegraphy, facsimile, and telephony were invented and put to use.

The emergence of mass media resulted from a combination of new attitudes toward public literacy and a stream of improvements in printing and transportation technologies and economics. A number of variants and extensions of existing print formats were created, as part of efforts to exploit the very large markets that were arising. The other late nineteenth century developments, except for photography, all involved use of transient tokens in forms

[1]See, for example, Altick, *The English Common Reader*.

that enabled long-range, essentially instantaneous transport of information. For text and the occasional image inputs, conversion back to durable tokens was completed prior to final delivery; the primary impact was an enormous reduction in the time required to deliver information, but with restrictions on quantity due to infrastructure bandwidth limitations and resulting high transmission costs. For voice, the change was far greater—telephony offered a new, participatory, and dynamic format, for use in "real time" and independent of distance as long as the participants had access to the telephone network.

Until the 1890s, communications formats were dependent, first, on mechanical technologies and, later, on electric and electro-mechanical means. The following fifty years saw the invention of movie projectors (mechano-optical devices) and the development and very rapid spread of electronic and electro-magnetic techniques. These technological advances made possible a series of wireless transmission applications that started with wireless telegraphy and then moved on to broadcast radio and, toward the end of the period, to mobile radio and early versions of broadcast television. All these were dynamic formats, but, like the movies, none of the broadcast families of formats permitted more than a minor degree of user participation.

As frequently happens, some of the newer formats competed directly with some older ones—such as broadcast radio with newspapers and, later, broadcast TV with radio. In response to the competition, the older format families adopted elements from the newer process technologies, whenever possible. This seldom was enough, and the organizations employing the older formats usually were forced to make broader changes—in the substance they provided, in their markets and their delivery mechanisms, and in their social roles. But most of the major old formats survived, and many even grew, in their new identities.

Another fifty or so years bring us to the present. For the general public, the most important information and communications advances during this period probably were the continuing improvement, the global penetration, and the extensions in scope of the major electric/electronic formats already existing. In the past two decades, a growing portion of advances made in these formats were derived from the use of new digital electro-optical techniques, and these techniques now dominate what is possible in the evolution of future formats.

Unlike most of the older key technologies, which made contributions primarily to one or a few important processes (that is, to specific types of input, movement, duplication, or output operations), digital electro-optics contribute in critical but often hidden ways to essentially all significant process operations. The presence of these digital techniques can make the difference between whether or not whole families of information formats are possible (for example, output image presentations with Zoom or 3-D rotation capabilities) or, if already in use, whether they can be made sufficiently low-cost to achieve popular market success (as happened with facsimile at the turn of the 1990s).

Because of their broad applicability, digital electro-optics tend to be identified with processes generally, rather than with specific formats; their strongest point of popular recognition, however, is a particular class of equipment—computers—which perform a wide range of processing activities and also have a variety of means for offering participative types of formats. A critical feature is that, in the workstation and PC operating environments that began to replace larger computer systems in the early 1990s, many of the process and formatting activities can be conducted under close user control.

Extensions or analogs of existing print or electronic products and services have been the primary source of the new computer-based higher level formats developed so far, although the new capabilities available are beginning to make the analogs rather tenuous! **Table 4-1** presents a sample of these formats and their predecessor formats. The output products and services shown in the first column are not easily described in the simple terms that could be used for earlier formats (e.g., "news by ink on paper" or "drama by broadcast TV"). In each case, however, the activity can be described in considerable detail using a sequence of the format processing steps described in **Chapter Three**.

The entries in **Table 4-1** start out as rather straightforward transfers of existing operations to a new, more capable technical environment. As one goes down the list, starting with Voice Mail, the new formats begin to go well beyond the older ones in several respects; in particular:

- The capabilities, or scopes of what can be done, become far greater; in the Consumer On-Line General Service, for example, the computer can provide elements of what amount to a newspaper, a shopping mall, an entertainment park, a travel agency, a training school and a special library, all combined. In prior experience, these resources would be encountered only as a number of physically separate entities

• The processes become increasingly user-driven—more and more, the role of providers is limited to offering a range of substance and capabilities for some kind of interaction, presented (hopefully) in a user-friendly environment; the user then does the rest. The real key to most of these formats is the interaction capability.

Table 4-1

Digital Electro-Optical Activities and Their Predecessors and Analogs

DIGITAL ELECTRO-OPTICAL ACTIVITY	PREDECESSORS AND ANALOGS
Voice reporting, inquiry, ordering, etc.	Human workers performing the same functions
Internal electronic mail	Inter-office memos
External electronic mail	Traditional letter mail
Automatic Teller Machines	Human bank tellers
Electronic catalogs	Print catalogs
Voice mail	Telephone message slips, telephone answering systems, multiple individual calls to specified distribution list
Electronic training materials, tutorials, and interactive exercises	Print training manuals and exercises
On-line information databases	Special libraries
Full-text searches	Manual searches of card files, indices, and print materials
Interest group bulletin board	Letters to the editor, hobby clubs, town meetings
Adventure game	Combination of: adventure stories, puzzle book, arcade games, animated cartoons, and more
Consumer on-line general service	Combination of: news services, encyclopedias, shopping catalogs, arcade games, puzzle books, electronic mail, bulletin boards, and more

Inclusion in the list of the table does not imply that an activity has proved itself as a successful format. Some have, others have not. Internal Electronic Mail appears well established, but Consumer On-Line General Services are still in a testing period. What matters is that fairly explicit formats are in place, being used, and furnishing market feed-back for their modification and improvement—or, in some cases, their delay or abandonment, if that is the market's judgment.

The big question is: where do we go from here?

4.2 The End of an Old Road

As we enter the mid-1990s, it appears that, *from a technological point of view*, the conventional print and electronic formats that dominated past information activities have reached the end of their road. This does not mean that there will be no minor extensions of existing formats or new niche markets to exploit (as radio did when TV took over most of radio's original markets)—there probably will be. It certainly does not mean that the current formats will disappear, although some may. What the statement means is that, *technically*, we could very soon be in a position to meet every requirement for creating and delivering *near-ideal* versions of the conventional format products and services as they have been conceived over most of their lives. We may choose not to exploit this position or believe the effort not worth the costs; but we will be able to do the job, if we so desire.

Table 4-2

Primary Formats Prior to Use of Digital Electro-Optics

TYPE OF COMMUNICATION		
Format Family	**One-to-One or Few**	**One-to-Many**
Speech	Telephone	Broadcast radio
Other audio	Telephone, records, tapes	Broadcast radio, records, tapes
Text, numbers	Letters, telegraph	Print media
Static image	Photographs, slides, facsimile	Photographs, prints, slides
Moving image	Home movies	Theater movies, broadcast TV

The major conventional formats to which these remarks apply are listed in **Table 4-2**. Although no single set of criteria can cover all situations, near-ideal versions of these formats would have the following capabilities:

• From an originator point of view, ability to:

- establish essentially instant contact with individuals, or authorized groups, anywhere on the earth and, then,

- deliver rapidly almost unlimited amounts of materials, in any of the format families of **Table 4-2**, using delivery tokens that can easily be made either durable or manipulable by the recipients, but with the materials

- subject to accepted controls for protection of intellectual property.

• From a recipient point of view, ability to:

- request delivery of any publicly available (and any authorized non-public) materials of any format family, independent of their location, and
- receive, essentially instantaneously, both recipient-requested and originator-initiated materials in all format families, as either an "addressed" individual or a member of an authorized group, independent of originator or recipient local or global locations, and, then,

- absorb or process received materials, and/or respond as appropriate in the same or a different format (thereby taking a turn as an originator), and/or temporarily or permanently store the received materials for later action or use, or discard the materials, with

- all the above taking place using light-weight, comfortable equipment that is highly reliable, easy to operate, and generally available at "consumer electronics" prices.

More simply, the criteria require ability to request and/or move any amount of material, instantly, in any desired conventional format, to any person, anywhere, with output that can then be absorbed, analyzed, responded to, and/or stored—and with total costs for the capabilities affordable to most of society! Clearly, all these criteria seldom will have to be met simultaneously but, ideally, ability to meet them should be available.

The criteria may appear unrealistic targets but, before the mid-1990s, almost all the necessary technology will be in place. There are only four major technical prerequisites, two critical and two desirable, and all are already receiving a great deal of attention. The rest, on the *technical side*, is mainly a matter of continuing with existing trends and allowing time for "commoditization" of what may start out as leading-edge hardware or software products.

The four major prerequisites are:

(*i*) A global communications system, with an adequate band width/data compression combination and local connection capability to both fixed and mobile terminals, independent of their location.

• The building of national versions of this type of basic infrastructure has been considered a high priority goal in many countries. Once started in one country, it may become difficult for other countries to avoid following suit. At issue, in most countries, are: the pace of investment, the balance of public and private contributions to this investment, and the primary initial beneficiaries.

(*ii*) A full-page size, light-weight, high-resolution and high-contrast, color flat-panel display system,[2] with associated control software and easily changed memory units.

• Potential use in portable TV sets, as well as with computers, provides strong incentives to develop this type of equipment.

(*iii*) High-quality scanners, with extensive font recognition, designed for both personal and organizational uses.

