SYSTEMS ARCHITECTURES FOR DOWNSIZING

INPUT

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Abstract

Systems Architectures for Downsizing continues INPUT's series of in-depth reports on downsizing. Its purpose is to examine the various layers of an informations systems architecture and assess the risks associated with downsizing. Many vendors and executives seem to lack understanding or awareness of the problems and complexities of data base management and of replacing knowledge workers with technology. Downsizing affects individual, group, and corporate performance and therefore contains some risks at each level. These risks can be minimized by careful consideration of the two major aspects of downsizing: technological and organizational. To better understand the innovation occurring in these two areas, the report looks "behind the screen" at hardware and software architectures, "at the screen" at business applications, and "beyond the screen" at management and organizational changes.

This report offers insights in the areas described above based on extensive secondary research as well as primary research. A bibliography is included. *Systems Architectures for Downsizing* also draws on research presented in a previous INPUT report, *Putting Downsizing in Perspective*. From this broad background, INPUT has constructed a "proper" architectural model for a downsized network of computer systems, which is illustrated in this report.

The report contains 130 pages and 27 exhibits.

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I

Introduction

During the research for *Putting Downsizing in Perspective*, it was determined that the architectural issues associated with downsizing ranged from controversies surrounding internal computer architectures to those manifested by changes in management and organization theory. In between, there are complex technical and management problems that have challenged experienced and knowledgeable professionals for decades without agreement on solution, or even direction. However, computer vendors promising more technological "bang for the buck" from downsizing and corporate executives who intend to eliminate middle management by downsizing are currently proceeding as if the only thing standing between more MIPS and leaner, more competitive business organizations is the central IS department.

MIPS merchants and corporate executives seem to share a common architectural point of view. It is called "client/server"—a term that didn't even exist a couple of years ago. What this seems to mean to intelligent-workstation vendors is that all of the responsibility of "data manipulation" (and quality) will be left up to a server; and "applications," which used to run on a mainframe, will now be run on the desktop. What it seems to mean to corporate executives is that, with direct access to data base servers and "unlimited" computer power, they will no longer have to depend upon humans to analyze, filter, interpret, and present this information to them.

What this means to us is that there are some computer vendors who either do not understand, or choose to ignore, the problems and complexity involved in data base management; and there are some executives who do not understand the current limitations of computer technology replacing knowledge workers. Considering the fact that both technological and organizational downsizing are proceeding with the intent of also reducing information systems costs, these oversimplified views of an information architecture appear to be quite dangerous.

A
Objectives

The purpose of this report is to look at the various layers of an information systems architecture and the risks associated with downsizing. The report has the following major objectives:

- To identify and explain the key architectural elements of commercial data processing applications
- To establish the importance and complexity of data base management in commercial information systems architectures
- To focus attention on the necessity for integration of computer and paper-based information systems
- To identify and examine the competing architectural concepts associated with information systems as they relate to downsizing, and to focus attention on information architecture rather than on tools
- To identify possible impacts of downsizing on individual, work unit, and institutional performance
- To provide frameworks for analysis of various downsizing innovations and their potential benefits and consequences
- To integrate technological downsizing with the various management and organizational initiatives of "human" downsizing—the purpose being to take an overall architectural view of the downsizing phenomenon
- To present a new architectural view of information systems as they relate to organization and management, with emphasis upon the changing nature of work, culture, and mind-set in the new downsized environment
- To explore the challenges and opportunities presented by downsizing for management, IS, and vendors, with special emphasis upon IS management, which seems to be caught squarely in the middle between expectations and reality
- To reach some conclusions concerning the risks inherent in various downsizing approaches and to make recommendations for minimizing IS risk while focusing on opportunities

B

Scope and Methodology

1. Methodology

The research for this report was initiated during the preparation of *Putting Downsizing in Perspective*. The primary and secondary research for that report also provided the foundation for this one.

That research also marked something of a departure for INPUT reports in that references and a supporting bibliography were included. This does not mean that INPUT is adopting a more "academic" format and placing more emphasis upon secondary sources. However, a brief explanation is required.

During the process of defining "downsizing" it was necessary to distinguish between the technological downsizing prompted primarily by microprocessor development, and organizational downsizing prompted by a complex set of factors including new management theories, the recession, the surprising decline of many leading companies during the 1980s, and the failure of information technology to provide competitive advantage. The exact relationship between technological downsizing and organizational downsizing is not clear. However, there can be no question that technology innovations are playing a major role in determining the global competitive environment.

Although INPUT maintains a full program of continuing research activities for information technology innovations, it had no formal research program in the management and organizational impacts of such innovations. Therefore, in parallel with the primary research for the downsizing study, an extensive literature search was conducted on issues associated with the management and organizational impacts of IT innovation.

The result was 50 pages of models, lists, matrices, processes, and rules for encouraging, discouraging, managing, exploiting and using innovations from over 90 publications. These publications were a valuable research source for this report. Some are quite well known and others are rather obscure. Some proved valuable in developing the models used in this report, and these sources have been appropriately credited.

In addition, during the course of this study, INPUT has been screening specific organizations as downsizing case study companies, and approximately 20 telephone and personal interviews were conducted with IS management on architectural aspects of downsizing in their companies. These case studies will be fully documented in *Case Studies in Downsizing,* which will be published in May of this year. The preliminary interviews have already proved valuable in the preparation of this report.

Then, of course, downsizing encompasses many of the technical subject areas in which INPUT has been, and is, conducting research on a continuing basis, such as open systems and client/server architectures.

2. Scope

The scope of this report is exceptionally broad. INPUT has looked down into the microcosm of processor architecture and outward toward what work will be like "in the age of the smart machine," and has put forth a "proper" architectural model for a downsized network of computer systems. We have identified and briefly analyzed competing architectural concepts associated with downsizing, and have established a general strategy for risk reduction. We have not gotten embroiled in detailed discussions of the controversies surrounding competing operating systems, communications protocols or vendor products, except to acknowledge the realities of certain technologies in the marketplace.

C
Related Reports

- *Putting Downsizing in Perspective*
- *Case Studies in Downsizing*
- *Client/Server Applications and Markets*
- *Open Systems Opportunities*

II

Executive Overview

A
Background and Methodology

This study is an outgrowth of *Putting Downsizing in Perspective*, a report that provides valuable background information for this one. Because the detailed research findings of *Putting Downsizing in Perspective* are not repeated in this report, it is recommended that the reader become familiar with the earlier report in order to achieve maximum benefit from this one.

During the process of defining downsizing, it was determined that the term is being applied specifically to traditional business applications that are currently running on IBM mainframe computers. It also became apparent that technological downsizing was being accompanied by management downsizing of organizational structures, and that one of the primary objectives of technological downsizing was to reduce information systems costs.

Because the architecture of information systems reflects human organizational structures, and information technology is aimed at improving human productivity, it is not logically inconsistent to expect that technological downsizing would be accompanied by downsizing of the human organizational structure. However, there were several things that disturbed us about the relationship between the parallel downsizing initiatives and their anticipated consequences.

- Before the term downsizing came into prominence, considerable downsizing of information systems technology had already occurred during the 1980s. Microprocessor-based workstations and personal computers (intelligent workstations—IWSs) replaced minicomputers and mainframes for many engineering and office functions.

- White-collar productivity in the United States did not improve during the 1980s, and it has been impossible to establish any positive correlation between investment in information technology and enterprise performance. In fact:

  - White-collar workers are working longer hours now than they did before they had the personal productivity aids provided by their personal computers.

  - Most American business enterprises classified as "excellent" in the early 1980s had lost positions of leadership in international markets by the end of the decade, despite investing substantially more in information technology than did their competitors. [16]

- Management's desire to cut IS expense may be based upon the fact that investment in information technology (including the personal computer revolution of the 1980s) has failed to achieve anticipated results. It seems obvious that the central IS function is being held responsible for this failure (or at least is considered part of the problem). However, it seems clear that the continued pursuit of technological downsizing is based on the assumption that this will somehow support organizational downsizing and lead to a more competitive organization.

In order to better understand the relationship between the innovations that are occurring in both technological and organizational architectures, this report established a research metaphor which looked "behind the screen" at hardware/software architectures, "at the screen" in terms of business application architectures, and "beyond the screen" at the changes in management and organizational architectures.

B

Behind-the-Screen Architecture

There is a complex set of information systems architectures behind the screen of any business system. The very essence of downsizing is the shift from a mainframe, host-oriented architecture to client/server architectures with minicomputers or IWSs as servers and IWSs as clients. Research from INPUT's previous study showed that minicomputers were top ranked as distributed data base servers by IS management, and INPUT concurs with that assessment.

The possible target platforms for downsized commercial applications fall into three general categories—proprietary minicomputers, RISC/UNIX-based minicomputers and IWSs, and PS/2-based LAN servers. In terms of architecture and market acceptance, one particular system would seem to stand out above the others as a distributed data base server in the commercial environment: IBM's AS/400. Though IBM has not seen fit to aggressively market the AS/400 for downsizing (for obvious reasons), it must receive attention as a downsizing platform, as shown in Exhibit II-1. Its advantages can be briefly summarized as follows:

EXHIBIT II-1

Behind-the-Screen Architecture
(Target Applications and Platforms)

	Target Applications	Minicomputer	Target Platforms	
			RISC/UNIX	PS/2
Hardware	System 370/9000 (CISC)	AS/400 (HLL) Other (CISC)	IWSs & Minis (RISC)	PS/2 (CISC, MCA) Comp. (CISC, EISA)
Systems/ Software (including DBMS)	MVS/ESA IMS, DB2, CICS	OS/400 - SQL Various Proprietary	UNIX & UNIX-like C+, Various relational	OS/2 vs. DOS, NT Various relational-like productivity tools
Commercial Applications Software	COBOL Programming "Investment"	RPG-COBOL-pkgd. COBOL-4GLs Same packages	Limited	Most "applications" are tools, few industrial strength
Data Bases	IMS, DB2	OS/400-many Various	Few installed	Few real data bases, many spreadsheets
Business Systems	"IBM oriented"	S/3X, AS/400 predominate DEC, HP, DG	Extremely limited	Office productivity Few mainstream applications
Innovation Phase	Consequences: complex, expensive	AS/400: extensive & diffused; quality award	Development, commercialization, limited diffusion, uncertain consequences	Development, commercialization, limited diffusion, uncertain consequences

- Against mainframe hosts its tightly integrated hardware/software architecture, single-level addressing, superior connectivity, and ease of use provide clear-cut advantages in terms of installability and usability. This results in substantially lower support costs for systems programmers, operators and data base administrators. IBM recently stated publicly that such support costs on the AS/400 are estimated to be one-fifth those for mainframes used for comparable size data bases and attached workstations.

- Against other proprietary minicomputers, the AS/400 has dominated the commercial midrange market since it was announced nearly four years ago. Other minicomputer manufacturers have embraced UNIX and "open systems" to attack the AS/400. Four years ago, DEC was stating that the System/3X (the AS/400 predecessor) had only a "niche market" and that UNIX was "snake oil." Today, the AS/400 exceeds DEC's total sales, and DEC is rubbing on the "snake oil" to protect its market share. Wang was a leader in departmental computing and image processing five years ago, and it is now selling AS/400s in an effort to protect its image processing market.

- Regardless of what one reads in the trade press, RISC/UNIX systems are not penetrating the commercial market in significant numbers as either midrange systems or as IWSs. Despite the development by major vendors of "UNIX-like" systems in an effort to improve the basic UNIX kernel(s) for the commercial market, UNIX still has a long way to go as a transaction processor or distributed data base server in a client/server architecture. Even vendors who have embraced UNIX and open systems are finding that their proprietary systems continue to sell well. Against the AS/400 as a downsizing platform, there is just no contest where data base integrity, synchronization and security are concerned—and those are precisely the concerns of IS management in a downsizing environment.

- The PS/2, and compatibles, cannot be taken seriously as distributed data base servers for downsized mainframe applications at this time. The PS/2's basic hardware/software architecture just isn't up to the job.

  - Customers (and software vendors) are still struggling with how to make effective use of contiguous, extended, and expanded memory under DOS 5.0.

  - Most PC "applications" continue to be software tools, and word processing and desktop publishing remain the most prominant business applications.

  - Most personal "data bases" on personal computers are stored in spreadsheet files, and standard error recovery consists of hitting the reset button.

  - Shrinkwrapped business applications are not industrial strength, and the next "Downsizing—International Conference & Exposition" will feature a paper on "The Danger of the Shrinkwrap Fallacy."

  - An operating system war is still going on, and while OS/2 EE holds promise of being an industrial-strength operating system, there is currently no proof that it is robust enough to serve as a distributed data base server for downsized commercial applications.

- The recent Michelangelo virus scare is a good example of the maturity of the personal computer industry: if you can't fix it with the reset button, push the panic button.

It is obvious that both RISC/UNIX and personal computer hardware/software are still undergoing development and commercialization for the business systems market. Both technologies have yet to be widely diffused in the commercial data processing market. Every month that passes, over $1 billion worth of AS/400s go directly into that market. When looking for data in the downsized environment, it will be necessary to interface with AS/400s, because they have already seized the high ground on what has never been a level playing field.

Any objective report card comparing the architectures and market acceptance of potential downsizing platforms as distributed data base servers in the commercial market would give the AS/400 a clear advantage over its competitors. The Malcolm Baldridge Award for quality that was given to the AS/400 confirms that it is a superior hardware/software product in the real world.

C

On-the-Screen Architecture

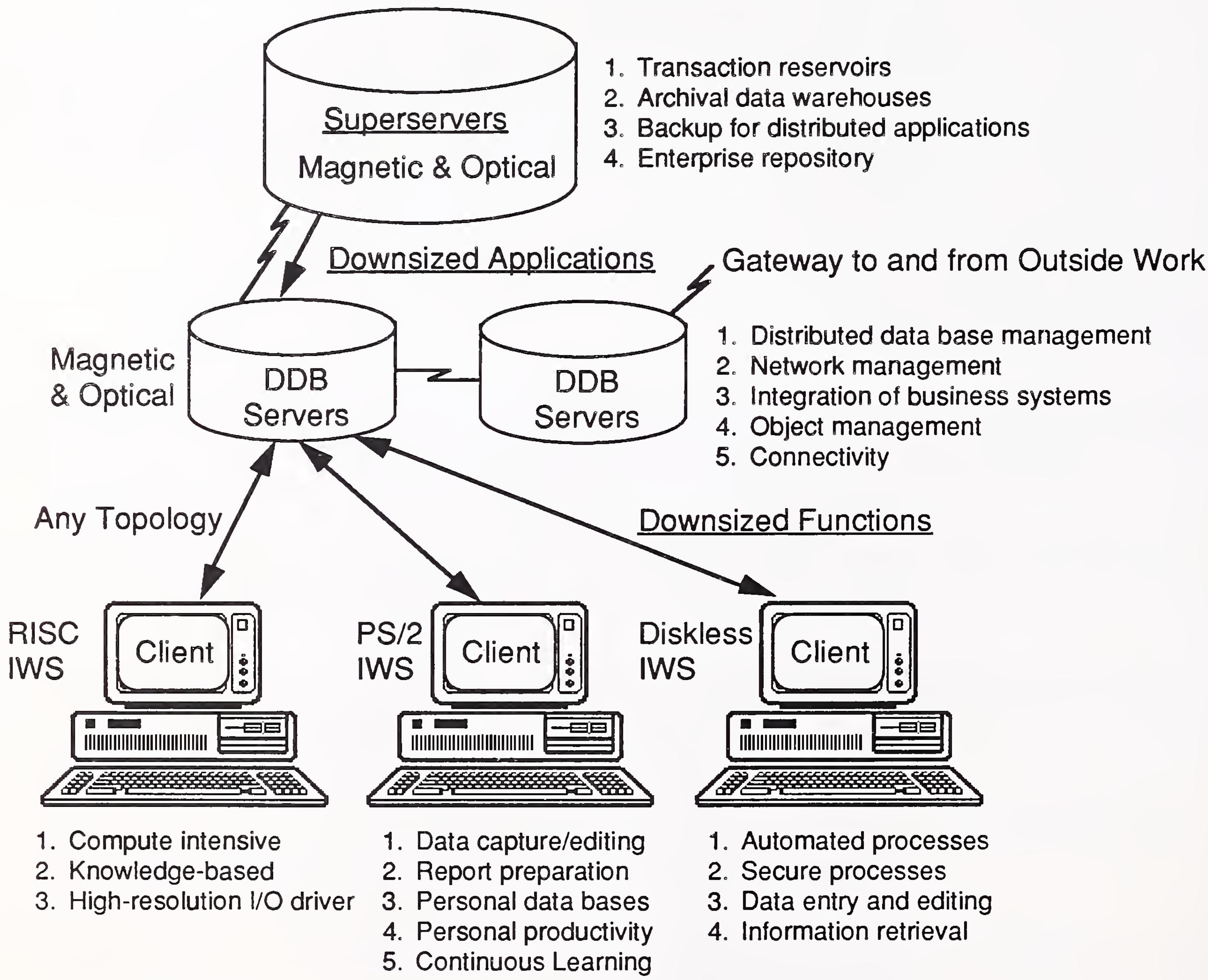
The reason we feel that minicomputer distributed data base servers are the most important component in the downsized application network is because the biggest challenge for the 1990s is going to be the integration of downsizing applications with paper-oriented systems at the work unit level. The user sitting at the screen should have access to data and information regardless of its medium of origin. Voice, image and knowledge rules will all become data to be distributed in the 1990s.

The AS/400 provides the necessary architecture to take the broadest possible view of data by directly addressing 281 trillion bytes of storage (48-bit addressing). However, it has been stated that the AS/400 is "implemented with a software and hardware architecture that could accommodate up to 64-bit addressing...." and that "this architecture accommodates the needs of advanced applications such as voice, image and artificial intelligence." [21] What this means is that the AS/400 will be able to directly address 18 quintillion bytes of storage—that is about 3 billion bytes for every human being on the face of the earth. It provides the broadest possible window on the electronic world that supports the person at the screen.

Does this mean that the AS/400 is the solution to all of the commercial data processing world's problems? No; a proper hierarchy of mainframes, minicomputers and IWSs will exist well past the millennium, and there is even good reason for co-existence with the RISC/UNIX world. The proper network architecture for the downsized world of the 1990s is depicted in Exhibit II-2.

EXHIBIT II-2

Downsized Applications and Functions



- There will be a continuing role for mainframe superservers regardless of how many applications are downsized.

- Clients of many types will perform essential functions:

- RISC IWSs will become increasingly important as business applications become more compute intensive at the human/machine dyad.

- Personal computers will expand their role of empowering information and knowledge workers with both computer power and ready access to increasingly complex data objects.

- Diskless IWSs will provide cost-effective automation of office processes where work simplification and a restricted view of data are desirable.

• However, the centerpiece of what is going on at the screen is the minicomputer distributed data base server that provides the essential data base and network management functions on an operational basis.

D

Beyond-the-Screen Architecture

IS management has traditionally concentrated on the architecture of information systems behind the screen and at the screen; frequently, at the expense of what is going on beyond the screen in terms of the human architectures associated with management and organization at the working level. This has resulted in the IS department being identified with the corporate planning and control functions—a mere extension of the corporate controller.

This highly centralized power structure has been supported by mainframe computer technology and corporate data bases, and it is difficult to determine which is cause and which is effect. However, during the PC revolution of the 1980s, computer power was distributed to operating departments. There were increased demands for data from operating departments, but operating management still did not have ready access to corporate data bases. This resulted in highly centralized financial planning and control systems coming under increasing attack from operating management as being unresponsive to their demands (and needs) for data and information necessary to run their day-to-day business. Then, as once-dominant Western enterprises started to lose competitive advantage to more flexible and responsive organizations, enlightened corporate leaders began to take action to change the human architecture of their companies.

This was normally accomplished by organizational downsizing in terms of:

• Drastically reduced corporate planning organizations, loosening of some traditional corporate financial controls, and delegating some responsibility to operating units

- Drastically reduced levels of middle management, with accompanying increases in span of control.

Once again, it is difficult to know what is cause and effect between the technological downsizing that was occurring and the management initiatives that were being taken. However, there is no question that the two downsizing initiatives are co-dependent, and that both trends are accelerating in the 1990s. Both technological and organizational downsizing depend upon:

- Availability and ready access to sources of high-quality data and information
- The capture of human knowledge at the human/machine dyad, and the shifting of some human intellectual activities to the artificial side of the interface
- Upgrading human knowledge through continual learning by working with the "intelligent artifact" (or corporate data base)

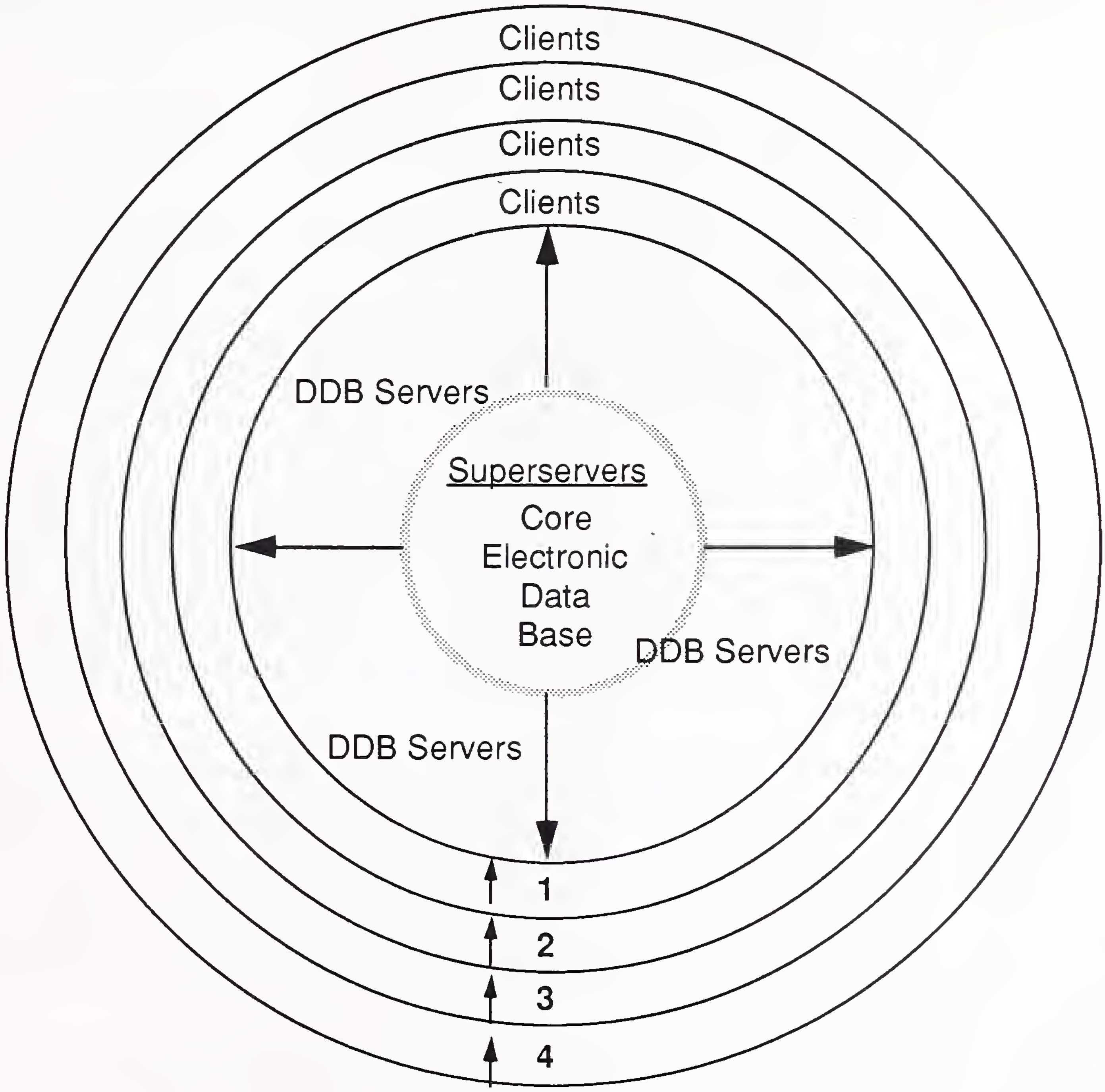
This synergistic relationship between information technology and humans will lead to drastically new organization structures and management responsibilities.

Research for this study resulted in the adoption of a "concentric ring" management architecture that was defined by Shoshana Zuboff in her book: *In the Age of the Smart Machine (The Future of Work and Power)* [15]. Although Dr. Zuboff found it necessary to coin some dreadful new terms for her vision of the future, her book does place the technological and human architectures in perspective and helps define the role of IS management as downsizing proceeds (see Exhibit II-3).

- We have superimposed a distributed network of superservers and distributed data base servers on Zuboff's "core electronic data base." This more accurately depicts the downsized environment and the breaking up of corporate control and data bases.
- This core electronic data base is then surrounded with four concentric rings of management with the following responsibilities:
  - The "intellective" skill development (or continuous learning) of workers who interact with the core electronic data base. Since everyone will interact with the core data base, such intellective skill development will involve everyone from entry-level employees to the highest corporate executives.

EXHIBIT II-3

Organizational Architecture



1. Intellective skill development
2. Technology development
3. Strategy formulation
4. Social system development

- Information technology identification and development necessary to assure the maintenance and expansion of the core electronic data base, which represents the accumulated experience and knowledge of the enterprise

- Strategy formulation for the enterprise based on interaction between humans and the "intellective skill base" (Zuboff's term) or "intelligent artifact" (Simon's term)

- The establishment of a social system that encourages the continuing improvement of the "living system" that is the total organization (both artificial and human)

It is INPUT's opinion that both technological and management downsizing are moving toward such an organizational architecture, and that qualified IS personnel have an important role to play, not only behind and at the screens that serve as windows on the "intellective skill base," but in positions of leadership in the first two rings of responsibility ("intellective" skill development and technology development). Because the other two levels of management are dependent on the core electronic data base, it would appear that future executives will also be drawn from among those most familiar with the "intelligent artifact."

The ramifications of "eliminating" middle management and empowering workers closest to the electronic data base would seem to be quite clear. There will be an aging executive elite and an emerging technological elite, and no established career paths for other operational personnel. The consequences of such a strategy, while not clear, would seem to argue for an increasingly important role for those with information technology expertise.

However, the degree of IS involvement in the downsizing of the 1990s will depend upon the mind-set of current executives. There are already reports of CIOs who have "downsized" themselves out of their positions. This can obviously occur if the primary purpose of technological downsizing is literally to cut IS costs. It would seem to be extremely short-sighted to downgrade (or disperse) the IS function as part of the downsizing process for the following reasons:

- The IS function has a major role to play in making technological downsizing successful, and it is unreasonable to expect very many IS employees to downsize themselves out of jobs.

- A weakened IS function, and technological base, will have an adverse, long-term impact on the management initiatives directed toward organizational downsizing.

Under any circumstances, IS management is presented with a significant challenge to both cut costs and preserve and expand the "intellective" skill base of the organization. Though this may be extremely difficult to accomplish, the rewards for those who are successful will be commensurate with the difficulty.

E

Conclusions and Recommendations

Exhibit II-4 contains a brief summary of the major conclusions and recommendations.

EXHIBIT II-4

Conclusions and Recommendations

- IS management has frequently been isolated from the mainstream of the corporation by being associated with corporate planning and control functions.
- Both technological and organizational downsizing will assure that IS management becomes more actively involved in the mainstream of the company.
- IS management is being placed in a difficult position by being asked to both cut costs and to assure that technological and organizational downsizing efforts are successful—this despite the fact that IS is identified as being part of the problem.
- INPUT believes that companies that weaken, or fragment, the central IS function will place their organizations in an extremely vulnerable position.
- IS' primary objective during downsizing should be to minimize the risks associated with unproven hardware/software technologies (this may not be a popular position).
- INPUT believes that the architecture depicted in Exhibit II-2 and employing AS/400s as distributed data base servers will be the safest and the most cost-effective architecture for downsizing.
- INPUT believes that the concentric ring model is a good representation of where technological and organizational downsizing may lead, and believes that IS has increased leadership responsibility in the resulting organization.
- Re-engineering of applications is necessary during downsizing in order to move toward management downsizing objectives. An improved systems development environment will be the result of the new organizational structure.

EXHIBIT II-4 (CON'T)

Conclusions and Recommendations

- INPUT recommends that IS management assume a leadership role while supporting both technological and management downsizing initiatives.
- Commitment to quality should be the primary emphasis of all downsizing efforts.
- Consider and evaluate all new (or unfamiliar) hardware/software technologies and select downsizing platforms based on their long-term applicability to your particular organization.
- Evaluate the need for distributed data bases from a strategic perspective. There may be simpler architectures that could satisfy a high percentage of your needs.
- Develop a long-range information architecture and technological plan for your organization with the agreement and cooperation of both corporate and operating management.
- Develop a downsizing plan based upon this architecture and technological scenario with special emphasis upon anticipated benefits and consequences.
- Assume leadership responsibilities for "intellective" skill and technology development within your current organization, but be prepared to share these responsibilities with operating management in the downsized environment.