(*iv*) Computer Speech Recognition, at a level that permits equipment control and dictation input, using normal speech but a reasonably limited vocabulary.

• Although not critical, items (*iii*) and (*iv*) round out token conversion capabilities for the conventional formats and can be quite valuable for many purposes.

The critical technologies, of course, are not the whole story. As already suggested, a variety of social and legal issues are far more problematic; for example, many standards and protocols must be established,[3] many interfaces between systems and software packages must be built and maintained, and a number of intellectual property and privacy protection measures must be legislated and enforced.[4] There also are a host of business relationships that will have to be built, and even some difficult technical support areas where further work is needed. But none of these alters the status of the conventional formats: we soon will have the

[2]For a more complete description of requirements and uses, see Ernst, *Electronic–Print Competition*. Use of this display will amount to changing the set of basic formats, because, when it is employed, products previously presented as ink on paper will now be, say, liquid crystals on an electronic screen. Recipient printing of the output will be possible, although it will be slower and more expensive than the electronic display. The display can be viewed simply as offering a case-by-case option the user can select as an alternative to the older format presentation output, even if it eventually becomes the preferred means for presentation of most materials.

[3]See Martin C. Libicki, *Information Technology Standards: Quest for the Common Byte* (Newton, Mass.: Butterworth–Heinemann, in press).

[4]See Branscomb, "Nurturing Creativity in a Competitive Global Economy" and *Technical Rips in the Seams of Intellectual Property Law*, previously cited.

ability to build near-ideal versions of them. This status means that there is little potential for them to achieve any major growth in capabilities and little likelihood of finding important new markets in developed countries or creating significant format extensions without changes large enough to justify calling the results "new" formats.

Some of the technical support areas mentioned above are important for multiple reasons: aside from helping to meet an inherent need for greater support capabilities, they illustrate why conventional formats have reached their limit, and they provide a link to future formats. The areas in question deal with providing assistance in *finding and using* information. The conventional formats, and especially the "one-to-many" families, almost always provide users with what might be termed "naked substance"—substance with, at most, little support for analyzing, interpreting, storing some or all of the materials, finding other related and potentially useful materials, or feeding back comments and suggestions. Since the recipients of the one-to-many formats are almost always regarded as passive users of the substance, this lack of support is not surprising.[5]

The problem of finding desirable information materials illustrates the general situation. In the past, traditional ink-on-paper lists, card catalogs, references, bibliographies, file indices, and the like were adequate to handle the quantity of information produced, given the manner in which it was employed. More recently, these techniques have become almost hopelessly inadequate for dealing with the massive (and growing) onslaught of information in business and private life. Although direct electronic analogs, such as electronic library card catalogs, can help, even these leave much to be desired. Yet this is an area where new applications of digital electro-optics have proved their value—and they do their best when the received substance, itself, is in a digital electro-optical format.

In this way, at least some of the traditional formats are losing part of their value if their use is not supplemented with digital electro-optical systems. And an extra cost is involved in handling materials received in a format class different from the one to be used for processing operations, even though our technical abilities to "mate" the different classes are improving.

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[5]Exceptions to these comments are the many types of TV and radio talk shows that grew in number, variety, and popularity during the late 1980s and became "legitimized" during the 1992 Presidential campaign. Even these were technology-dependent in that they only became practical as the number of transmission channels available was increased by the availability of cable and by more dense spectrum utilization.

4.3 Start of a New Road

4.3.1 Contrasts

Some aspects of the formats now emerging are best understood in terms of their contrasts with the more conventional formats just discussed. The general territories occupied by the two groups of formats were established quickly. The primary tool for creating or manipulating materials in digital electro-optical formats is the general-purpose computer—the PC, in this report—and these computers are very good at "doing" things. Computers have had major ergonomic weaknesses, however, that made them poor devices for extensive reading operations, so they could not get away with offering formats for presenting only "naked substance." But that is just what print, radio, and TV were good at—straightforward information presentation for relatively passive absorption. On the other hand, these formats had very limited manipulation capabilities and lacked practical feedback mechanisms that could enable easy and widespread audience interaction. These weaknesses, in turn, forced the use of awkward procedures and raised the costs of conducting "many-to-one" and "many-to-many" communications.

As a result of these factors and some specific technical advantages, and relative to the older formats, individual applications in digital electro-optical formats have a number of special qualities:

- They can evolve quickly, in response to market needs, improving and expanding their capabilities until they have far greater scope and coverage, and as much or more detail, than did their predecessors or earlier equivalents.[6] These features arise from the manipulation capabilities of digital electro-optical technologies, supported by a tremendous amount of easily accessed storage which can be employed for storing instructions as well as input and output.

- They tend to be action-oriented, thus concerned not only with substance itself but also with *how this substance can be or is used*. This orientation came about because computers have been so good at "doing" and so poor for reading. Most serious computer applications have been devoted to helping users, *in a direct action mode*, perform manipulative functions on substance—that is: create, locate, interpret, employ, or communicate substance.

[6]See Martin L. Ernst, *The Personal Computer: Growth Patterns, Limits, and New Frontiers* (Cambridge, Mass.: Harvard University Program on Information Resources Policy, October 1991, P-91-6), which describes in detail the growth pattern of typical major PC applications, and the reasons why such growth is practical and likely to continue through the 1990s. More advanced types of PC applications, such as for filtering and prioritizing incoming flows of information items, are also discussed in the reference. A few of these applications are already in limited use; most seem unlikely to become major applications until at least the mid-1990s.

- They are user-driven and designed for interactive operations rather than passive recipient-users. These characteristics flow from the functional orientation just mentioned and from the heavy user investment of time (and often money) required to benefit from any individual application.[7] To be successful, product developers have had to establish a variety of user feedback channels and service mechanisms, so they can respond to the many user requests for assistance.

- They are increasingly multimedia at least in informal ways. Some audio capability was normally built into even early PC equipment, so that simple sound signals could be used to supplement visual output. For some PC models, improved audio began to be provided as an option for users interested in applications concerned with music. Games brought animation; and, in the mid-1990s, video capabilities are expected to be common. Full-scale interactive multimedia systems almost certainly will be employed in special application areas, like training, even if general usage of this type of format is slow to develop.

- They can offer a spectrum of formats between static (text-equivalent) and dynamic (video and audio), using a largely common set of equipment. Also, they offer ability to combine or move back and forth between digital and analog formats and user tools (as with GUIs).

- They provide an excellent base for building participatory systems; as exemplified by Interest Group Bulletin Boards, they can offer the biggest advance in effective "many-to-few" and "many-to-many" communications since the invention of Town Meetings!

- They can offer, if or when adequate flat-panel displays become available, competitive electronic versions of many types of traditional text products. These could easily incorporate capabilities for simple types of value-adding electronic manipulations of both the substance (text) and features of the presentation format.

Many of these characteristics were at least partly evident in the process sequence diagrams in section **3.3** and in **Table 4-2**. **Table 4-3** adds more examples and presents a sample of applications devoted to supporting a variety of information use functions: finding, controlling, understanding, experiencing, creating, and communicating substance. The horizontal headings provide general categories; their order is arbitrary, although an effort was made to place the more closely related categories next to one another. The entries tend to increase in complexity (and in recency of development) down the lists. Some of the last entries in each column have been technically proved but are not yet on the market; others have promise but are only at the demonstration stage and may be many years from commercialization.

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[7]This subject is discussed in considerable detail in Ernst, *Users and Personal Computers*.

Table 4-3

Computer-Aided Capabilities to Support Improved Use of Information

← REPORT/COMMUNICATE →		← USE		→	← EXPERIENCE →
CORRECT–INTEGRATE	LINK–FIND	EXAMINE	ANALYZE	INTERPRET	SENSE
Edit text (or audio or video)	Indices, cross indices	Graphics, images	Tabulations, statistics	Automatic plots and graphics	Sensory and organ monitors/inputs
Edit any graphics or visuals	Card catalogs	New map formats	Spreadsheets	"Synthetic color" coding techniques	Tactile inputs
Integrate text and graphics, etc.	References, bibliographies	Zoom capabilities	Simulations	Matching techniques	Integration of sensory data; feedback
Page/document layout	Full-text search and retrieval	3-D rotation capabilities	Mathematical models—many types	Speech recognition	Virtual reality systems
Edit mixed media	Associative search and retrieval	Holographic presentations	Artificial intelligence techniques	Artificial intelligence techniques	
Integrate multimedia	Filtering and prioritization systems			Pattern recognition	
	Hypertext, hypermedia				
PARTIAL CONVERGENCE? (Multimedia and Hypertext)					

4.3.2 Paradigms

A few examples of "model" digital electro-optical formats illustrate how the abilities underlying the contrasts just described are being (or are planned to be) exploited. Two broad formats are examined below: Computer Bulletin Boards (BBs) and Interactive Multimedia Systems (IMMs).

Bulletin Boards offer an excellent example of an effective format for "many-to-many" communications. The basic concepts and designs were conceived and developed by groups of users, rather than by commercial entrepreneurs. Ideas and examples spread by word-of-mouth (and by electronic mail), resulting in a relatively uncontrolled, almost helter-skelter pattern of evolution. Important support, however, was provided by government financial aid in building and operating a network infrastructure (DARPANET, later INTERNET) available at little or no direct cost to most early developers.