III

Downsizing and Hardware/Software Architectures

During research for INPUT's earlier report on downsizing (*Putting Downsizing in Perspective*), it was determined that "upsizing" was proceeding in parallel with downsizing, and that "rightsizing" should really be the objective. However, the rapid advances in microprocessor technology, and the resistance of mainframe commercial applications to change have resulted in a price/performance discontinuity between the two that will make downsizing the predominant architectural trend of the 1990s.

It is important to understand that downsizing is not just another fad in the computer industry. It represents a fundamental shift in information systems architecture at all levels—from hardware design to presentation media. In some ways, there are striking similarities between the downsizing phenomenon and the shift from unit record equipment to computers in the 1950s. This is ironic because many of the commercial applications that may be downsized still bear the stamp of their punch-card heritage; and, as we shall see, this will be passed on to the next generation of commercial systems in a rather surprising way.

The metaphor we have adopted for this architectural analysis is the graphic user interface (GUI), which is currently being promoted as the solution to all of the data processing world's problems. Theoretically, the user at the GUI should not have to be concerned about the underlying hardware/software architecture behind the screen, or even where data resides. The basic premise of this report is that someone (and we assume that someone is IS management) must be concerned not only with what is happening behind the screen, but what is happening beyond the screen in terms of the " human architectures" of organizational structures and processes that currently exist in the real world outside the computer.

We will start behind the screen with the computer hardware itself.

A
Hardware Platforms

Over 15 years ago, INPUT decided to classify mainframes, minicomputers, and microprocessor-based "intelligent terminals" based on their price, and how they fit within the organization, rather than on their then-prevailing 32-, 16-, and 8-bit architectures. This decision was based on the fact that internal architectures and performance would change, but the limits on investment in computer technology at the individual and work-unit levels would remain relatively constant. Therefore it was decided that computers costing less than $20,000 would be classified as intelligent terminals (or workstations), and those costing less than $200,000 would be classified as minicomputers, and everything over that would be classified as mainframes. These classifications continue to prove useful despite several orders of magnitude of improvement in price/performance at the lower levels (see Exhibit III-1).

EXHIBIT III-1

Processor Architectural Definitions and Attribute Evaluations

	Cost	Terms	#1 Attributes
Mainframes	>$200,000	Host Superserver	Security Connectivity Commercial applications H/S reliability Data base management Network management Vendor support Applications software H/S architecture Complexity
Minicomputers	>$20,000	Distributed processor Departmental processor Midrange systems Small business system Server	Distributed data server
RISC	$20,000 + or -	Intelligent workstation Engineering workstation Server Client/requester	Scientific applications
IWS	<$20,000	Personal computer Programmable workstation Intelligent workstation Intelligent terminal PC LAN (client/server) Client/requester	Cost effective Easy to program Open architecture "Bargain" Easy to use Easy to operate
Other Microprocessors	<2,000 | 200 | 20	Application-specific Integrated circuits Embedded processors	

When INPUT conducted the research for *Putting Downsizing in Perspective* it used the terms mainframe, minicomputer, RISC and PC; and used examples from the IBM product line.

Let's examine each part of that hierarchy.

1. Mainframes

The $200,000 cost threshold for mainframes is for the processor alone, and obviously mainframe systems as we have come to know them usually cost considerably more than this lower limit. One of the reasons there is usually a "giant step" associated with crossing the line into mainframe territory is because of IBM operating systems. This is also the reason that large IBM mainframes are such an attractive target for downsizing.

Mainframes serve a large number of users and their primary strength is the ability to move and store a lot of data. This is facilitated by a complex set of I/O channels that are, in effect, reduced instruction set computers that operate independently of the central processing unit. Therefore, using mainframe central processor MIPS a a measure of performance against other architectures is meaningless.

Though mainframes are increasingly incorporating multiple processors to boost performance, they remain "von Neumann machines" that treat instructions and data in a similar fashion. This means that they funnel data back and forth between storage and the processor(s) one word at a time. This has been referred to as the "von Neumann bottleneck" by advocates of more esoteric architectures, but large mainframes are not so much concerned with compute speed as they are with moving, arranging, storing and retrieving data. Even supercomputers find it convenient to have a mainframe front end to handle data manipulation.

Mainframe hosts have struggled to keep up with the processing demands made on them for both transaction and batch processing of large data bases. In the mid-1980s, it was reported that large commercial installations devoted between 15% and 30% of their usable CPU cycles and I/O activity to sorting. [1] This is quite remarkable, because it exceeds on either end the amount of time spent by major IBM installations on sorting in a serial batch environment in the early 1960s (20% to 25% of wall clock time). Despite advances in DASD, multiprogramming, data base management systems, memory size, on-line transaction processing, and sorting algorithms themselves, these large installations still spend approximately the same amount of time sorting.

For some reason, the reality and importance of large-scale data manipulation (of which sorting appears to remain a major factor) seems to be difficult for many computer scientists and hardware/software engineers to grasp. The architects of the IBM System/360 refused to incorporate indirect addressing in the architecture, and IBM's early research on locality of reference in virtual storage systems failed to take sorting into consideration. Large IBM mainframes continue to struggle under the burden of these oversights.

However, despite the fact that the sacred IBM mainframe architecture is not especially well suited for either scientific or commercial environments, it has provided the balance necessary for the management of large data bases. As downsizing proceeds in the 1990s, the role of the large mainframe as a "superserver" will remain reasonably secure. IS management recognizes this fact. Although INPUT's research showed that there will be a significant shift away from mainframes toward more cost-effective platforms in the 1990s, few respondents felt that mainframes were going to disappear.

In addition, IS management ranked mainframes first (above minicomputers, RISC systems, and PCs) on the following attributes (see Exhibit III-1):

- Security
- Connectivity
- Best for commercial applications
- Hardware/software reliability
- Network management
- Vendor support
- Applications software availability
- Hardware/software architecture

These are practically all of the attributes that are important for commercial applications, and the only drawback is that mainframes were also ranked first in terms of complexity. As downsizing proceeds, an important consideration will be how much of this mainframe complexity is necessary to make effective use of information technology, and how much cost can be justified based on the strengths of mainframe systems.

2. Minicomputers

Minicomputers have been around for several decades and have offered attractive alternatives to mainframe computers for specific applications by employing simpler technology, more specialized systems software, and better price/performance. INPUT's price range of $20,000 to $200,000 for minicomputers has held up remarkably well in terms of functional use despite enormous increases in processing power, which have tended to make minicomputers an ever-increasing threat to offload mainframes.

IBM has been exceptionally adroit at resisting the advance of minicomputers into conventional mainframe environments. Historically, this was done by announcing a variety of "solutions" with various architectural characteristics and priced to compete on a selected basis in the minicomputer market. The purpose of this architectural and market fragmentation was to limit the offloading (downsizing) of large IBM mainframes; this strategy was highly successful over an extended period of time.

Among the "minicomputers" that were used in this strategy were:

- The Series/1, which was a legitimate minicomputer but supported primarily for process control and other real-time applications

- The 3790/8100 cluster controllers, which were used for controlling dumb terminals. (The 8100, though promoted as a distributed processing engine, remained underpowered and the DPPX operating system placed enormous demands upon the customer who really wanted to offload major functions from mainframes.)

- The System/3...36 series of small business computers started as the last gasp of punch-card-oriented technology and was directed primarily toward the first-time computer user.

- The System/38 was originally designed as a replacement architecture for the System/360/370 machines. It was called "Future System" (FS) and featured tight integration of hardware and software. After a half billion dollars of development expense and some technical problems with the implementation of the complex architecture, it was decided that IBM customers had "too much investment in programming" on their old mainframes to pull the platform out from under them. So the System/38 was announced and remained a mystery to the IBM sales force, customers and competition—practically everyone except those interested in the innards of computer architecture and the hardware/software interface.

- The 43XX and 9370 line of midrange systems were downward extensions of the 360/370 line of computers, with engines too weak to carry the burden of IBM mainframe operating systems but designed to provide a bridge at the high end in order to make the giant step necessary to get into the IBM mainstream. These systems were supported and even promoted as distributed processing engines by IBM, but with minimal success. It is possible that the original code name of "Hydra" for IBM's distributed processing support had something to do with it. (For those unfamiliar with Greek mythology, Hydra was a many-headed water serpent that grew two new heads for every one that was cut off.) Certainly, the vision of chopping off a mainframe and having two grow back was not far from IBM's mind when it code-named the project, but it is probable that customers sensed the strategy also.

- In addition to all of these minicomputer "solutions," IBM also had clustered word processing systems that were competing in the office environment against departmental processors from competitive vendors such as Wang.

This confusion at the work unit (office) level became especially troublesome after the PC was announced and it became obvious that a great deal of work from both mainframes and minicomputers could potentially migrate to the desktop. The resulting chaos at the minicomputer level was the primary reason that IBM announced its Systems Applications Architecture; and, subsequently, the AS/400 as the first real SAA machine. The AS/400 combined the architecture of the System/38 and the ease of use of the System/36, and it has been a phenomenal success in the marketplace. A more detailed analysis of its architecture will be presented in the next section of this report.

We have gone through this rather lengthy history of IBM's minicomputer strategy because it has shaped the downsizing competitive environment, and because we believe that servers in the minicomputer price range hold the key to downsizing. Our research for *Putting Downsizing in Perspective* revealed that IS management rated minicomputers as the best distributed data base servers. We agree with that assessment, and the hardware/software architecture of those distributed data base servers is going to be an exceptionally important consideration in selecting appropriate downsizing applications and platforms.

3. RISC Workstations/Servers

RISC technology has been isolated as a separate platform because of marketplace perception and because this is a report on architecture. INPUT's $20,000 razor splits RISC systems into intelligent workstations (IWSs) on one side and minicomputers (servers) on the other side. (It should be pointed out that direct access storage is included in the cost of RISC systems and PCs, but only processor and channel costs are included in the costs for mainframes and minicomputers.)

RISC architecture is conceptually an old idea, and merely the latest manifestation of the continuing battle between hardware/firmware/software implementation of computer systems. John Cocke, the IBM inventor of RISC, was a "wild duck" who refused to fly in formation with the other System/360 architects in the 1960s; several computers prior to that time (such as the RCA 601) were built on processors featuring "elementary operations." RISC architecture will be discussed in somewhat more detail in the next section of this report, but the following characteristics are fundamental:

- RISC architecture requires the execution of more rather than fewer instructions to accomplish the same task (regardless of what some trade press pundits have had to say on the subject).

- It is especially fast at binary arithmetic, but isn't especiallygood for either floating-point or decimal arithmetic. This means it is great for driving high-resolution displays with complex graphics, and for image processing, but frequently requires a coprocessor for floating point.

- The reduced instruction set also places more burden on systems programmers who must develop efficient compilers to handle character-oriented operations such as decimal arithmetic; and for building operating systems that must handle I/O.

- There has always been a tendency on the part of engineers to drive down costs by leaving certain functions to "programming." The track record on large systems programming projects raises serious questions concerning the wisdom of such design trade-offs.

IS management ranked RISC systems as best for scientific applications, but generally tended to favor PCs as the platforms of choice for downsizing. Vendors, on the other hand, were more favorably disposed toward RISC for a wide variety of applications.

4. Intelligent Workstations

As can be seen in Exhibit III-1, there are considerably more terms than concepts associated with microprocessor-based computer systems selling for less than $20,000. As long as we recognize that these are basically desktop computer systems, this is not terribly important in the discussion of architecture except to point out the following:

- As personal computers have progressed in price/performance, it has become obvious that users should be concerned about what is on the other side of the screen. Even casual users of systems have suddenly become painfully aware of the 640K barrier built into their hot microprocessor-based systems, and when IBM announced its micro-channel architecture along with the PS/2, there were arguments about whether it was useful, desirable or necessary to implement advanced applications.

- It is difficult not to be concerned about architecture when you find you must be concerned with concepts of expanded memory, extended memory, disk caching, shadow memory, RAM disks and memory management utility programs that require a systems programmer to understand them—all to take advantage of the additional RAM you need on your system.

- GUIs may hide architectural limitations of systems, but they don't help very much when an application requires more conventional memory than the system can find for it, or when all the windows shut down with an unrecoverable system error.

IS management rated IWSs highest as being cost effective, easy to program, easy to operate, easy to use, the best "bargain," and having the best open architecture. However, there doesn't seem to be any question that users are currently concerned with a great deal of complexity in making effective use of all the wonderful technology that is becoming available on the desktop.

All of this brings us to the subject of operating systems—but first, let's dig one level deeper into the hardware.

5. Other Microprocessors

IS management was not asked to rate this processor category, but it has been included as a logical extension of downsizing.

Microprocessor technology is advancing so rapidly that even general-purpose microprocessor-based systems are threatened with "downsizing" of certain functions into application-specific integrated circuits (ASIC) and other embedded processors. Intelligent peripherals (printers, DASD, scanners, optical memory, audio recognition systems, image processing, etc.) are already appearing; and even complex applications (such as expert systems) will be differentiated and mechanized in silicon.

The very IWSs being used for CAD/CAM will permit the cost-effective design of these ASICs, and one of their primary benefits will be that they will not require the complex systems software and expensive applications software currently evolving for RISC and IWSs.

B
Operating Systems

Operating systems are designed to make computer hardware easier to use. A brief history follows:

- It was discovered early on that getting data and programs together in memory presented a substantially more difficult programming problem than did the actual logic and arithmetic operations performed on the data. Therefore, input/output control systems (IOCSs) were developed.

- Then, when there were the scheduling problems associated with getting jobs through the system, simple stack job monitors were developed.

- Since CPUs were so fast (even 25 years ago), commercial data processing applications were "I/O-bound." So, in order to keep the processor busy, multiprogramming was invented. This added another level of complexity in terms of:

  - Job and priority scheduling

  - Accounting and billing for systems use

  - Access to shared resources

  - Storage management (memory tended to become fragmented)

- Concurrent with multiprogramming on the commercial data processing side, timesharing developed for scientific and engineering applications; and, because of the slow speed of keyboard interaction, every user could be made to feel that he/she had exclusive use of the processing resource.

- Because of fragmentation of the limited memory then available (1 or 2 meg), and the requirements of multiple users and larger programs (especially the large matrices needed by some scientific and engineering problems), memory management became a primary concern; this resulted in the development of virtual storage systems.

- Virtual storage systems solved for all time the trouble of having to worry about keeping CPUs busy. At first, these systems were able to keep the CPU busy without doing any useful work—even the largest systems spent all of their time "thrashing" away at managing memory and were unable to get any useful work done. This problem was solved with a combination of improved systems software, faster CPUs and more real memory, but the fact remains that large mainframes (the target of downsizing) spend most of their time in "managerial" overhead.

- Due to the fact that IBM had several operating systems to support, it was found desirable to be able to run "virtual machines" on the same system so systems programmers could debug the various operating systems being developed. This resulted in VM, which permits various users to have their own operating environments (or virtual machines) on the same system. VM is important conceptually because "shells" to run both UNIX and proprietary operating systems are becoming quite important at all levels in the processing hierarchy.

- Along the way, large mainframes have had their own addressing problems, which have been solved by MVS/XA and MVS/ESA, etc. These Extended Architecture systems have been referred to by some familiar with the history of IBM mainframe architecture as "extended accommodation," the implication being that there remain fundamental architectural flaws in the mainframe hardware.

- Then, of course, shared resources and the very complexity of mainframe operating environments raise immediate problems of data security and privacy protection—issues that still have not been adequately resolved in many systems. And, it should be pointed out, neither privacy nor data integrity can be assured in a system that is not secure.

We have gone through this brief history of operating systems development because the RISC systems and IWSs used as file and data base servers in downsized environments will be confronted with all of the problems briefly outlined above, and their operating systems were not designed with such complex environments in mind. Operating systems are currently a hot topic for good reason—they will determine the success or failure of many downsizing efforts.

Exhibit III-2 presents the primary operating systems abstractions [2] that have developed over the years and some of the attributes associated with those abstractions. These abstractions will be used to provide an operating system "report card" later in the report.

EXHIBIT III-2

Operating System Abstractions and Attributes

Abstractions	Attributes
Process	Concurrency Timing "Deadlock"
Memory Management	Fragmentation Virtual/real storage Process isolation Access control
Data Protection & Storage	Object access control Data flow control Information flow control
Scheduling & Resource Management	Time-scale decomposition Timsharing Timeslicing Queue management Performance prediction
Systems Structure	Integration of above Resource level management Virtual machines Kernel extension
Abstraction & Technology	Interplay - Software - Firmware - Hardware

C

Applications and Tools

Terminology has always been a problem in the computer industry from the day someone called an early computer a "giant electronic brain." However, we find the currently popular misuse and appropriation of the term "application" especially perplexing. There was little confusion about the term application before the personal computer hype started in the 1980s. Practically anyone associated with the computer industry would have agreed with the definition contained in *The Dictionary of Computing*; Oxford Science Publications, 1983. That definition is the one we will use in this report, and it is as follows:

> Applications Program - "Any program that is specific to the particular role that a given computer performs within a given organization and makes a direct contribution to performing that role. For example, where a computer handles a company's finances a payroll program would be an applications program. By contrast, an operating system or a software tool may both be essential to the effective use of the computer system, but neither makes a direct contribution to meeting the end-user's eventual needs."

The problems started when everyone started talking about users being interested only in "solutions" and not problems. At that point, personal computer vendors started looking around for application "solutions" and all they found were some word processing, spreadsheet and data base packages. These were then sold as "solutions" and labeled as applications. It seems patently clear that none of these packages is an applications program by the above definition. They are tools, just like a typewriter, an adding machine, and a cash register are tools. More specifically, they are applications enabling tools, just like a programming language.

Perhaps a brief description of a simple applications system s architecture will help to explain why these tools do not qualify as applications, and also provide a framework for discussing how and what may be downsized from mainframes.

1. Computer Applications Systems Architecture

An applications system or program has five essential elements:

- It must have an identified and specified source of *input* data.
- It must have a set of logic and procedures which *process* those data in the memory of the computer.

- It must be able to *communicate* (move) the input data (or information) to the computer memory and the output data (or information) out of the computer memory.

- It must have some medium (external to memory) on which to *store* data (and programs) before and after processes (for future use in other processes).

- It must have some medium on which to produce *output* of the process.

All of the above elements of an applications system must be integrated in order to make a "specific contribution to the role of the organization."

It seems obvious that when I bring up my spreadsheet package and it presents me with a blank screen, I have just begun to develop an application. Spreadsheet packages can be used to develop entire applications, and for data storage between runs or processes. However, their suitability for replacing downsized production applications is highly problematic.

2. Examples of Functions and Media

Exhibit III-3 shows some of the functional and media combinations associated with computer applications systems. We shall refer back to this later, but at the present time is important to make several points.

- Computer applications are only part of business systems. Even where the computer/employee ratio is high, business systems remain highly dependent upon paper.

- Office automation systems have automated the production of paper documents, and all of these documents require human handling and "processing" (reading, routing and 'rithmetic). All too frequently data from computer-produced reports are re-entered in other applications.

- One of the most promising opportunities of downsizing is to "squeeze" the paper out of computer applications by re-engineering existing applications during the downsizing process.

- A comparable opportunity exists to eliminate the transfer of data between applications by physically moving magnetic media between applications systems (floppy disks, tapes, etc.).

Downsizing, coupled with the reduction in paper flow and the physical transfer of magnetic media between (and among) applications systems, implies that distributed data bases will play an increasingly important role as downsizing progresses.

EXHIBIT III-3

Application Systems Architecture, Functions and Media

Input	Process	Communicate	Data Store	Output
Data Bases Keyboard Input	Computation	Human <—>.Human	Paper	Printers
Sensing Devices	Arrangement	Computer<—> Computer	Magnetic Disk	Screens
Media Conv. Dev.	Logic	Computer <—> Device	Magnetic Tape	Computer —> Computer
TeleCom	Route	Human <—> Computer	Optical Storage Microfilm (fiche)	Computer —> Device

D

Data Base Management

Despite the trend to downsizing, only 6% of IS management felt that mainframes would actually be replaced. The future role of mainframes seems assured as "superservers." However, 50% of IS management respondents felt that downsizing would result in a transfer of responsibility for "data and/or management information quality," and that many users and vendors do not understand this. Since only 22% of vendors agreed that such a transfer of responsibility would take place, it is probable that users buying vendor downsizing "solutions" are in for something of a surprise.

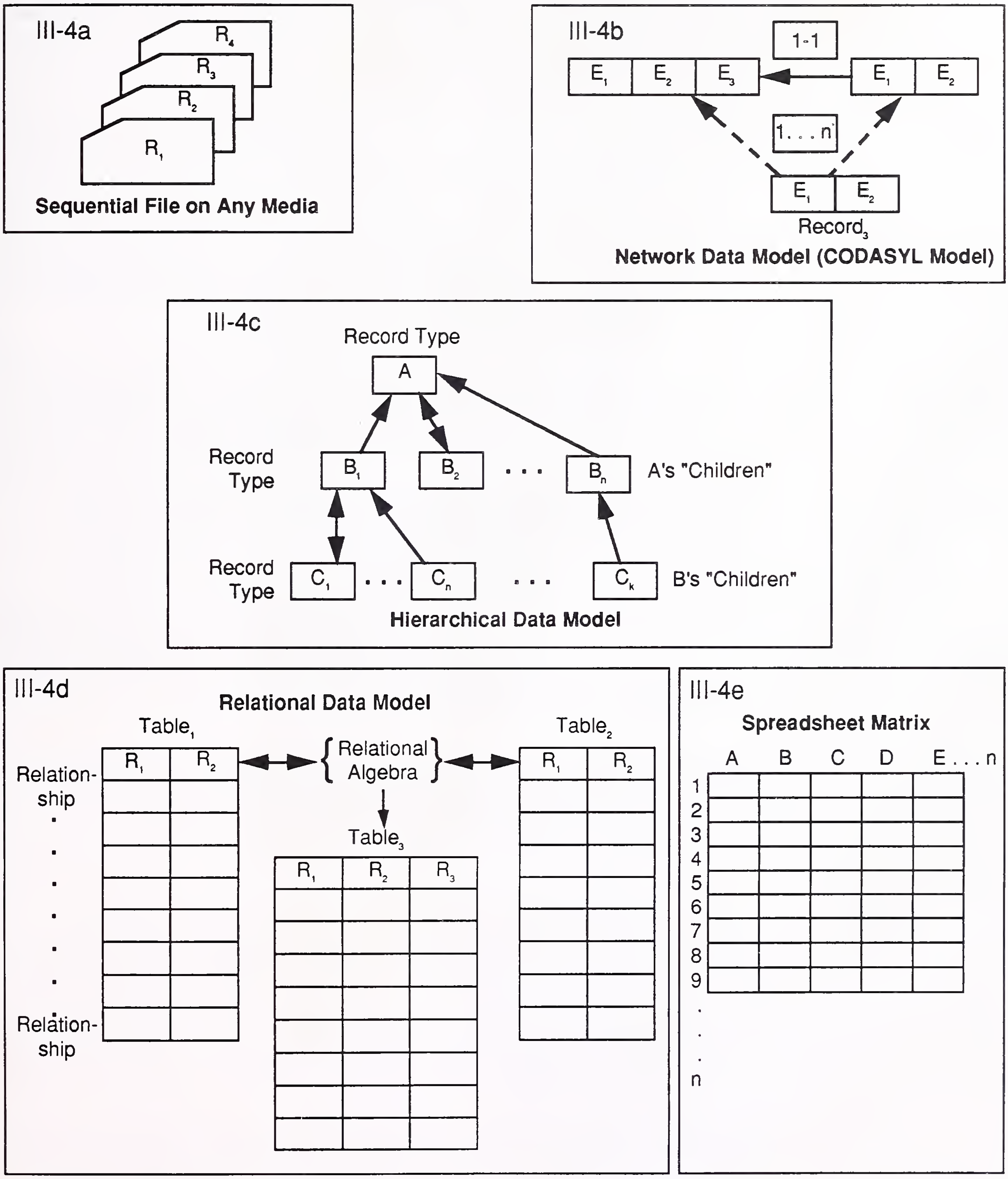
Because data base management is the key to successful downsizing, it is necessary to take a look at data models, which are, in effect, the data architectures of commercial applications. About ten years ago, during an INPUT research effort on data models, one IS executive said: "I don't want to talk about data models; in fact, I don't even like to think about data models—the whole subject bores me." But, please bear with us—this is important.

1. Files, Matrices and Data Models

Exhibit III-4 depicts various data models. Each has a significant message.

EXHIBIT III-4

Files, Matrices and Data Models



a. Sequential Files

Data base management has always been a problem. Early programmers and users had to deal with card decks on which their programs and data were stored. It wasn't fun. The "graphics user interface" was frequently the view of a bunch of holes in an uninterpreted punch card. Those were *not* the good old days.

Magnetic tape, which replaced punch cards as the primary input source to commercial applications, was also a serial medium. Sequencing (sorting) of both master files and changes (transactions) was necessary in order to update files with one pass of the master tape. It was also found that data had to be exchanged between various organizational entities in order to build new applications programs. These imported files were frequently in a different sequence and this again required sorting and the building of another master file to support a specific application.

Obviously, sorting was an exceptionally important function in commercial applications in the days of serial batch data processing. The fact that it remains such an important function on mainframe superservers in today's environment (as mentioned previously) is somewhat difficult to understand, but it supports the fact that most users prefer to view and work with their data in some logical sequence. In addition, sequenced data are substantially easier and faster to retrieve (even if the sequencing is in indices rather than the physical data). It is unlikely that sorting on superservers is going to diminish as files are transferred and data are distributed to downsized platforms. In fact, it is more likely that increased demands for file transfers for downsized applications will increase serial batch processing against existing data bases. This is an important consideration in the overall economics of downsizing.

The problem with serial batch processing was primarily associated with building and maintaining separate master files for various applications. That is how data base management systems came into being.

b. Data Models

Nearly thirty years ago, in response to the problems of building and maintaining master files that had interapplication dependencies, the General Electric Company came up with something called Integrated Data Store (IDS). It was a data base management system built on the network data model. IBM originally rejected even the concept of IDS, stating that it wasn't needed because ISAM would solve all of the world's problems.

However, GE was a big IBM customer and, working through GUIDE and CODASYL, GE representatives managed to get IBM customers interested in data base management systems, and even got the network model accepted as a data base "standard" by CODASYL (Exhibit III-4b).

IBM didn't go along with the data base standards effort because it was working on its own data base management strategy. This strategy culminated in IMS, which was built on the hierarchical data model (Exhibit III-4c). IMS, and the hierarchical model, became the de facto standard for large IBM mainframe data bases despite the availability of attractive alternatives from competitive vendors. Early in the life of IMS, a respondent to an INPUT study stated: "IMS has managed to burn more CPU cycles than IBM ever imagined in its fondest dreams." After years of improvement, IMS performance is now used as a benchmark for transaction processing. Many downsized applications will remain, either directly or indirectly, dependent upon IMS for data.

One of IMS's major weaknesses is the reason it will be around for a long time: it lacks flexibility. Once established, the structure of a hierarchical data base is difficult to reorganize; and, more importantly, so is the business organization the data base supports. For this reason, IBM found it extremely difficult, if not impossible, to use IMS for many of its major internal information systems. In fact, based on the experience of large IBM customers, IBM has warned that selecting a DBMS is a "thirty-year decision". [1] Since IMS didn't become prominent until the 1970s, we can expect it to be around well beyond the turn of the millennium.

While IMS was being installed in customer accounts, the relational model was being invented by Dr. E.F. Codd of the IBM San Jose Research Laboratory in the late 1960s (Exhibit III-4d). It had a long gestation period (over 10 years) before being announced by IBM as DB2. The relational model represents data in tables of unsequenced (unsorted) relationships. Despite the fact that it is a mathematically sound model (as described by Dr. Codd), the relational model is easy to visualize—it is similar to decks of unsorted punch cards.

The relational algebra (select, project, cartesian-product, union and set-difference) is performed on the relational tables (sets) just as the old tab supervisor "wired boards" and ran his various decks through collators, sorters and tabulators—except no sorting is permitted in the relational model. Since the algebra processes sets, some derived operations of the algebra (such as an unrestricted JOIN) can present substantial performance problems. Even IBM acknowledged these performance problems; that is the reason that a relational DBMS was not announced for IBM mainframes for over 10 years. Today, performance optimization of relational systems remains a major technical challenge, and the quality of relational products varies accordingly. Various relational products also vary considerably in conforming to Dr. Codd's specifications—there are more "relational-like" systems than there are pure relational systems.

The relational model is important for many reasons:

- It is the preferred model for distributed data base servers and open systems.

- It is also the supported data model for IBM's SAA—providing reasonable certainty of becoming an industry standard.