Growth has been dramatic. The earliest recognized Bulletin Board software was written in 1978; by 1992 there were about 160,000 BBs operating (40,000 public, 120,000 private) with about ten million users; estimates for the year 2000 are for twenty to forty million users.[8]

In structure, BBs are closely related to database systems (DBSs), with one critical difference. Most DBSs develop, or acquire rights to offer users, all the information directly accessible through their system. This means they are (or control access to) the provider(s) of all the substance that forms the database; their customers are receivers of that substance but normally make no contributions to it. In contrast, BBs are more like cooperatives, with users contributing as well as receiving substance. In some situations contributions are a requirement for maintaining the privilege of access to a BB.

There are other differences, but they mostly derive from the differences in purpose and structure; for example:

- Public DBSs are commercial activities, managed by full-time, paid professionals, and have well-structured organizations and sets of policies. Most BBs are less formal, often managed more as a hobby or service by some of the participants; they seldom have been expected to be significant sources of revenue.

[8]John V. Hedke, *Using Computer Bulletin Boards* (MIS: Press, Henry Holt and Co., Inc., 2nd ed., New York, 1992).

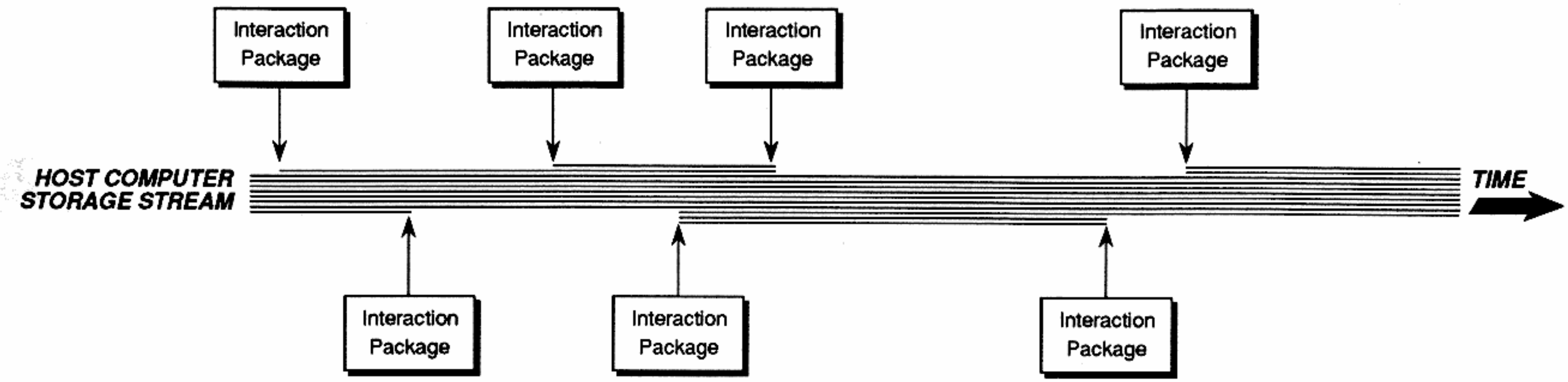
• To achieve adequate economies of scale, most commercial DBSs (other than specialized types that stress a particular attribute of value, like extreme timeliness) must appeal to a fairly large market, which implies offering coverage of a single very large subject area or a number of related smaller ones. The basis for most individual BBs is a single interest area and, because viability can be achieved with a small number of participants, it can be narrow in scope.

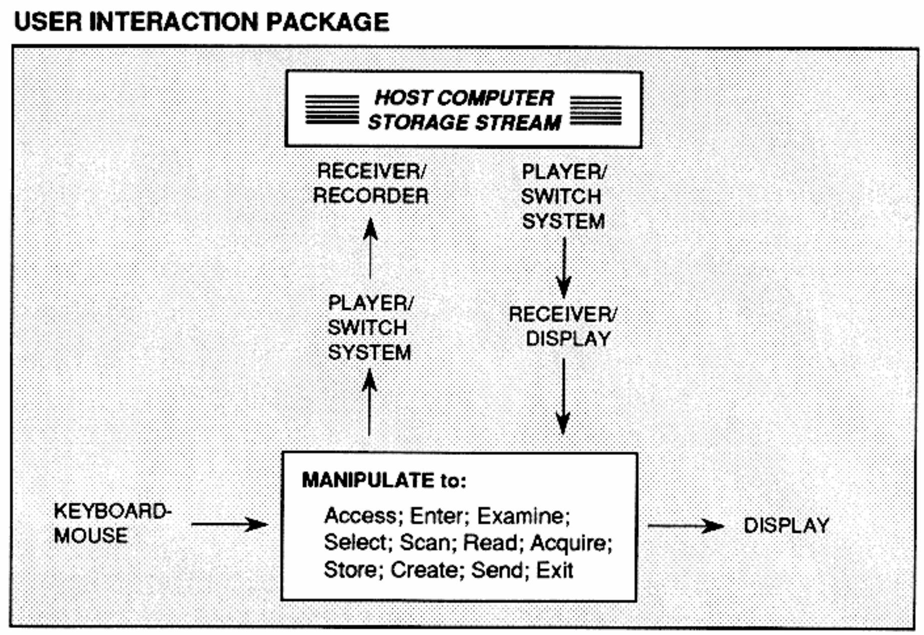
Figure 4-1 illustrates the operation of a typical Bulletin Board. A continuing stream of information items is kept stored in the memory of a host computer. The specific items in the stream are always changing, and the number may increase (subject to an upper-capacity limit) or decline. The source of the changes is a series of user interactions with the stream, shown in the figure as "Packages." Each package involves user conduct of a variety of manipulation and communications activities, many performed iteratively. The interactions allow users to engage in activities such as: select and read BB contents, retrieve or create and enter personal or group messages, load or download public software and shareware, enter comments and suggestions, and many others of the same general character.

The BB sysop (system operator) also interacts with the stream and through it with users. The sysop's interactions can come from a different "menu," and the sysop will have special action authority (such to delete items posted by other users under various conditions). Because the interactions are very similar structurally, they are not shown separately in the figure. A fully detailed listing of the process sequences of a typical interaction package would be boringly complicated, but all the individual steps are relatively simple.

Part of the reason Bulletin Boards have been successful is that they were grown from the ground up, by a diverse group of skilled users prepared to do the design and implementation work required to satisfy their individual and group needs. Also, and not to be underestimated, opportunities to use BBs during their formative stage were available at little or no direct cost to users. The result was considerable disorder, a good trial by fire of proposed ideas and a lot of rapid, mutually supportive transfers of knowledge as it was gained. How will these systems grow and change in the future?

There are two obvious paths BBs can follow—and they already show signs of following both. The first is to become more commercial and to adopt typical business objectives and structures. By the early 1990s, organizations such as Prodigy and America Online were well started in this direction. The second path is to maintain the past non-commercial pattern, with





NOTE: Processes (shown in Table 4) are indicated by upper case letters.

Figure 4-1

Schematic of Bulletin Board Operations

the pace of improvement, expansion of coverage, and growth in participation set primarily by actions of individual members, or prospective members, of the using community. Between these extremes is a spectrum of possibilities.

For the first path, both entrepreneurs and existing information services organizations can have key roles. For their BBs, it seems likely that, over time, professional editors would come to handle much of the work now done by sysops and would install relatively formal objectives, policies, and procedures for participating in particular sections (or all) of a BB's contents. Specific products and services might be offered, some perhaps developed mainly out of earlier BB contributions; this possibility and other incentive factors might lead to the copyrighting of many BB contributions. Access could be controlled in various ways—such as by having membership categories with different rights (e.g., those who can read only, those who can both read and write) for different levels of skill or experience or for different fees. Existing commercial BB operators have experimented with a variety of approaches to the problem; the most common one appears to involve offering a mix of different access requirements related to the BB subject. Advertising of some types (personal ads of members, ads for courses, meetings, equipment and software of interest, etc.) might be sought on an individual BB basis. At its best, a wide variety of different formats could evolve, all with strong user-contribution elements; but some of the current highly democratic atmosphere, and perhaps some of the existing low user cash costs might be lost in the process. Other differences in user operations can arise; for example, Prodigy was accused, quite early in its operations, of censoring user inputs. Some level of content control over entries on all BBs is apt to be required for legal and liability reasons, but commercial BBs probably are more sensitive than non-commercial ones to the threat of legal measures taken against them.

Continuation of the present pattern of expansion will keep most of the innovation in the hands of active users. This environment will foster highly utilitarian forms of growth but may slow simplifying types of standardization (which the leading and more expert users do not need so badly as users in the general public). New products and services that require significant initial capital investment or face potentially high market development costs, probably will not fare well within the current cooperative systems structure. Yet for many situations current-type BBs will be both viable and the preferred solution to user needs. The net effect is that there seems to be plenty of room for both paths to be followed; indeed, they seem to complement each other quite well.