- The preferred relational language—SQL (Structured Query Language or Sequel)—has become the de facto standard for data base distribution, the glue for integrating the emerging downsized environment.

Although there are other promising data models, such as the Entity-Relationship model, they have not currently achieved significant market penetration. Neither IS management nor data base administrators seem ready for more complexity in the area of data models. However, the predominance of spreadsheet "data bases" at the IWS level may result in unprecedented complications for the data base administrator.

Overall, INPUT believes that relational data base technology will play a major role in the downsizing revolution. Users understand it and it will simplify the IWS-to-server connection. Its adoption will be a key factor in the pace of the downsizing revolution.

c. Matrices, Spreadsheets and Data Bases

Personal computer users have not taken to DBMSs with enthusiasm because constructing an application using even the relatively simple PC DBMSs in common use means that one must begin to understand some of the basic principles of systems design. This has not come easily to casual users, and has resulted in the more popular spreadsheet packages being used to construct applications and, more importantly, to serve as data base systems.

The ability to view a portion (or all) of a two-dimensional matrix as a table for purposes of sorting and query has led personal computer users to construct real computer applications using their misnamed spreadsheet "applications." This means that data are stored, updated and retrieved all within the spreadsheet program. Because spreadsheet programs are somewhat like the von Neumann architecture run amok, with data and operations indistinguishable and splattered throughout the work space, it violates all principles of data and program isolation and has potentially (frequently realized) disastrous consequences for data integrity.

Since much of the impetus for downsizing is based on access to corporate data bases so the user does not have to take a report produced by the IS department and key information into a spreadsheet matrix, it seems inevitable that many of these data (which are necessary for downsized applications) will either trickle (or gush) down to the desktop regardless of how many servers they pass through. To the degree that these data are stored in spreadsheet programs, they will be virtually unmanageable. As spreadsheets gain functionality the problem only gets worse; think of the problems of multidimensional matrices.

2. The Importance of Data Base Management in Downsizing

The importance of DBMSs in a central data base environment is depicted in Exhibit III-5. The same classes of users in this general systems architecture will exist in the downsized environment, regardless of the formal titles.

- *Naive users* will vary from data entry personnel to corporate executives, but they will use the application system for a specific purpose and will not have to be concerned about either the physical or logical data structures underlying the specific application nor will they manipulate or quiery the data base (although they may be familiar with several applications).

- *Applications programmers* will exist to define the applications for both naive and casual users—whether by designing a screen, laying out a spreadsheet program or developing a mission-critical application. The qualifications of these "applications programmers" will vary over an extreme range also. Applications may be developed by entry-level personnel because they "know the package" and help others in their work, or they may be corporate executives who prefer to write their own programs because it is "fun." Application development in a downsized environment will have a tendency to be unstructured.

- *Casual users* who are able to make queries of application data bases can use PC tools to build personal data bases, which may then be used as a source of power. However, such personal data bases can create horrendous data management problems.

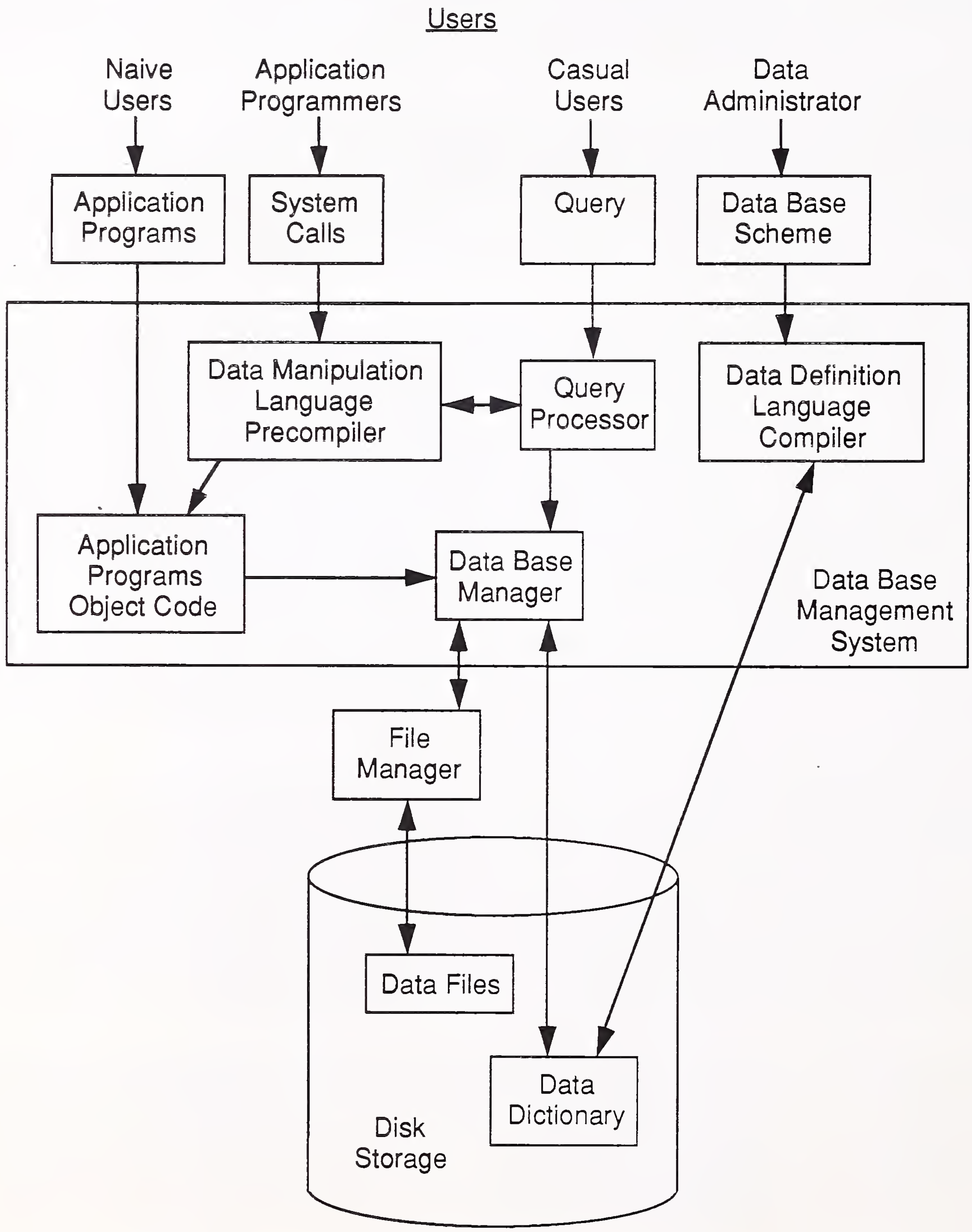
- Data base administrators will exist in the downsized environment regardless of what they are called. It will be found that leaving data base administration to individual users will lead to chaos, and the central data base administrators are saying responsibility for data quality is going to be transferred whether users know this or not. The need to coordinate file transfers and maintain data dictionaries and documentation will have to fall on someone at the local level. This can become an important element when cost justifying downsizing.

Considerations of data base quality and the architecture for data base use will be critical factors in the success or failure of downsizing to achieve its objectives. Imposing such discipline on free-wheeling end users who have finally shattered the walls of the traditional "glass house" will not be easy. The end-user revolution has been a long and bitter struggle in many organizations, and systems discipline is not going to be easy to enforce.

This brings us to the point where we will stop looking behind the screen and start looking beyond the screen.

EXHIBIT III-5

DBMS System Architecture



E
Business Processes

As soon as we stop staring at the screen and look around, we will notice that despite all of the computer equipment that has been installed in offices, there is still paper everywhere. Modern civilization and commerce have been built on paper, and paper remains the primary medium for most business processes and communications.

1. Computers, Paper and People

The impact of getting computer power to the people has resulted in automating the production of paper and making it prettier, but the core paper processes remain firmly in place in most organizations. It is INPUT's opinion that this is true for two reasons:

1. Most substantive business applications (and their supporting data bases) have remained on mainframe computers, under the control of the IS department and the corporate controller. Central planning and control functions thrive on paper, and most financial people feel extremely insecure without it.

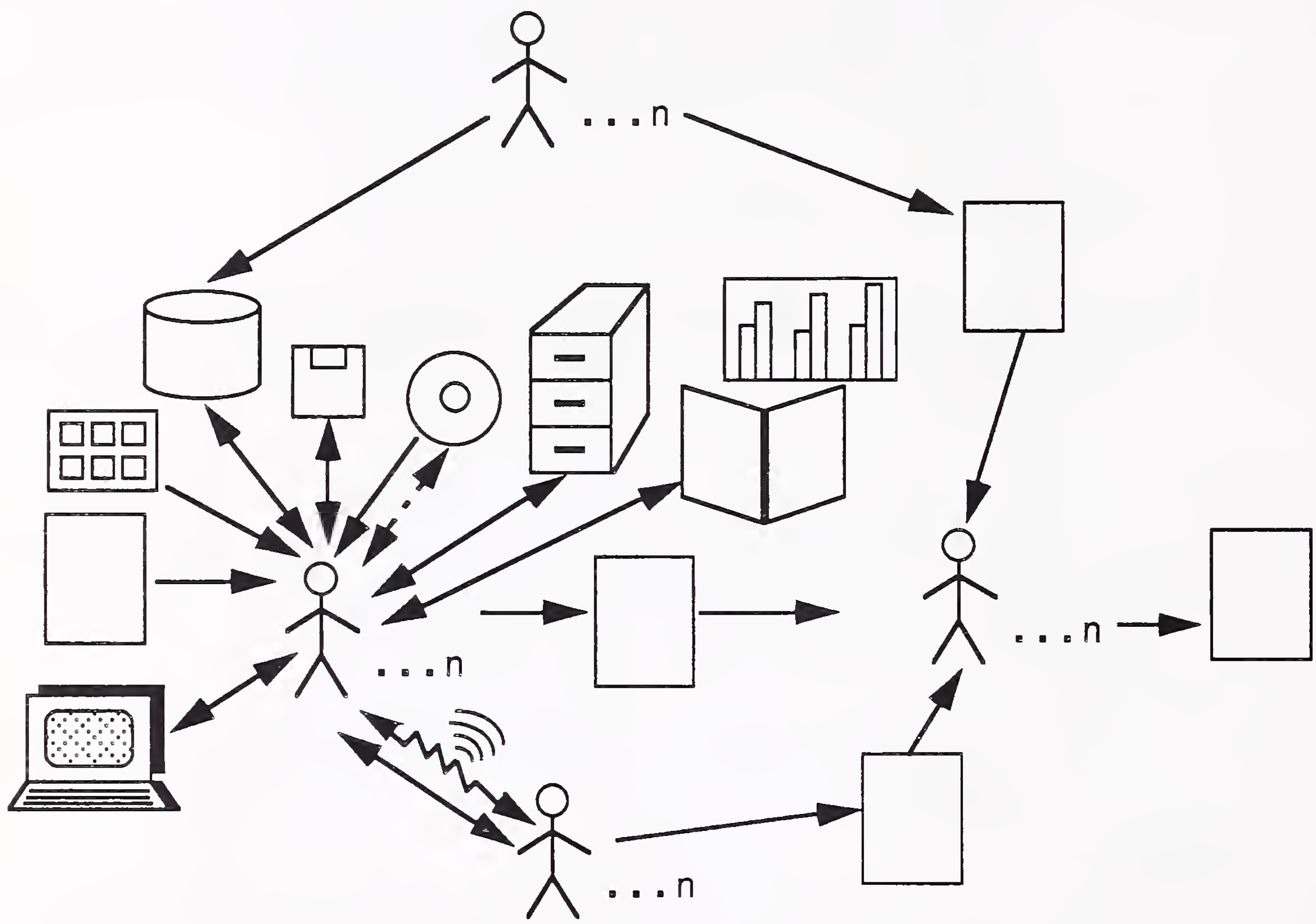
2. Mainframe "solutions" to office systems problems—specifically the reduction (or control) of paper flow—have been too expensive to be easily cost justified.

The extension of personal computer power to the desktop while data remained on central computer systems merely made another source of data and information available for the knowledge worker, who was already surrounded by "multimedia" sources (Exhibit III-6). In addition to mainframe data bases, the user was already exposed to the following:

- The regular flow of paper documents into, and through, the organization
- Paper files
- Libraries of professional publications and reference works
- Microfiche and microfilm archival records
- Face-to-face and telephone conversations with other humans (most of which result in paper documentation and confirmation)

EXHIBIT III-6

Business Processes and Media Conversion



And, since the personal computer arrived in the 1980s:

- Personal data bases developed and maintained by the individual
- Direct data interchange through floppy disks
- Electronic mail and messaging
- And, FAX—far from a new development—has suddenly become all the rage, and dumps paper from point to point faster.

The primary benefit of downsizing existing applications (and their supporting data) to office work units will be the recognition of the need to integrate all of these diverse data and information sources. It is one thing to exchange voluminous amounts of data and paper with a remote mainframe computer installation and quite another to know first-hand how burdensome and/or useful this information is in the actual working environment.

Even if downsized applications are not re-engineered (and they usually should be) moving these applications and their supporting data directly into the working environment will prompt rapid innovation in the basic business systems themselves. The benefits from substituting electronic for paper media in the office will far outweigh any savings from cutting back on mainframe expense; and early (and continuing) end-user involvement in the development (and maintenance) processes should improve both white-collar productivity and the effective application of information technology to business systems.

The architectures of both computer systems and business processes are bound to change when a single 5.25-inch optical disk (CD ROM at present) can hold not only the entire corporate planning data base, but also all of the paper files in the average office.

With all this potential lying just beyond the screen, what is standing in the way of immediate, massive downsizing?