The main social impacts of Bulletin Board systems are:

- the availability of a very effective and responsive means for two-way communications between people, whether as individuals, in small or large groups, or any combination thereof. This capability fills gaps in the general communications process (for easy many-to-one and many-to-many exchanges) that originated with the development of writing and have not since then been filled in a fully satisfactory way.[9]

- the potential availability of a low-cost means for individuals to engage in personal publishing in a format that offers the possibility of exposure to large audiences. This characteristic also completes a revolution of sorts. The invention of print, once other forces made literacy desirable, led to means for users to have convenient access to massive amounts of information at low cost; but the cost for individuals to produce and distribute information to large numbers of others remained high. The BB structure can go a long way toward ameliorating this condition.

- a possible means for scientific and professional publishing that is faster and more participative but still meets the formal requirements—such as for peer review—that characterize current journal publishing.[10] If existing experiments prove successful, both new variants of the BB approach and opportunities for moving into other publishing areas will abound.

The second paradigm, Interactive Multimedia (IMM), is in a very different situation. At the beginning of the 1990s, Bulletin Boards already had millions of users and were experiencing fast growth. At the same time, IMM was in a position of hope and hype, rather than proven accomplishment. The definition of what constituted, or should constitute, IMM was still somewhat fuzzy. Although a number of products had been offered, there had not yet been a clear-cut commercial success that could provide guidance for product developers. Judgments concerning the future of IMM therefore have a far weaker performance base behind them than those about BBs.

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[9]Traditional "many-to-one" methods, such as individual phone calls and letters, certainly can have impacts, but they are often slow and awkward for the "many" to use. More important, the "many" are often fragmented—that is, none of them may know what the others are saying. The power (and other benefits) gained by the more public nature of BBs is well illustrated in James Gleick, "Chasing Bugs in the Electronic Village," *The New York Times Magazine*, June 15, 1992.

[10]The description of a very successful BB well on its way to becoming a formal "electronic journal" (if users choose to try this direction) is given in "Publication by Electronic Mail Takes Physics by Storm," *Science*, **259** (26 Feb. 1993), 1246-1248, which also covers many facets of the publishing issues involved and factors critical for success.

In this report, the definition of IMM employed will be full in its inclusiveness of media and advanced, but not extreme, in its required quality of interaction. Thus, the multimedia component *must include*: extensive amounts each of text, full-range audio, and animation or video. It also may include static images, drawings and maps, and non-alphabetic alternatives to text like icons. The interaction level cannot be defined so sharply; it amounts to requiring that the user be meaningfully involved in a way that can influence the outcome of participation, relative to the purpose of the IMM offering. In other words, the user can win or lose a game of some type, be successful or fail at a simulation, gain or not gain a degree of new knowledge or skill, or in some other way benefit or fail to benefit from the experience, *but only* through the user's active intervention in how the IMM proceeds. Many forms of more passive multimedia are technically possible and may even be very pleasurable, but in the context of this report these will not be considered as contributing value.

The structure of an IMM product comprises two main elements:

- a collection of segments of materials in each of the selected types of media (text, audio, video, etc.), edited, linked, and integrated according to a script or plan governed, in part, by

- a set of interaction points, established by the script, or by the user's choice, or as a result of earlier user choices, or by some combination of these types of actions.

The interaction points offer or force the user to undertake physical manipulation or control actions, or make active decisions among a variety of alternatives. The user selections can have implications of many kinds: for advances, retreats, or sideways movements through the script, for changes in the medium to be displayed or the level of detail to be provided, for the nature of ensuing activity (e.g., rapid physical control activity, in contrast to temporary passive reading or listening), and for other kinds of changes within or among media. In some IMM structures, interactive choices might be made available to users only on request; at the other extreme, they may be required from users on almost a continuing basis. In all cases, there is a stated or implied purpose for the IMM, ranging from serious training and knowledge acquisition to pure entertainment.

IMM is a broad rubric, and many categories of products existing in the early 1990s had the potential to evolve to where they would meet the IMM definition given above. Some example are: adventure games, simulations, simulators, specific training materials, "how to" manuals, multimedia reference materials, and hypertext types of mixed educational and recreational materials. Most marketed consumer products in the first three categories were devoted almost entirely to entertainment and incorporated large amounts of physical control activity; this is likely to continue to be the case. Our primary interest, however, is in the limited portion of these products which have a more serious intent and which seek deliberately to incorporate elements of knowledge about some subject into their program.[11]

At this point one might ask, "So what's new? There's been hype about the potential value of computers for education since long before PCs—and not much has ever come of it.[12] What's different now?" IMM may not live up to its promise either, but it starts from a stronger base than earlier hopes did and with far better equipment and software and more experience to build on. Provided ambitions are kept under control, significant benefits can be expected simply from the ability to mix quite different media in a single product.

This single factor allows products to be built that make the borders between those that are game-like and the more traditional education formats become quite blurred. A lot of history, or geography, or mythology can be learned by osmosis while playing a *carefully researched* adventure game; such games can offer at least a partial alternative to more traditional computer or other types of education products. The same holds for learning about social problems, history, military tactics, and many other subjects. Meanwhile, PC simulator programs of all types are improving and becoming more realistic: this trend increases their potential for providing better quality training, as well as education, in at least some useful areas. And much of this learning activity can be done *outside any formal institution*. Much as the spread of public libraries enabled some past generations to attain quite respectable levels of self-education, IMM and related techniques may create equivalent opportunities for future generations. As indicated earlier, most of the products available in the early 1990s did not yet

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[11]Descriptions of many of the more popular games of the early 1990s, along with a discussion of their characteristics, are given in Eugene Provenzo, *Video Kids: Making Sense of Nintendo* (Cambridge, Mass.: Harvard University Press, 1991). An example of a successful product of the more serious type (one not covered by Provenzo) is Broderbund Software's "Where in the World is Carmen Sandiego?"

[12]An early but still useful example of such a critique is Anthony G. Oettinger, *Run Computer, Run: The Mythology of Educational Innovation* (Cambridge, Mass.: Harvard University Press, 1969).

fully meet our definition for IMMs, but members of all of the product classes were moving toward incorporating the required types of capabilities.[13]

Central to the hopes that IMM can have a healthy role in serious education is a characteristic of information that could not be exploited fully until appropriate digital electro-optical capabilities were available: the different natures of what users can get out of information received in different formats. Marshall McLuhan's oft-quoted statement that "the medium is the message"[14] reflects the observation that different formats not only enable different types of substance to be delivered but also produce different impacts on recipients when the same (or closely equivalent) substance is being provided. The observation also implies that different media can have different functional effectiveness in meeting the purposes for which a body of information is being used.

In 1985, Dan Lacy, a highly experienced senior executive at McGraw-Hill, Inc., examined this subject with regard to print (e.g., text) and audiovisual materials (mainly formats of the Electronics era, in the terminology used in this report). To summarize his comparison of the two families of formats: print is the means by which we *master experience*, while audiovisual media tend to be the means by which we *enjoy experience*. The achievement of "mastery" derives from the extensive abstraction, selection, arranging, and encoding processes that the author must conduct when preparing text and that the recipients then have to process back to understand the material. "It is simply impossible for any idea or information to be conveyed by print without both the author and the reader having thought intensively about the message." And "Reading. . .is an indispensable [way] when the purpose is to require a structured understanding, rather than an impression or an emotional experience, of reality."[15]

When Lacy prepared his views, the spread of PCs was underway, but neither the future market growth rate nor the future power of the hardware and software were fully appreciated.

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[13]The primary IMM deficiencies in the early 1990s were lack of video capabilities and generally limited "reading" type text. Large amounts of text might be present in reference materials, but these were intended to be used in small chunks, one or two at a time, rather than in more continuous reading operations.

[14]*Understanding Media: The Extensions of Man* (New York: McGraw-Hill, 1964). The title of Chapter One is "The Medium Is the Message."

[15]Dan Lacy, "The Diverse Psychologies and Functions of Print and Electronics," *Book Review Quarterly* (Spring 1985), 19.

With perfectly good reasons for that time, he treated "print" and "text" almost as equivalent but, in this report, electronic means are considered a possible successor to print as the preferred way to view many types of text. Following his line of thought, however, one can take the view:

- text enables us to master experience
- passive audio visual systems enable us to enjoy experience
- simulators (and, perhaps eventually, virtual reality systems) can enable us to "experience" experience, and
- a mix of interactive multimedia can enable us to get a balanced combination of different relationships to experience, in a form that, to some extent, can be customized to individual personalities.

This description suggests that, by combining media to obtain an optimum (or, more reasonably, a highly desirable) combination of presentation formats for a specific purpose and subject type, IMM may become a powerful teaching tool—or a powerful, individually controlled tool for learning outside formal educational institutions. While these results are likely to become at least partly true, there are some important limits:

- A previous work[16] noted that computers can be very useful aids for learning *skills* but have not been very helpful in acquiring *knowledge*. Yet for many subjects, knowledge (i.e., "structured understanding") is the primary ingredient of what Lacy terms "mastery." So gaining a mastery still is an area where text can be critical. If electronic presentation devices improve to where they turn out to be successors to print for working with text, there is no problem. Even if not, IMM can compensate for the display deficiencies or add to their advantages in at least two ways:

  – Provide means to integrate better the base text with other text and other media in order to: illustrate features, offer alternative perspectives, offer glimpses of related subjects that can help understand the current one, and a host of other quickly accessed and potentially useful items. Activity of these types is likely to be crude at first, but feedback can lead to the continuous improvement characteristic of digital electro-optical products.

  – Simply make learning more fun. For a lot of subjects, especially those that can build on general knowledge and "common sense," well designed games may become a standard way to learn a subject at the elementary, and even at an intermediate level.

[16]Ernst, *Users and Personal Computers*.

• The economics can pose problems, especially at the start. IMM development costs for a *good product* (that is, an accurate, well-researched one, with good presentation quality and user interaction features) are likely to be very high—more like TV or movie production costs than like book-preparation costs. To be successful, the products must be affordable by individual users, so they will need to have large markets. The market requirement in itself can limit the subjects that will receive attention during an early growth period.

• Unless or until equipment costs go down, or subsidies somehow are provided, there will be the classic social issue of the new technology favoring the "haves" of society over the "have-nots." We have faced this situation before with many technologies and normally have grown out of the problem. If the products do prove useful, rapid commoditization of the hardware and software will follow and any period of inequity will be brief. Given past experience with consumer electronics, there is reason for optimism. Somewhat similar remarks apply to the substance of IMM products and services. The IMM industry structure, combined with the control of substance that copyright law permits, may lead to a level of oligopoly of substance ownership that, at least temporarily, can be socially deleterious. Again, experience suggests that the problem, if it arises, will be temporary.

For years, marketers have known that the best means of entry to the household is entertainment, not information. Educators have known that the best means to encourage learning is to make it more stimulating for the learner. At its best, IMM can combine these two themes and make a significant difference to people, a difference that can keep growing over time. At its worst, only the first theme will be implemented strongly in IMM products, leading to lots of entertainment but also, perhaps, some socially undesirable side effects in how people spend their time.

The digital electro-optical technologies will spawn a wealth of new formats for providing information.[17] Some will be quite narrow, designed to meet the needs of a particular business or profession; others will affect business and government more broadly. The two examples discussed here were selected because they offer possibilities for impacting wide populations, influencing much if not, all of society. While each example faces a variety of barriers before achieving such a role, they both have much of value to offer.

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[17]This paper has largely ignored industrial applications of computers and, in **section 4.3.2**, has placed fairly stringent requirements on the interaction level needed to qualify as IMM. Many industry IMM-like applications, however, can be very supportive in creating and improving technologies important to IMM. A number of such interests are described in W. Robert Tirman, *The Elephant and the Blind Men: The Phenomenon of HDTV and Its Would-Be Stakeholders* (Cambridge, Mass.: Harvard University Program on Information Resources Policy, April 1991, P-91-3).

4.4 How Fare the Foundations?

Chapter Two of this report contains a fairly detailed description of two sets of concepts that provide a basis for understanding and structuring the various ways we communicate information. The first set concerns the procedures of symbolizing, patterning, and instantiation needed to create the substance to be communicated; the second is devoted to the substance-format-process package that provides the structure and actions needed for the substance to be delivered. In **Chapter Three** this background was used to examine the evolution of formats and, then, to identify particular features that characterize the newer types of formats. An appropriate question to consider is what impacts, if any, the features of the new digital electro-optical formats and processes have had on the validity, value, and uses of the underlying concepts employed to describe the evolutionary process?

Consider that question applied to the substance-format-process package concept in the context of a computer display operating with a hypothetical, near-future IMM application. The display has a role very comparable to that of the movie projector cited in section **3.3.2**—converting tokens into a presentation format at the point of consumption. Yet the IMM display is part of a system so flexible that the display can go far beyond the movie film-projector combination. Given suitable information input, the display can end up showing an analog (or imitation) of almost any conventional format (including the movie format). Within limits, it can be switched back and forth, showing the same substance presented in different formats, or with either analog or digital features. In some cases, it can be made to change the substance itself, such as by performing standard manipulations on data in real time. What is critical is that all these changes are made *under the control of, and using inputs from, the user*. In effect, a broad range of format and substance control has been transferred from provider to user; and the user has been transformed from a passive observer to a processor. These changes raise no problems concerning the validity of the information package concept, but they do influence how easily the concepts can be applied.

To gain a sense of how application of the information package concept can be altered, recall the process sequences given for various formats in section **3.3**. For most of the historical formats, the information communication activity had a clean cut-off. There was a transaction and it was completed—a newspaper was delivered, a TV program was received, or a book was borrowed at a library. In contrast, a major difficulty in trying to write-out the sequences for many of the digital electro-optical formats is that, because they are under user control, they often do not end cleanly. One search or data entry can suggest another, and then still more. The individual operations may have simple sequences, but, because one thing leads to another, they often cannot be determined until they happen.[18] The net effect is that the process sequence approach loses some of its value for defining formats and for describing what is going on at the detailed level.

Let us now turn to the other area of concern—symbols, patterns and tokens. If there is a problem here, it is rooted in how we instantiate and use symbols. For example, most of us know what a pen is, and we will quickly recognize a drawing of a pen as a kind of symbol for the real thing. Now consider such a drawing on a computer display. Each time one moves a stylus while pressing against a pad, the pen in the drawing moves and, at the nib end, produces a line that represents the stylus movement—and, simultaneously, the action produces an ink line on a piece of paper at the computer printer and another on a piece of paper a thousand miles away. And this procedure may be the only way (with this program) that a line can be drawn.

Is the drawing of the pen just a symbol, or something more? Is the stylus a pen, even though it may lack all pen-like appearance and features? Is there a pen anywhere in the system? If not, what is producing the drawing? Is this just a definitional problem, or is something more at work? Clearly, the most important aspect of the situation is that there is a mass of processes taking place between the physical stylus motion and the visual drawn output, and this intervention is changing the nature of the pen analogy. The image of the pen is still a symbol, but now it is more the symbol for a process than for an object! Once again, the concepts have not been damaged, but their application can be made less intuitive and more complex.

The intermediate processes mentioned above amount to what might be termed a "layering" operation—a feature frequently found in personal computer applications (and in other higher technology consumer products). Layering is used for many purposes, some of

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[18]This type of situation is not new; for example, it is a normal feature of telephone conversations. It can also appear in other older formats, but, for most of these, the user process operations were conducted very slowly, and with far fewer changes in substance and format details than are practical now. As a result, the older formats tended to terminate quickly, and with only simple, repetitive cycle structures. This is not true of the newer formats.

them of tremendous value. For example, it is the means by which the complexity of PC applications is hidden from users, in layer after layer of instructions written in a series of different languages. But for these advantages, there always is a price. Most commonly, the price is that the user is being further and further separated from ability to make direct contact with what "really" is going on!

An example of this price in the area of computer applications is that operations a user may very much want to perform and that are entirely practical (and even may be quite easy to arrange) may be impossible, because the means to conduct them involve making minor changes in one of the inaccessible hidden levels. In other situations, the separation may be more subtle. A concert performance with various extensions offers a good example. Aside from personally attending the performance, the closest one can come to the *reality of the event* is a "live" telecast, an unedited TV broadcast made while the program is in progress. But consider what a few layers of intermediate processes can (and often do) do thereafter. What about a taped recording of the concert, broadcast a few hours later in order to compensate for the different time zones in which some prospective viewers live? Or a few months later, for marketing reasons? Or edited by selecting and splicing in the best segments from a series of performances by the same orchestra playing the same music? Or making further "improvements" by correcting digitally (that is, changing the tokens for) any mistakes a soloist may have made?

At each of the above steps, the departure from representing the original event has become greater until the output—while apparently a brilliant performance—can surpass real "live" human capabilities. At each step, the output has become a "new" reality, but one that differs more and more from being an accurate version of what once happened. Increasingly, the output becomes a new work of art or a counterfeit, depending on one's feelings about such matters! Once again, the type of event described here is not new[19]; it is just a matter of new digital capabilities making simple what once was difficult. The very flexibility that gives digital technologies much of their value can undermine the security and integrity of instantiated token systems.

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[19]This basis, for example, and many others in different fields, are described in Gary Gumpert, *Talking Tombstones and Other Tales of the Media Age* (New York: Oxford University Press, 1987).

A still greater challenge to the stability of one's sense of reality is offered by what happens when operating a good professional simulator (such as one for training airline or military pilots or astronauts)—or, perhaps, when acting as a subject in a demonstration of an experimental Virtual Reality system. While there still is a long way to go, we are moving toward a time when a kind of Turing Test—that is, a test of whether a competent observer can decide whether an experience was "real" or just "virtually real"—may tell us that reality can be a pretty blurry matter![20]

These subjects go far beyond the scope of the present report, but it seems clear that there will be new digital electro-optical formats that can challenge how we use some of our key concepts concerning our means to communicate information. More socially important, these and other changes described here mean that our current concepts of literacy (which are grounded in the steam technology of the nineteenth century) and the means available to achieve literacy as an individual and on a national scale (which are grounded in the politics and economics of the early twentieth century social and industrial environment) will face new challenges. These concepts will have to evolve to exploit and incorporate (or to accommodate) the products of the new technologies, raising issues at the level of the national intellectual infrastructure.