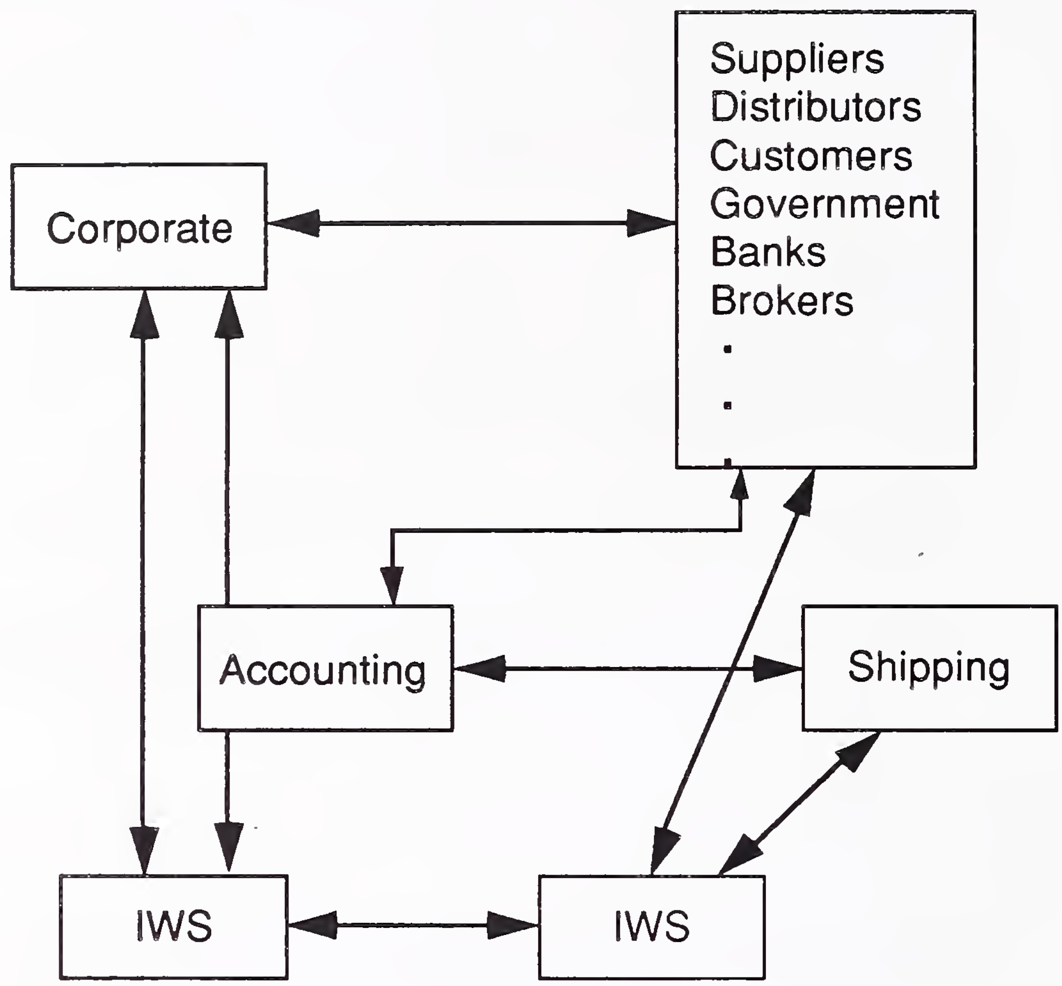
Essentially, it is the well-founded IS fear that downsizing may result in a complex "network of systems" that is unmanageable.

F
Networks of Systems

Exhibit III-7 depicts a fairly simple architectural representation of a "network of systems" that could develop among corporate planning, accounting, shipping, and the outside world. All of these functions are interrelated and must be kept in synchronization; otherwise unfortunate consequences can result. For example:

EXHIBIT III-7

Networks of Systems



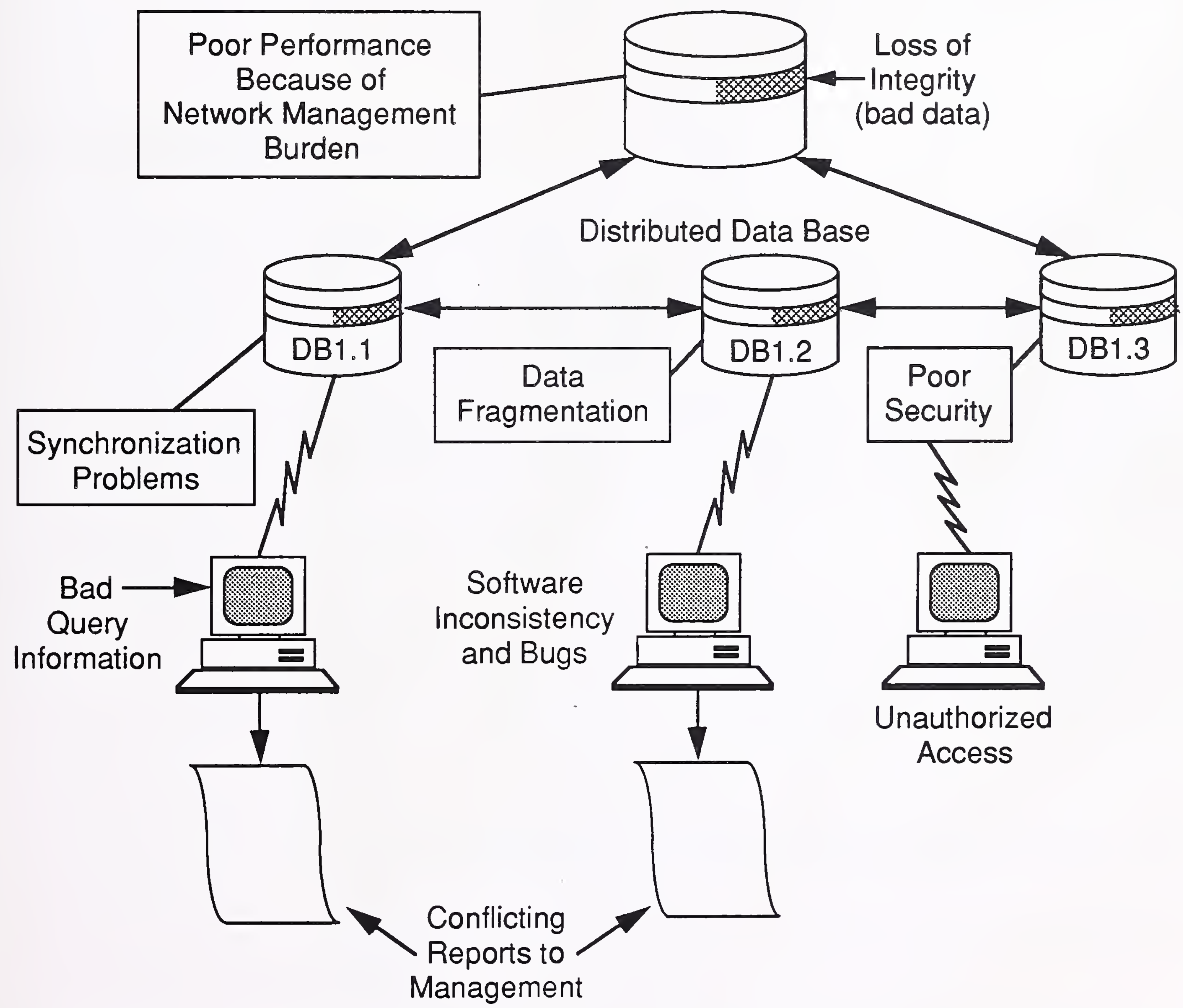
A number of years ago, corporate planners for a major computer manufacturer (that shall remain unnamed) were reviewing the data dictionary for the corporate planning data base. This data base tracked the movement of each box from the time it was placed on order until it was scrapped. Among the data elements were date of order, scheduled for production, scheduled for completion, shipped but unbilled, etc. All of these were quite understandable, but then someone spotted the category "billed but unshipped"!

The designer of the data base was promptly called on the carpet to explain this obvious error. Asked why the category was included, he stated simply: "Because it happens all the time. We bill for things that haven't been shipped fairly frequently, and sometimes we even get paid." It was also found that salesmen were spending a considerable amount of time working with customers on billing problems, and some customers were delaying payment until they received a proper bill. The company had a classic problem with data base synchronization and integrity between shipping, accounting, and field engineering.

What IS management fears is that downsizing (and distributed data bases) will result in exactly the same problems encountered by decentralized data processing and standalone applications systems. These data and information quality problems are depicted in Exhibit III-8. INPUT believes there are very real problems associated with distributed data base management, but technology has improved substantially in the last few years. It is possible that some IS managers are more concerned about data quality problems than the situation warrants.

EXHIBIT III-8

Data and Information Quality



Under any circumstances, data quality and security are central issues in the downsizing environment of the 1990s and they warrant additional research. A report on *Data Quality and Security in Downsized Environments* will be included in this report series.

IV

Competing Architectural Concepts

Although the fundamental technical issues associated with downsizing are data quality and security, there are a number of peripheral issues that surface as competing architectural concepts.

A
Open versus Proprietary Systems

The open versus proprietary systems controversy surfaces at several levels—hardware and systems software behind the screen, at the screen itself in terms of GUIs, and beyond the screen in standards activities. We will not concern ourselves here about arguments as to whether Sun's UNIX-SPARC system is more (or less) open than MS-DOS for Intel processors. The open versus proprietary issue for downsizing is clearly between IBM's SAA and UNIX. In fact, it is INPUT's opinion that the real downsizing competition will be between UNIX-based servers and the AS/400—a battle that really hasn't yet been joined (except within IBM).

1. The SAA World

Regardless of what one thinks about the progress of SAA, it is obvious that it specifically concerns itself with "networks of systems" and in shielding the user (or applications developer) from the complexities behind the screen. The major SAA abstractions are:

- A Common User Access (CUA) to all SAA systems
- A Common Programming Interface (CPI) and compatible applications enabling tools (including the relational model and SQL)
- Portability of applications across the hierarchy of SAA operating environments
- A cooperative processing environment featuring client ("requester") architecture

- A commitment to provide network management facilities for increasingly complex networks of systems

- And, last but not least, a comprehensive plan to develop an industrial-strength distributed data base management system

IBM's vision of the 1990s was clearly presented at conferences for the computer services and consulting industry and to IBM user organizations even before SAA was announced. The fact that SAA is an effort to get the IBM house in order, and is self-serving in the sense that acceptance of SAA effectively locks out many competitive hardware/software vendors, is beside the point—SAA does address, head on, the most serious architectural problems in the commericial data processing market.

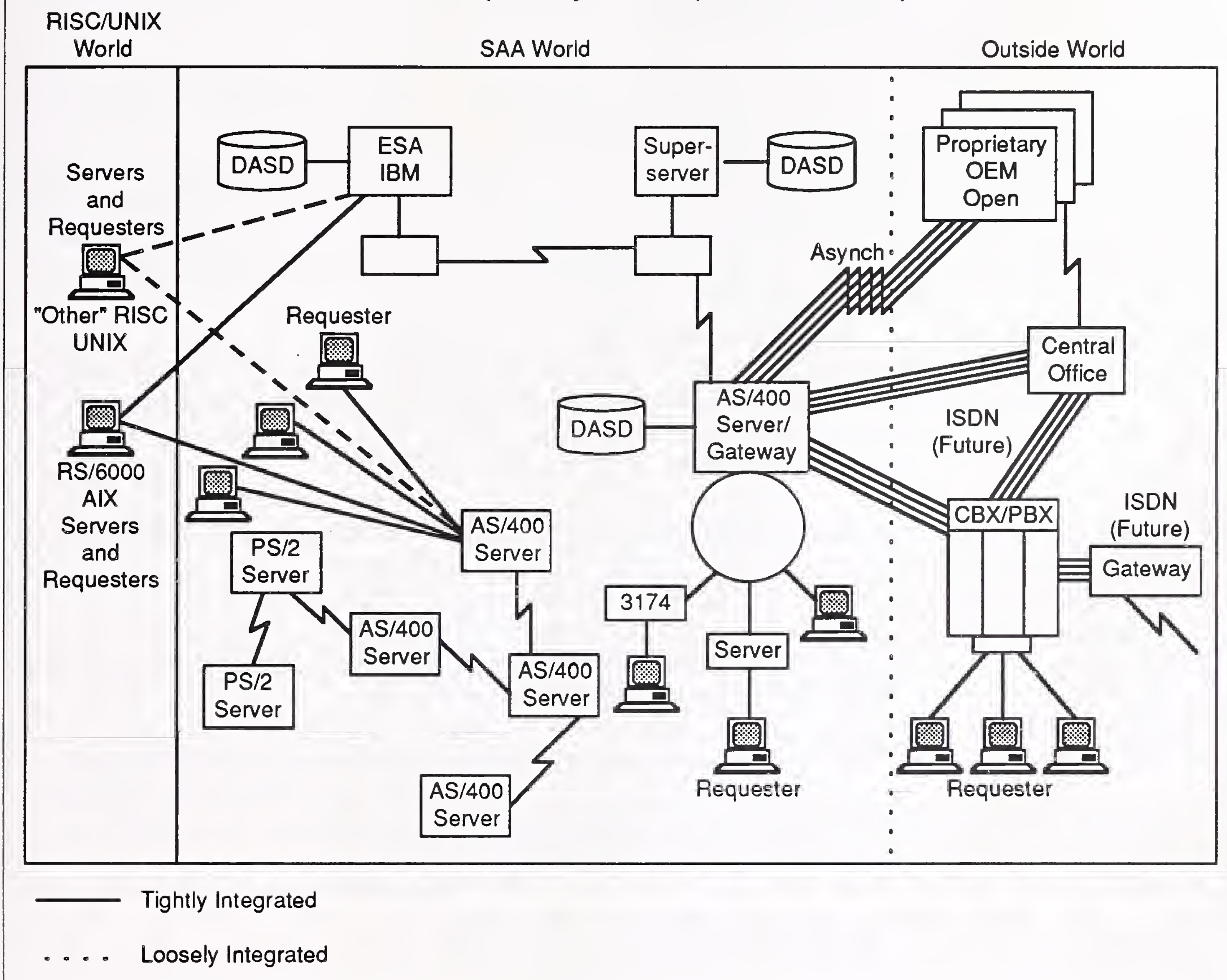
In addition, the need for co-existence with the outside world was recognized at the time of the SAA announcement, and an integral part of SAA was the Common Communications Support (CCS), which was stated as being an extension of SNA (the de facto standard in the commmerical market) and "selected" international standards. Once again, though IBM's standards activities may appear to be self-serving in proposing APPC with LU.6.2 and PU 2.1 as standards (as well as APPN), IBM certainly isn't doing any more than other vendors in attempting to protect its (and its customers) interests. In addition, IBM has been the recipient of some rather opprobrious treatment at the hands of standards organizations going back to early COBOL and ASCII decisions.

2. The RISC/UNIX World

Exhibit IV-1 presents a slightly modified diagram of the SAA and outside worlds which was published by IBM around the time of SAA announcement. Since IBM had already supported UNIX in the form of AIX prior to the announcement of SAA, it can be assumed that UNIX and SQL were the preferred "standards" for asynch connection with the outside world of other proprietary and "open" systems.