[20]Key advances that could exacerbate this situation include the development of new types of tokens and new processors to create and manipulate them. These processor-token combinations might deal with sensory inputs concerned with feel, touch, and smell and others not covered by existing, widely used equipment.

Appendix

Developing and Interpreting Format Process Sequences

This appendix expands on information given in the body of the report and provides some additional examples, related data, and commentary. Perhaps equally important, information on all the format sequences that were developed is presented in tables, in a form that allows easy comparisons, rather than in the more extended, narrative form appropriate to the text.

It is assumed that readers have already examined the contents of **Chapter Three,** including the detailed processor definitions of **Table 3-2**. This material will not be repeated. Similarly, the notation for presenting sequences of processors was described in **Table 3-6** and supplemented in footnotes. This material also will not be presented again, although some minor changes and additions to the notation will be introduced and explained as needed. Also, for the reader's convenience, the revised processor notation will be summarized in **Table A-1,** immediately before presentation of detailed sequence information.

A.1 Processors and Sequences

Limitations due to Definitions

Process sequences are used in this report as a means to define formats *operationally*—that is, to define them in terms of the stream of process operations necessary to take information in an input form and deliver it, often at a different location, in a specific, presentation form. These sequences then provide the basis for examining the evolution of information products and services, as portrayed by changes in the formats used during different periods of history. Although comparisons are made of the relative complexity of different formats (and of some other attributes, like interactivity and ease of user control or participation), it is important to recognize the limitations that apply to these comparisons.

Processors were selected and defined on the basis that:

- individually, they were distinct in their function(s), differing from all the others in one or more critical aspects of their operations, and

- collectively, they were the minimum required to describe each of the formats in a sample that included examples of all significant historical, current and (recognized) near-future types of information/communication systems.

The requirement to cover all the formats in the selected sample had the beneficial side-effect of making the processor set one which can conduct all possible conversions among token durabilities and among the main underlying token technologies (i.e., mechanical, electronic, etc.). The requirement for minimizing the number of types of processors employed brought with it a less comfortable requirement that the individual processors be defined so as to have considerable breadth of applicability and "endurance" over time. For example, "Pen–Typewriter" must cover equipment ranging from sticks shaped for inscribing marks on moist clay to modern electric typewriters; and "Duplicate" must be applicable to crude, hand-set printing, to high-speed photo-offset operations, and to record and compact audio disk stamping.

The requirement that individual processors have broad application and temporal coverage sets some constraints on the general approach. It is meaningless to discuss many features of the individual processors, such as their market sizes, physical attributes, speeds of operation, complexity, costs, the skill and training requirements to use them, and others. Each characteristic has varied, often by many orders of magnitude, over time and among different applications and use environments.

Notwithstanding the above, it is very desirable to be able to make comparisons among formats and to identify temporal trends in their characteristics. It is practical to do this because formats can be examined using far more narrow coverage contexts than those applicable to processors. Each format has limited time periods, or eras, of special interest—normally the period associated with its earliest significant use and sometimes a later period when technological advances and socio-economic needs combined to give rise to a period of dramatic growth in its status. By concentrating on these specific eras, and considering only what appear to be standard applications of the formats during these periods, comparisons and trend analyses can be made. Even these, however, must be regarded as relative estimates and treated with care. Compared with writing a letter for mechanical delivery, the downloading and later use of material from an international database may seem complicated in terms of the number of processes in its sequence, but most of the actual complexity is hidden from users. From the point of view of human participants, the residual complexity of database downloading almost certainly pales in comparison with the complications of making the "simple" mechanical delivery of a letter from, say, London to Rome in the early 1500s!

Grouping Processes

As electronic formats began to be introduced, a change arose in how certain processors related to one another. Situations began to be encountered where two general but functionally quite different types of processes had to be conducted simultaneously, if the format was to work. Simple examples are radio, where a "Receiver" (in this case including a tuner) and a "Speaker" had to work together, and record or tape players, where "Player" must feed "Speaker" (or "Display" for TV tapes). In these situations, the equipment for the processors may be packaged as a single physical unit or, if marketing reasons encourage it, kept physically separated and connected by a standard interface of some type.

Because of the close relationships of the partners in the processor combinations, they have been "grouped" together in this report and treated as though they constituted single processors when counting numbers of processes and durability changes in a sequence.[1] The main groupings include:

Player feeding: Printer, Display, Speaker, Switch System, Transmission System, and Duplicator

Receiver feeding: Printer, Display, Speaker, and Recorder; and fed by: Switch and Transmission Systems

Recorder fed by: Pick-Up, Keyboard-Mouse, and Receiver

In addition, Manipulator can be grouped, but it is subject to special rules explained in **Chapter Three**. In particular, it can be built into Scanner, Switch and Transmission Systems, and Recorder, where it can provide capabilities needed for some formats to be effective. It also can be applied externally by a user exercising control over Recorder or Player or conducting independent processing of personal or work-related data.

Eras

Since the evolution of formats, and the dependence of new formats on the development of new processors, are major foci of this report, a time or progress scale was needed. The need was met by defining "Eras" established in terms of the approximate dates at which major changes took place in the information-communications industries. These included:

[1]This is mainly a matter of convenience and a way to remind readers of the close relationships involved; the participating processors can easily be treated as separate operators if desired.

- Era 1: Pre-writing; up to about 1000 B.C.
  – A single processor (Instruments) was developed during this era; two simple format sequences of the period are shown in tables presented in section **A.2**.

- Era 2: Writing; 1000 B.C. to 1460 A.D.
  – Three processors (Pen–Typewriter, Mechanical Delivery, and Storer) were developed. The sequences for two formats, one for essentially fixed-location items and one for transported materials, are given in tables in section **A.2**.

- Era 3: Early Print; 1460 A.D. to 1840
  – Two processors (Arranger and Duplicator) originated in this era; the only format sequence in the tables is for basic print publication.

- Era 4: Late Print; 1840-1900
  – Ten processors (Camera, Developer, Keyboard-Mouse, Projector, Pick-Up, Recorder, Player, Speaker, Scanner and Switch System) were developed during this period. The pace of technological development speeded, with still photography, telegraphy, phonographs, early facsimile, movies, and telephony all getting their start. Rotary presses, typewriters, typesetting equipment, and mass media all made their first appearances. This also was a period when the availability of public libraries expanded rapidly, and literacy began to be considered a national goal. Formats multiplied; eight of them are given in the tables.

- Era 5: Electronic; 1900-1950
  – Four processors (Transmission Systems, Receiver, Display, and Printer) were introduced. Wireless telegraphy, broadcast radio and TV, mobile radio, and a myriad of other electronic applications and mobile communications devices entered the market. Seven format sequences representing the period are given in the tables.

- Era 6: Digital Electro-Optical; 1950 to the Present
  – Only one processor, but a very important one (Manipulator) has been added so far in this Era. Until the early 1990s, new applications primarily emphasized better ways to produce or deliver old formats, such as cable or satellite for delivering TV, voice mail, electronic messaging, and home VCR systems. Almost all equipment incorporates computing elements; and computer-based formats have begun to appear. Eleven format sequences illustrate the developments of this era.[2]

As mentioned earlier, some processors can be closely associated with several eras—the first for its era of initial use and later ones for periods of special growth. However, the absence of any later references to a given processor should not imply any lack of continuing

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[2]Numerous sources contributed to the information provided here; one particularly useful was the tables in James R. Beniger, *The Control Revolution* (Cambridge, Mass.: Harvard University Press, 1986).

growth and improvement. Current Transmission operations, for example, bear little resemblance to those of the systems first used in Era 5; and today's Receivers mostly rely on quite different technologies from those of even the very recent past. Yet neither of these processors is associated with a later era.

The decision of whether to assign multiple eras to a processor is a judgmental one. In general, the criteria used here have emphasized either:

- being a key factor in exploiting major new markets, as was the case for Pen–Typewriter and Duplicator, when popular literacy became a national policy of many Western nations around the mid-1800s, or

- major changes in the types of underlying technologies of a processor and/or its applications. Examples here are Pick-Up, Recorder, and Player, as they underwent the changes from the (largely mechanical) phonograph and record to (electronic) radio and acoustic tapes to (magnetic and magneto-optical) TV cassettes, compact audio disks, and, most recently, computer storage operations.

A.2 Format Sequences and Related Characteristics

The main substance of this appendix is provided in a pair of tables that list thirty-one formats, their process sequences, and related information. About two-thirds of the formats and some of the other material has been presented in the text, but in a rather scattered fashion as the individual formats were discussed. In these tables they are all shown together, organized to give a more comprehensive sense of the evolution of formats.

To make the sequences more compact, so that a larger number of attributes and other information items could be associated with each format in the tables, abbreviations are used for the processors, instead of the full names given in the text. **Table A-1** lists the processors and their abbreviations; it provides other reminders of some processor properties and eras of use.

Tables A-2 and **A-3** provide the format and process sequence listings, with **Table A-2** emphasizing the numbers of processes and durability changes involved in each format and **Table A-3** illustrating historical and user control trends. In both, the information in the first three columns is the same (format number, descriptive name, and processor sequence) but the ranking order is different.