EXHIBIT IV-1

SAA and Open Systems (Co-existence)



It was after the announcement of SAA that AT&T and Sun Microsystems tried to gain control (or bring order to) the UNIX world by preaching "open systems" and rallying around the SPARC processor. This brought on the revolt by HP, DEC, IBM and others which led to the founding of the Open Software Foundation (OSF). The success of RISC-based workstations and the apparent attraction of the "open systems" movement re-opened longstanding hardware/software conflicts within IBM. For example:

- The previously described RISC, CISC, HLL controversy
- The old DOS...VSE versus OS...MVS/ESA war of simplicity versus complexity. The latest battle was fueled by young IBM computer scientists who had cut their teeth on UNIX systems during their academic days.

- The internal antipathy of IBM's large mainframe crowd against mini-computers (except the 9370)—including the AS/400, which was doubly damned because it was also considered an architectural threat to the 370 architecture machines

- The general reluctance on the part of practically all of the internal IBM development groups to submit to the discipline imposed by SAA

The result was that IBM created a RISC/UNIX world around the RS/6000 that is a parallel strategy to SAA. Considering the architectural positioning of the RS/6000 and the AS/400 in the downsizing world, it is obvious that IBM has recreated conceptual problems and confusion at the mini-computer (server) level for its customers.

However, it is both possible and probable that IBM either knows (or feels) that UNIX and the RS/6000 hold the promise of increased penetration in scientific and engineering markets without significant exposure in the commericial market.

Consider how RISC/UNIX open systems stack up against SAA platforms.

a. RISC/UNIX versus AS/400

The following points were made by IBM concerning UNIX when the AS/400 was announced in 1988:

- "We've said in the past that our AIX (IBM's version of UNIX) platform—which runs across the PS/2, the RT (now RS) and the System/370—should be the primary choice where customers have UNIX requirements such as for federal government programs.

- "And that still applies.

- "But there's a really important point to consider in comparing the AIX operating system with the AS/400 operating system. That is they represent two totally different philosophies.

- "AIX is the right choice for companies whose primary requirement is portability across multiple vendors, and who have an established base of UNIX programmers...programmers who are willing to build the systems themselves and to work with the operating system to customize their solutions.

- "For those customers who don't want to get involved in the internals of an operating system... who don't have large, expert computer staffs...who operate in the commercial business world where immediate solutions provide the competitive edge...or who need to migrate System/36 and 38 programs...

- "The high level of integration on the AS/400 makes it the solution that fits like it was made-to-order. It's just plain easier to learn and use." [3]

Later, after the AS/400 had been announced for awhile, it was stated that there was no plan to have UNIX on the AS/400, but that it could serve as a "tightly integrated data server" for RS/6000 workstations.

The fact that the AS/400 is the most proprietary of systems does not seem to have had any impact on its market in the commericial environment. It is selling at a rate of approximately $14 billion per year, has actually gained market share in international markets, and was one of the few IBM products to "make its numbers" during 1991. Compare this with sales of the IBM 9370 (with or without AIX) or the RS/6000 in the commercial market and someone at IBM should be getting the message. And perhaps they are—IBM is just beginning to market the AS/400 as a departmental processor in large organizations and as a development platform.

b. RISC/UNIX versus PCs/LANs

In the research conducted for *Putting Downsizing in Perspective*, IS management rated PCs above RISC/UNIX systems for having the best "open architecture." At present, DOS is rated as easier to use (or at least more familiar) than UNIX; and both OS/2 2.0 and Microsoft Windows with NT are promising to leapfrog UNIX in terms of functionality in the commericial client/server environment. In addition, early downsizing efforts directed toward UNIX platforms have encountered the difficulty of having to hire relatively expensive UNIX experts at remote locations.

IS management obviously feels more comfortable with PC/LANs than they do RISC/UNIX systems for downsizing, and this is probably true of end users also.

c. RISC/UNIX versus System/370 Platforms

UNIX is easier to use than IBM/370 mainstream operating systems (MVS, VM, and VSE); and, in a classic time-sharing environment, it is also substantially more cost effective. However, UNIX does not currently have the functionality and robustness required for large commercial applications, and all vendors have had to extend their versions of UNIX when competing in that environment. It may be possible to create a UNIX that will compete directly with MVS/ESA, but it will no longer be UNIX, and it is not likely that such a product will ever come out of the cooperative efforts of either OSF or UNIX International. As functionality and robustness increase, ease of use (even with a GUI) and performance will decrease.

Then, of course, there are the critical issues of data quality and security. We strongly urge that anyone concerned about these issues study the AT&T Bell Laboratories *Technical Journal* (Vol.63 No.8 Part 2; October

1984) before opting for a UNIX platform; the entire issue is devoted to UNIX. The matter will be reviewed in more detail by INPUT in *Data Quality and Security in the Downsizing Environment*, but for now we will merely quote the following:

"Such open systems cannot ever be made secure in any strong sense; that is, they are unfit for applications involving classified government information, corporate accounting, records relating to individual privacy, and the like."

Then, after describing the **cu** (Call UNIX) program as a security disaster, another author gives the following advice:

> "1. Do not use **cu** from a machine that is not trusted.
> "2. Do not use **cu** to a machine that is not trusted.
> "3. Do not browse on the remote machine." [4]

It is not by chance that major network security intrusions usually involve UNIX systems, and this should be taken into consideration when selecting applications to be downsized to UNIX platforms (or, evidently, before communicating with other UNIX platforms using cu).

The message of SAA is that compliance will provide a framework for downsizing and eliminate many of the integration problems inherent in open systems. In addition, it also promises connectivity to the open systems world. Although public support of SAA is negligible at present, 30% of respondents to INPUT's downsizing study felt it would be the predominant architecture for commercial work by 1995, and nearly 60% felt that would be by 1999.

B

Top-down versus Bottom-up

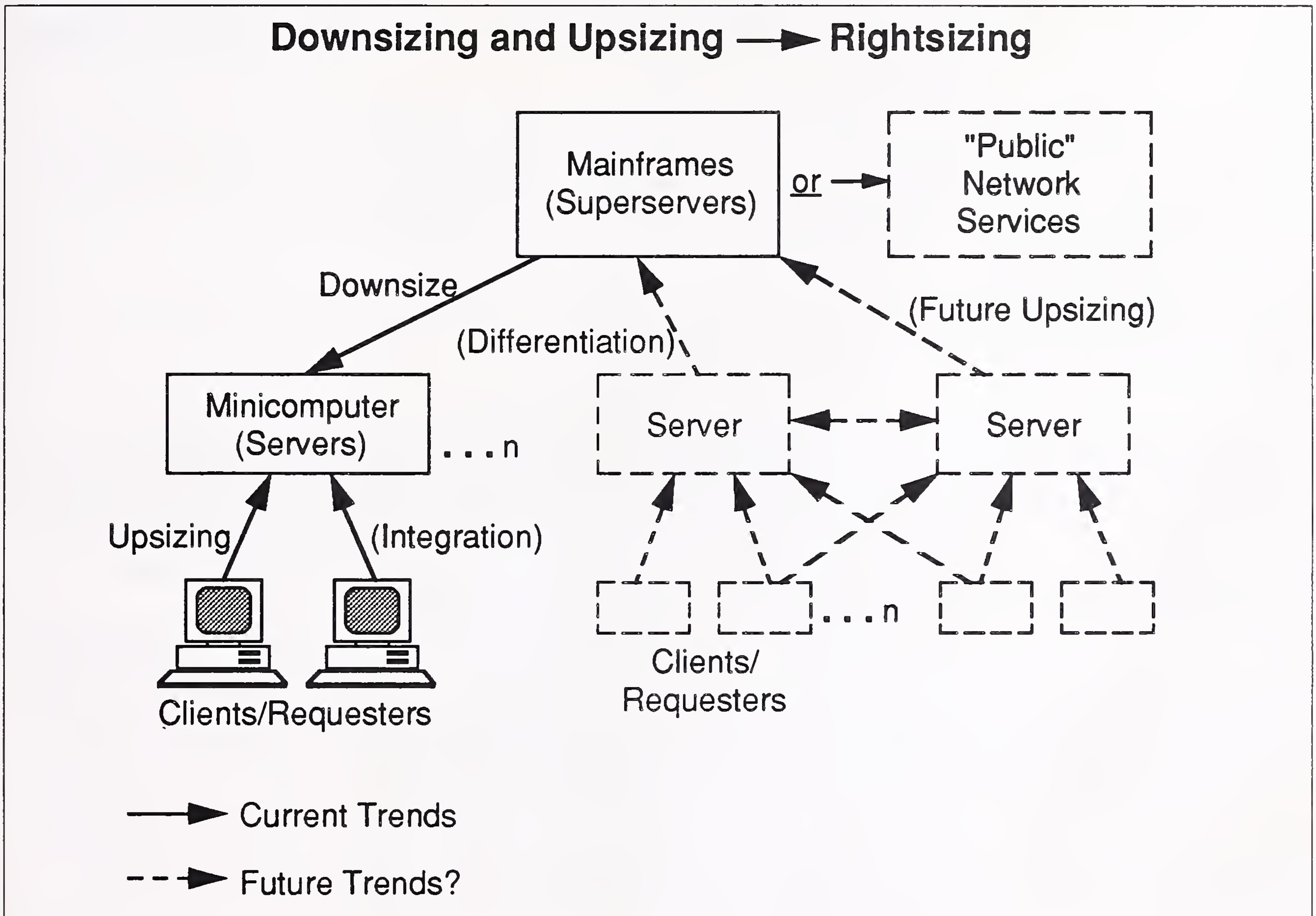
One of the less than remarkable discoveries associated with structured programming was "top-down design/development." We say less than remarkable because the reaction of many experienced project managers was: "Is there any other way?" It is only since the advent of the personal computer that there are those who propose "bottom-up" systems development.

In parallel with the trend toward downsizing existing applications, there is a trend toward "upsizing" of applications that were originated from the bottom up (see Exhibit IV-2). Both downsizing and upsizing result in a client/server architecture that focuses on minicomputer (by INPUT's definition) servers.

- Mainframe applications (and data) are being *differentiated* and downsized to work unit servers (departmental processors).

- Personal computer applications are being *integrated* and upsized to work unit servers.

EXHIBIT IV-2



Since practically everyone agrees that mainframe computers (superservers) will not disappear as downsizing occurs, the result will be a three-tiered network architecture. This has some critical ramifications for downsizing efforts. For example:

- If some applications work is offloaded from mainframes, but essential data remain on the superservers, it is probable that mainframe workload will diminish more rapidly than will the supporting mainframe cost structure (hardware, software, facilities, personnel, et cetera).

- This could mean that cost recovery of the central organization may be difficult unless rates from the central facility are increased.

- Increased rates from the central facility could mean that initial cost justification for the downsizing effort may prove to be illusory.

- What all this means is that outsourcing of central functions becomes increasingly attractive in a downsizing environment.

In addition, as a "bottom-up" upsizing effort progresses, additional levels of integration will be required and will eventually result in either: 1) additional demands on a central facility for data base and network management support, or 2) the necessity to contract with an outside services organization.

Under either downsizing or upsizing, it appears that many organizations will be reluctant to invest either financial or human resources in the care and feeding of large mainframe-oriented data centers.

C

Client/Server versus Cooperative Processing

Since both top-down and bottom-up systems development result in a client/server architecture, it is necessary to examine this rather loose term, especially as it relates to cooperative processing. Although client/server is general enough to encompass cooperative processing, it is important to understand the different mind-sets associated with the terminology.

The simplest distinction between the two is that cooperative processing is associated with the top-down, SAA-oriented school of thought, and client/server is associated with the bottom-up, open systems school of thought. Another related distinction would be that cooperative processing places emphasis on data base management as the most important element of an application, whereas client/server places emphasis upon the display of information (reporting) as the most important element of the application. In other words, cooperative processing has the central IS department strongly behind it, and client/server is supported by advocates of end-user computing.

Based on past experience, good arguments can be made for both sides.

- IS management can rightly say: "If the data aren't any good, the information being generated isn't going to be any good. The garbage in, garbage out lesson is one of the oldest in data processing."

- End users can counter: "What good does all the data do, when the IS department can't provide the information we need to run the business until after the fact? The IS department just can't respond to our needs fast enough in a rapidly changing business environment."

There is truth in both of these positions, and it would be wise for both sides to recognize that effective downsizing must be a cooperative effort—regardless of terminology or past differences.

The primary issue remains centered around data base management, and how tight or loose the architectural standards are going to be in a distributed data base environment.

D

Loosely versus Tightly Integrated Architectures

Exhibit IV-3 relates the terms client/server and cooperative processing to data and information management. Client/server is a broad term capable of being applied to all three levels of "data connectivity." These levels of connectivity came from a presentation by Dr. Allan Scherr of IBM in the late 1980s. It was titled: "Distributed Data in the 1990s", and remains a good model of where SAA is headed in terms of distributed data base management.

1. Pair-wise Connections

Scherr referred to *pair-wise connections* as "yesterday's solutions" and they remain remarkably similar to the capabilities available in the UNIX client/server environment.

- Hand-tailored application-to-application data connectivity can be effective, but it is expensive.
- Virtual disks permit the sharing of DASD, but they do not permit the sharing of data. This results in a great deal of redundant and unmanaged data and enormous demands for disk space, but performance against these specific files is not burdened by the overhead of a DBMS.
- File transfer can provide for bulk transfer of data between servers and requesters (clients). The efficiency of file transfer connectivity is a function of the percent of data actually needed by the requester. The potential for excessive demands upon the central host and the communications network is substantial when inexperienced end users are involved. In addition, there is no multinode concurrency; and the result, once again, is redundant and unmanaged (and perhaps unmanageable) data.

Nevertheless, file transfer, properly architected, can be all that is needed for many applications. This is an extremely important consideration when downsizing.

2. Architected Cross-System File Models

Scherr referred to *architected cross-system file models* as "today's solutions" and used IBM's Distributed Data Management (DDM) facility as an example. In the UNIX open systems environment, this is being addressed to varying degrees, by various DBMS vendors, in various ways, with SQL serving as a standard for many implementations. This model has the following attributes:

- It does provide record-at-a-time access, thus avoiding unnecessary bulk file transfer.

- It provides local/remote transparency among servers at various levels.

- There is concurrency between local and remote users—thus avoiding problems of data base synchronization.

- There is a single, manageable copy of data with which all users are working.

- There is a published data connectivity architecture upon which applications can be developed.

Because of the loose hardware/software/firmware integration that is implicit in the UNIX open systems environment, competing vendors offer different architectures for data connectivity (gateways, pass-through, bridges, data models supported, etc.). It is reasonable to expect most vendors to provide data connectivity to the SAA world at all levels—there is just too much of an installed base to ignore. However, the integration between SAA and the outside world can never be as tight as it is within the SAA world.