Table A-1

Major Processors and Key Attributes

	PROCESSOR	ABBREV.	TOKEN DURABILITIES		ERAS
			IN	OUT	
INPUT	Instruments	Ins	T	T	1
	Pen–Typewriter	Pen	T	D	2, 4
	Camera	Cam	T	T	4
	Pick-Up	Pup	T	T	4, 5, 6
	Scanner	Scn	D	T	4, 6
	Keyboard–Mouse	Key	T	T	4, 6
DELIVERY	Mechanical Delivery	Mek	D	D	2, 4
	Switch Systems	Swx	T	T	4, 5
	Transmission Systems	Twx	T	T	5
TERMINAL	Developer	Dev	T	D	4
	Player	Ply	D	T	4, 5, 6
	Receiver	Rvr	T	T	5
PRESENTATION	Projector	Prj	D	T	4
	Speaker	Spk	T	T	4
	Printer	Prn	T	D	5
	Display	Dis	T	T	5
ENHANCER	Arranger	Arr	—	—	3
	Storer	Str	D	D	2, 4
	Duplicator	Dpl	D	D	3, 4
	Recorder	Rdr	T	D	4, 5, 6
	Manipulator	Mnp	T	T	6

PROCESSORS INDEXED BY ABBREVIATION

Arr = Arranger
Cam = Camera
Dev = Developer
Dis = Display
Dpl = Duplicator
Ins = Instruments

Key = Keyboard-Mouse
Mek = Mechanical Del.
Mnp = Manipulator
Pen = Pen-Typewriter
Ply = Player

Prj = Projector
Prn = Printer
Pup = Pick-Up
Rdr = Recorder
Rvr = Receiver

Scn = Scanner
Spk = Speaker
Str = Storer
Swx = Switch System
Trx = Transmission System

DEFINITIONS OF ERAS

1 = Pre-writing, oral tradition societies: up to about 1000 B.C.
2 = Writing: 1000 B.C. to 1460 A.D.
3 = Early print: 1460 to 1840 (in Europe)
4 = Late print, mass media, early electric: 1840 to1900
5 = Electronic: 1900 to 1950
6 = Digital electro-optical: 1950 to present

Table A-2 (for which the format numbers are in arithmetic sequence) has formats ranked in order of increasing number of processes per sequence, with increasing number of durability changes as a second sort key. Among sequences having the same values for these two sort criteria, the numbers of processes and durability changes per sequence that take place on user equipment, serve as third and fourth sort keys. The order of listing corresponds very crudely to growth in complexity, but with all the cautions mentioned earlier (in section **A.1**) applying.

From information given in the text, the column headings of **Table A-1** should be self-explanatory, but the coding for the Durability Change columns requires some explanation. The "In" and "Out" columns are concerned with:

- the durability of the initial input—sound, writing, keyboard strokes, images, a document to be scanned, etc.; these tokens (and the processes that created them) are not included explicitly in the process sequence listings, and

- the durability of the output, which is the durability of the presentation device's output tokens.

The durability listings start with the input token durability and indicate the changes that arise during each processing operation, using the following code:

- "o" means that there has been no change in durability,

- "+" means that a change in durability from Transient to Durable has taken place, and

- "—" means that a change in durability from Durable to Transient has taken place.

Note that a "+" must be followed by an "o" or a "—", and that a "—" has similar restrictions. These restrictions cause the possible combinations of durability changes in a sequence to increase as 2^n, where n is the number of processes in the sequence. It is obvious that many of the theoretical sequence possibilities could not arise in a sample of the size selected for study, even though the sample includes members from most of the commonly encountered formats of history![3] Note that the durability change sequences in **Table A-2** do not include the brackets, underlining, or the special bracket separator (::) used in the process sequences, so some of the fine detail is not shown.

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[3]No effort was made to determine which of the possible combinations represent feasible formats, much less useful or valuable ones.

Table A-2

Process Flows for a Sample of High-Level Communications and Information Formats

	ACTIVITIES	MAIN PROCESSES	DURABILITY CHANGES			PROCESSES		DURABILITY CHANGES	
			INPUT	SEQUENCE	OUTPUT	TOTAL NO.	NO. BY USER	TOTAL NO.	NO. BY USER
1.	Speech; Sign languages; Debate; Drama	[None]	T	—	T	0	0	0	0
2.	Sound signals (bells, trumpets, drums, whistles); Flag signals (semaphore); Smoke signals	[Ins]	T	o	T	1	0	0	0
3.	Personal lists, diaries and reminders; On-site agreements	[Pen]	T	+	D	1	1	1	1
4.	Public address system	[Pup > Spk]	T	o > o	T	2	0	0	0
5.	Personal or business letter	[Pen > Mek]	T	+ > o	D	2	0	1	0
6.	Personal (film-based) still photography	[Cam > Dev]	T	o > +	D	2	1	1	1
7.	Document scanned into computer memory	[Scn & Mnp > Mnp & Rdr]	D	– > +	D	2	2	2	2
8.	Live radio or television	[Pup > Trx] > [Rvr & Spk or & Dis]	T	o > o > o	T	3	1	0	0
9.	Telephone conversation (two-way capability)	[Pup & (Rvr & Spk)] > [Swx] > [(Rvr & Spk) & Pup]	T	o > o > o	T	3	1	0	0
10.	Early printing	[Pen > Dpl > Mek]	T	+ > o > o	D	3	0	1	0
11.	Modern print mass media of all types	[Key & Rdr > Dpl > Mek]	T	+ > o > o	D	3	0	1	0
12.	Personal (film-based) movie photography	[Cam > Dev > Prj]	T	o > + > –	T	3	2	2	1
13.	Telegraph and telex—private line	[Key > Swx] > [Rvr & Prn]	D	– > o > +	D	3	1	2	1
14.	Early facsimile	[Scn > Swx] > [Rv r& Prn]	D	– > o > +	D	3	1	2	1
15.	Computer speech recognition; VDT output	[Pup > Rdr & Mnp > (Mnp & Ply) & Dis]	T	o > + > –	T	3	3	2	2
16.	Telegraph and telex—delivery from central office	[Key > Swx > Rvr & Prn > Mek]	D	– > o > + > o	D	4	0	2	0
17.	Records; Audio or video tapes, disks, etc.	[Pup & Rdr > Dpl > Mek] :: [Ply & Spk or & Dis]	T	+ > o > o > –	T	4	1	2	1
18.	Delayed TV broadcast of material made earlier and stored	[Pup > Rdr] :: [Ply & Trx] > [Rvr & Dis]	T	o > + > – > o	T	4	1	2	0
19.	Voice mail—view of one-way message	[Pup > Swx] > {Rvr & (Rdr & Mnp)} :: [(Mnp & Ply) & Spk]	T	o > o > + > –	T	4	2	2	1

Table A-2, continued

	ACTIVITIES	MAIN PROCESSES	DURABILITY CHANGES			PROCESSES		DURABILITY CHANGES	
			INPUT	SEQUENCE	OUTPUT	TOTAL NO.	NO. BY USER	TOTAL NO.	NO. BY USER
20.	Modern facsimile (fax)	[Scn & Mnp > Swx] > [Rvr & (Rdr & Mnp) > Ply & Prn]	D	– > o > + > o	D	4	2	2	1
21.	User delayed VCR playback of live TV program	[Pup > Trx] > [Rvr & Rdr] :: [Ply & Dis]	T	o > o > + > –	T	4	2	2	2
22.	Electronic mail; VDT output at user site	[Key & Rdr > Ply & Swx] > {Rvr & (Rdr & Mnp)} :: [(Mnp & Ply) & Dis]	T	+ > – > + > –	D	4	1	4	1
23.	Audio database inquiry; User view	[Pup > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & Spk]	T	o > o > – > o > o	T	5	4	1	1
24.	Movies—delivered in theaters	[Cam > Dev > Dpl > Mek > Prj]	T	o > + > o > o > –	T	5	0	2	0
25.	Remotely printed text mass media	[Key & Rdr > Ply & Swx > Rvr & Rdr > Ply & Dpl > Mek]	T	+ > – > + > o > o	D	5	0	3	0
26.	Database inquiry; Provider view of process	[Scn & Mnp > Mnp & Rdr > Str] :: {Rvr & (Mnp & Ply) > Swx}	D	– > + > o > – > o	T	5	1	3	1
27.	Traditional public library system; Data Item view	[Pen > Dpl > Mek > Str] :: [Mek > use > Mek]	T	+ > o > o > o > o > o	D	6	2	1	0
28.	Database inquiry; User view of full cycle; VDT output	[Key > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & Rdr > Ply & Dis]	T	o > o > – > o > + > –	T	6	3	3	2
29.	Database downloading, with later retrieval and viewing; user view of full process; print output	[Key > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & (Mnp & Rdr)] :: [Mnp & Ply & Prn]	T	o > o > – > o > + > o	D	6	4	3	2
30.	PC personal records operations	[Key > Mnp & Rdr] :: [Key > Mnp & Ply > Mnp > Mnp & Rdr > Ply & Prn]	T	o > + plus o > – > o > + > o	D	7	7	3	3
31.	Database inquiry; Data Item view of full cycle; VDT output	[Scn & Mnp > Mnp & Rdr > Str] :: {Mnp & Ply > Swx} > [Rvr & Rdr > (Mnp & Ply) & Dis]	D	– > + > o > – > o > + > –	T	7	3	5	3

Table A-3

Features of the Development of a Sample of High-Level Communications and Information Formats

	ACTIVITIES	MAIN PROCESSES	ERAS OF USE FIRST	ERAS OF USE LATER	TYPES OF USER CONTROL
1.	Speech; Sign languages; Debate; Drama	[None]	1	—	Participation
2.	Sound signals (bells, trumpets, drums, whistles); Flag signals (semaphore); Smoke signals	[Ins]	1	—	None
3.	Personal lists, diaries and reminders; On-site agreements	[Pen]	2	—	Manipulation
5.	Personal or business letter	[Pen > Mek]	2	4	Convenience
10.	Early printing	[Pen > Dpl > Mek]	3	4	Convenience
6.	Personal (film-based) still photography	[Cam > Dev]	4	—	Partial Manipulation
12.	Personal (film-based) movie photography	[Cam > Dev > Prj]	4	5	Partial Manipulation
13.	Telegraph and telex—private line	[Key > Swx] > [Rvr & Prn]	4	5	None
14.	Early facsimile	[Scn > Swx] > [Rv r& Prn]	4	6	None
16.	Telegraph and telex—delivery from central office	[Key > Swx > Rvr & Prn > Mek]	4	—	None
17.	Records; Audio or video tapes, disks, etc.	[Pup & Rdr > Dpl > Mek] :: [Ply & Spk or & Dis]	4	5, 6	Convenience
24.	Movies—delivered in theaters	[Cam > Dev > Dpl > Mek > Prj]	4	—	None
27.	Traditional public library system; Data item view	[Pen > Dpl > Mek > Str] :: [Mek > use > Mek]	4	—	Convenience
4.	Public address system	[Pup > Spk]	5	—	None
8.	Live radio or television	[Pup > Trx] > [Rvr & Spk or & Dis]	5	—	None
9.	Telephone conversation (two-way capability)	[Pup & (Rvr & Spk)] > [Swx] > [(Rvr & Spk) & Pup]	5	—	Participation
11	Modern print mass media of all types	[Key & Rdr > Dpl > Mek]	5	—	Convenience
18.	Delayed TV broadcast of material made earlier and stored	[Pup > Rdr] :: [Ply & Trx] > [Rvr & Dis]	5	6	None
23.	Audio database inquiry; User view	[Pup > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & Spk]	5	—	Convenience

	ACTIVITIES	MAIN PROCESSES	ERAS OF USE		TYPES OF USER CONTROL
			FIRST	LATER	
25.	Remotely printed text mass media	[Key & Rdr > Ply & Swx > Rvr & Rdr > Ply & Dpl > Mek]	5	—	Convenience
7.	Scan document into computer memory	[Scn & Mnp > Mnp & Rdr]	6	—	Manipulation
15.	Computer speech recognition; VDT output	[Pup > Rdr & Mnp > (Mnp & Ply) & Dis]	6	—	Manipulation
21.	User delayed VCR playback of live TV program	[Pup > Trx] > [Rvr & Rdr] :: [Ply & Dis]	6	—	Convenience
19.	Voice mail—view of one-way message	[Pup > Swx] > {Rvr & (Rdr & Mnp)} :: [(Mnp & Ply) & Spk]	6	—	Partial Manipulation
22.	Electronic mail; VDT output at user site	[Key & Rdr > Ply & Swx] > {Rvr & (Rdr & Mnp)} :: [(Mnp & Ply) & Dis]	6	—	Partial Manipulation
20.	Modern fax	[Scn & Mnp > Swx] > [Rvr & (Rdr &Mnp) > Ply & Prn]	6	—	None
26.	Database inquiry; Provider view of process	[Scn & Mnp > Mnp & Rdr > Str] :: {Rvr & (Mnp & Ply) > Swx}	6	—	Manipulation
28.	Database inquiry; User view of full cycle; VDT output	[Key > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & Rdr > Ply & Dis]	6	—	Partial Manipulation
29.	Database downloading, with later retrieval and viewing; User view of full process; Print output	[Key > Swx] > {Rvr & (Mnp & Ply) > Swx} > [Rvr & (Mnp & Rdr)] :: [Mnp & Ply & Prn]	6	—	
31.	Database inquiry; Data item view of full cycle; VDT output	[Scn & Mnp > Mnp & Rdr > Str] :: {Mnp & Ply > Swx} > [Rvr & Rdr > (Mnp & Ply) & Dis]	6	—	—
30.	PC personal records operations	[Key > Mnp & Rdr] :: [Key > Mnp & Ply > Mnp > Mnp & Rdr > Ply & Prn]	6	—	Manipulate

The sources of the growing complexity of formats is fairly evident in the material in **Table A-2**. The simple presence in a process sequence of underlining or, even more, the use of the separator "::", suggests that the associated format is likely to have a significant level of user activity and responsibility. Similarly, cycles of durability changes (such as -> + >-, or + >-> +) are indicators of the rapid movement of information, and/or its storage over time. These cycles also are typical of formats with multiple participants or with repeated user interactions with (one's own or others') materials.

When formats are ranked as in either **A-2** or **A-3**, the features discussed above all suggest growing *inherent format complexity* over time. It is important to recognize that this trend is closely related to the fact that most of the newer formats became broadly successful only after hardware and software had been developed that could hide most of their inherent complexity. Complexity-hiding may well be the pacing technology for many of the potential formats of the future; failure to recognize its importance can easily become a source of disaster in efforts to market new products and services.

Entries in **Table A-3** are ranked by increasing order of their Era of initial application. Within Eras, the total number of processes per sequence is used as the secondary sort key. The order of listing is only a crude approximation of the historical order of development, because no effort was made to keep to historical order within Eras. To establish such an order would have posed a variety of definitional problems (concerning, for example, the level of use needed to qualify a format as the "winner" over other formats in the "race" to be first in use), with little to be gained from the resulting fine structure.

The primary matter of interest in this table concerns changes in the nature and extent of user control, as a function of the format being used and its era of initial development. Five categories of user control are employed:

- **None**: The user is a passive absorber of what is offered him or her, at the time and place set by the provider.

- **Convenience**: The user has control over when and where the format output will receive attention but no control (except with regard to the decision to acquire the material) of the substance being provided.

- **Participate**: The user is an active participant, sharing control over substance (with share size dependent on numerous factors) but often with little or no control over the time and place of the sharing activities.

• **Partial Manipulation**: The user has control over time, place, and some aspects of substance. The most common limitation on control arises when the user is accessing a provider's (or other type of owner's) files; usually the user can conduct, say, search-type operations but cannot alter the files unless authorized to do so.

• **Manipulation**: Full manipulation corresponds to essentially complete control in the hands of users—control over when and where substance is accessed and total freedom to add, delete, or modify substance and local format features.

There will, of course, be gray areas where the choice of a category could go in one of several directions. For example, depending on details of the number and types of user choices offered, a computer game might be considered as falling in either the Partial Manipulation or the full Manipulation category. In most situations, however, category selection is clear cut.

Returning to **Table A-3**, the pattern is not very complicated. Until recently, Participation was possible only with voice formats; in the cases shown, this meant vocal communications either in-person or by telephone. During the same periods, Convenience was based on having in one's possession products with Durable output tokens, like printed materials or records. Partial Manipulation was available only to users of photographic formats, and full Manipulation was possible only for users who were also creators or originators. This pattern continued until computer-related formats came into use.

Almost all computer-age formats allow some form of user manipulation—generally Partial Manipulation when another's files are being used and full Manipulation for downloaded materials, other received and acquired materials, and information in one's own files. Formats like Electronic Mail and Bulletin Boards (discussed in considerable detail in section **4.3.2** but not sequenced for the tables) allow extensive and active user Participation, even though full manipulation generally is not possible. In due course, all these capabilities will be able to be applied using the full range of types of information presentation—text, image, audio, and video. The required token conversion and process capabilities are available and rapidly becoming very affordable. The availability of these capacities suggests that, until we have a large-scale advance so fundamental that it requires new token types, the main near-term bottlenecks are likely to become the design of software to perform new functions of value to users and the closely related area of complexity-hiding.

At some point in the future, progress will depend on creating new kinds of tokens. Virtual Reality (VR) furnishes a possible example where such a requirement could arise. Most VR types of products of the early 1990s are inexpensive, limited, and simplistic home game equipment, more expensive arcade games with somewhat greater scope, or very expensive but often realistic training simulators. To build and make available a range of effective products at mass market prices, it may be necessary to have new families of token types to acquire/create/input and later present/output "materials" with features such as: touch (perhaps "Feeler" and "Stroker"), odor ("Smeller" and "Olfactorer"?), three-dimensional vision ("Holo"?), and others!

Acronyms

BB	computer bulletin board
DBSs	database systems
GUI	graphical user interface
IMM	interactive multimedia system
PC	personal computer
VR	virtual reality