3. Architected Cross-System Data Base Models

Scherr referred to *architected cross-system data models* as "tomorrow's solutions." In other words, this is where SAA is heading in the 1990s. And where SAA is heading in the 1990s is toward distributed data base management in the broadest sense of the term, but with a very important caveat: be prepared to go relational in a big way.

EXHIBIT IV-3

Client/Server versus Cooperative Processing (Data and Information Management)

Client/Server

- Pair-wise Connections
  - Hand-tailored Application-to-Application
  - Virtual Disks
  - File Transfer

Client/Server (Potential)

- Architected Cross-System File Models
  - Record-At-a-Time Access
  - Local/Remote Transparency
  - Concurrency with Local/Remote Users
  - Manageable Single Copy of Data
  - Published Architecture

Cooperative Processing (SAA)

- Architected Cross-System Data Base Models
  - For All Data Types
  - Consistent SQL Interfaces
  - Consistent End-User Interfaces
  - Data Administration Facilities
    - Data Description
    - Security
    - Recovery
    - Auditability
  - Automatic Data Conversions
  - Intersystem Data Integrity and Recovery

The following are the attributes of architected cross-system data base models:

- The architecture will encompass all data types. The significance of this statement can appreciated by looking at Exhibit IV-4. This is multimedia integration in a big way.

- There will be consistent SQL interfaces across SAA operating environments.

- There will be consistent end-user interfaces (within SAA).

- Data administration facilities will include the following:

    - Data description
    - Security across systems
    - Recovery across systems
    - Auditability

- There will be automatic data conversions across systems (and, hopefully, this includes most of the data types in Exhibit IV-4).

- There will be intersystem data integrity and recovery.

Scherr pointed out that System R* was a prototype of such an architectured cross-system data base model, but it should be obvious that what we are talking about here goes far beyond either System R* (a follow-on development effort to System R that was the prototype system for the relational model at IBM's San Jose laboratory), or the plans of any other DBMS vendor. For one thing, no other vendor is prepared to provide "intersystem data integrity and recovery" for the tightly integrated SAA systems such as the AS/400, which has its DBMS and communications system built into its operating system (OS/400).

In fact, this is the critical architectural point that separates the SAA world from the open systems world: IBM has an announced distributed data base management strategy that is tightly integrated across the SAA platforms. In the open systems world, there are many competing DBMSs; and they all must be prepared to interface with SAA systems already installed in the commercial environment, and which currently control the data bases for applications that may be downsized.

EXHIBIT IV-4

Types of Data To Be Distributed

• Records	• Graphics
- Accounting	- Charts
- Inventory	- Maps
- Sales	- Drawings
• Text	• Images
- Notes	- Facsimile
- Letters	- Video
- Documents	- Pictures
• Voice	• Other
- Messages	- Programs
- Annotations	- Knowledge Rules
- Audio Response	- Metadata

This results in the following problem(s) when downsizing to UNIX-based open systems:

- No competitive vendor can promise to provide "intersystem data integrity and recovery" across the UNIX/SAA boundary; and, in most cases, essential data bases to support downsized applications will continue to reside on SAA systems.
- Of equal significance, IBM (even if it was so inclined) cannot promise "intersystem data integrity and recovery" once data are distributed to "foreign" systems.
- If anticipated problems of data quality and security are the limiting factors in downsizing existing applications, those problems become increasingly acute as one moves farther away from the SAA world.

- It certainly is not difficult to imagine IBM exploiting fear, uncertainty and doubt about the quality of data in the open systems world; and there is every reason for its customers to move cautiously when distributing data outside the tight confines of the SAA world because there are some very real technical problems with distributed data bases—both in the SAA world and out of it.

IBM may be moving slowly toward "tomorrow's solutions," but it is proceeding according to a published plan. The only question is whether IBM will succeed or fail; there are no competitive alternatives to reach the goal IBM has set itself. It is INPUT's opinion that IBM's customers and its competitors have an interest in seeing IBM succeed in solving the problems of distributed data base management. It is a necessary step in the effective use of rapidly advancing information technology.

E

Centralized versus Distributed Data Bases

With all that said about the thrust of SAA and "tomorrow's solutions" to the problems of distributed data base management, there remain several major questions concerning the necessity or desirability of distributed data bases. Who needs distributed data bases? Which applications require distributed data bases?

These are legitimate questions when dealing with traditional commercial data records (see Exhibit IV-4). Many such encoded data bases can be legitimately centralized, and some do not even need the "benefit" of an elaborate DBMS. There are still some applications that can do very well with indexed sequential files. Portions of these applications (data entry and reporting) can be downsized to good effect, leaving the data bases centralized.

However, when we take a look at the probable future of downsized applications, we are confronted with the other data types listed in Exhibit IV-4, and these other data types will, of necessity, result in distributed data bases. Consider the following example:

- An existing order entry system is downsized to multiple branch offices, but a central data base remains in place.

- Initially, the application is split so that all editing of incoming orders and preparation of customer documents (including billing) is now done in each branch office, but the data base of record remains on a host mainframe.

- Assume that orders are accompanied by supporting documents which are processed for both financial reasons and technical feasibility, and the individual branch offices may occasionally call on other organizations to assist in the analysis. It is only after the paper process is completed that the centralized data base is updated.

- Once the application has been downsized, it is determined that the order processing can be improved substantially by truncating the flow of paper documents in the mail room at the branch office. It is determined that an image processing system can expedite the routing of all necessary "paperwork" among organizations. This means that the order, and supporting documents, can be at several workstations and/or organizations simultaneously.

- In addition, it is found that an expert system requiring extensive analysis of customer historical records can be used to clear a subtantial portion of the orders currently being routed outside the branch for expert opinions. It is decided to standardize on the use of the expert system for all branches, and one of the decision rules of the expert system involves a continuing assessment of time spent processing certain orders.

- As soon as it is decided to "improve" the order processsing applications with image processing and expert systems capability, a distributed data base is required. Moving all of the document images required for intra- and interoffice use to a central computer just doesn't make much sense, nor does it make sense to keep detailed work measurement data on a remote computer.

Downsizing and advanced computer/communications applications will lead logically to distributed data bases if we accept a definition of data that includes everything stored in a computer.

F

HLL versus CISC versus RISC versus ASIC

Though this report is concerned specifically with systems architecture as it relates to downsizing, it will not go into a great deal of technical detail concerning hardware architectures. Suffice it to say that there are strong advocates of HLL, CISC, and RISC among computer architects and engineers; and it is INPUT's belief that all three architectures have significant roles to play in the downsizing environment.

The CISC architecture has been, and continues to be, dominant in the commercial data processing market. Applications built on CISC platforms interface at various levels of the computing system. [5] As mentioned earlier, it is difficult for applications programs (and software development personnel) to avoid interfacing at all four layers of the computer systems architecture. Exhibit IV-5. These interfaces are apparent:

- At the subsystem level, where the application program depends upon a DBMS or "office" system to support its implementation

- At the network interface level, where the application program must depend upon network control and management facilities to connect to the LAN and navigate the WAN

- At the operating system level, where a familiarity with commands remains essential, regardless of how much buffering is done with a GUI

- Then when an application programming language is employed, the developer is face to face with the instruction set of the computer, and may even get involved in "peeking" and "poking" around at the digital level.

Starting with an IBM personal computer (a CISC machine), downsizing developers are confronted with a bewildering array of systems software, communications packages, networking systems, and applications enabling subsystems. It matters not whether the developers are experienced with developing systems under MVS/ESA—just the evaluation process of selecting the software cushioning to build on the microprocessor can be extremely expensive and time consuming.

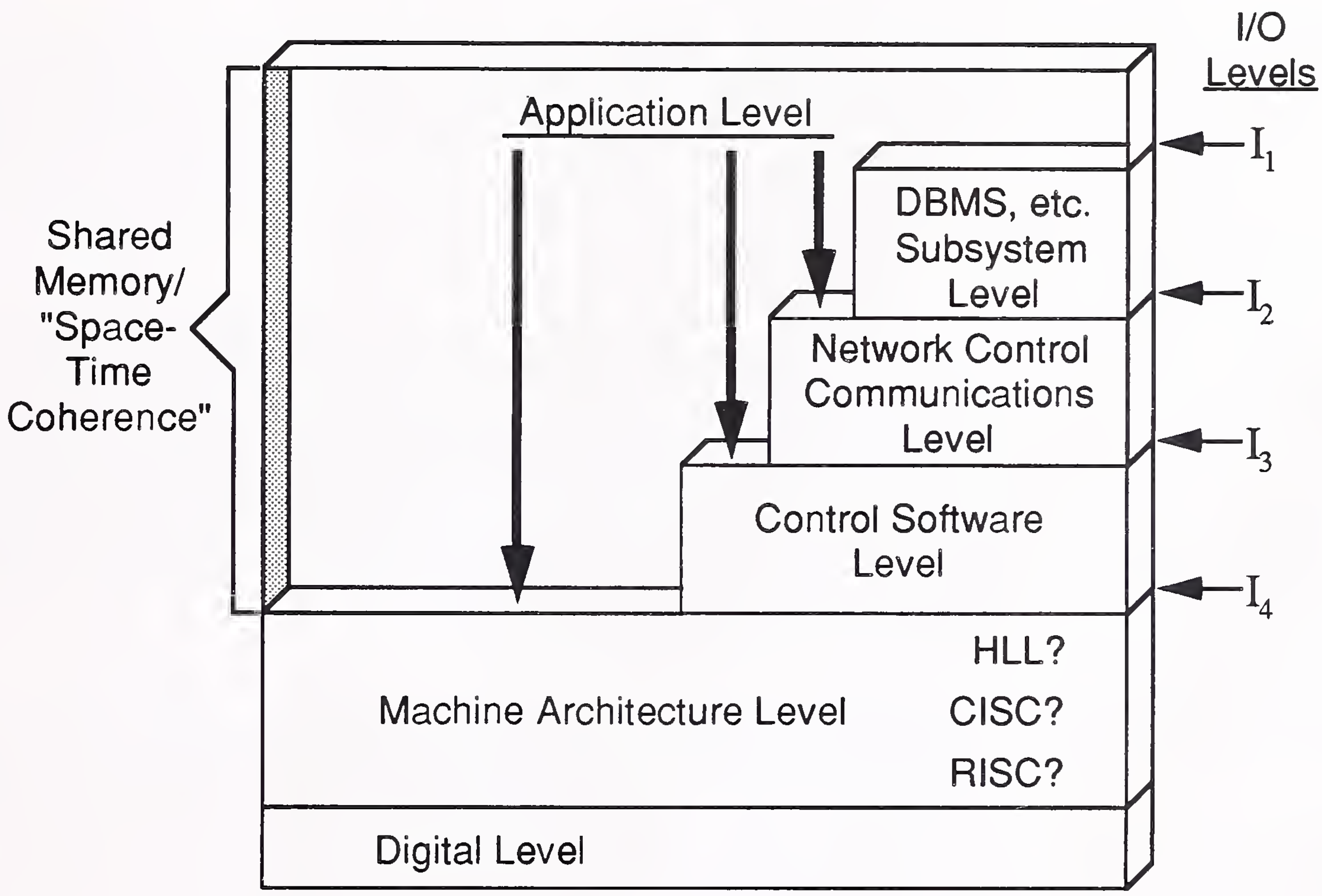
If one decides to go with a RISC platform, the operating system decision becomes relatively simple: some brand of UNIX will be the answer. However, the multilayered interfaces remain, and this can be a problem when downsizing, because UNIX will not have the functionality of the mainframe operating system. This will increase the burden of porting the application to the RISC platform. Then there is the RISC architecture itself, and what this means in terms of the downsized application is difficult to say. Here is what one computer scientist had to say on the subject:

> "In this area (the CISC, RISC, HLL controversy) there is sometimes more passion than crisp definition. A full understanding of the various trade-offs in the processor architecture area involves an appreciation not only of architecture, but for design methodologies, underlying technologies, and compiler methodologies as well as for the costs of hardware and software production in different technological intervals. A 'good architecture' (processor architecture) should be easily and efficiently represented in the technology, and should provide for simple, efficient compilation. But there may be other considerations whose importance becomes greater over time. A serious problem is that we lack a universally accepted metric either for a 'good architecture' (although many have

been proposed) or for the 'complexity' of a compiler, and we seem certainly unready to deal with issues about the quantitative impact an architecture should have on the cost of producing and maintaining code, etc." [5]

EXHIBIT IV-5

Hardware, Firmware and Software Layering



I_1 Application, Subsystem Interface Level

I_2 Network Interface

I_3 Operating System Interface

I_4 Software Interface

Thus, it can be stated that the decision to go from a mainframe CISC environment to a RISC/UNIX environment is to leave something that is relatively well known, through actual usage and measurement, to go to an environment that is highly speculative at best.

Having touched on the CISC and the RISC architectures, we also have an HLL architecture to deal with—the AS/400. This is a machine with a truly different architecture, which starts by pushing the DBMS and network control functions down into the operating system—many functions of which have, in turn, been pushed down into the machine architecture level. The AS/400 has a single address level and was announced with 48-bit addressing. Anyone who has watched the struggles of the 370 architecture machines to increase addressing through "extended architectures" will understand that they just arrived at this level along with the AS/400. Then shortly after announcement of the AS/400, it was stated that the architecture could "easily accommodate" 64-bit addressing if it was needed for "image processing" or large networks.

Though the AS/400 remains enigmatic to both CISC and RISC advocates, there is considerable experience in implementing business applications on these systems. One striking example was the implementation of IBM's ImagePlus, which was developed for both the MVS/ESA and OS/400 platforms. IBM's *THINK* magazine [6] reported the following experience with implementation.

- The MVS/ESA version of ImagePlus was reported to be a "new approach in systems development" and involved "standard IBM software enhanced by the contributions of 14 IBM development laboratories, along with selected components not part of IBM's current product line." (The original MVS/ESA version required customers to have IMS, DB2 and CICS installed.) The description of the pilot installation at USAA was full of qualifiers such as "when fully operational" and alluded to the expansion of the system "over time."

- The OS/400 version of ImagePlus was originally developed on the System/36 by a single IBM Advisory Systems Engineer with the help of an IBM business partner in Sioux Falls, SD, who wrote the necessary software on a "tight deadline (which was met)." This system was readily ported, without fanfare, to the radically different architecture of the AS/400 using plain vanilla OS/400. The installation of the prototype ImagePlus system was reported in *THINK* as follows: "Unlike the USAA project, there was no gradual phase-in of the Citibank system...70 IBM image workstations were connected to an ImagePlus system and went into immediate operation."

It seems to us there is a message here concerning the ease with which mainframe applications may be downsized from MVS/ESA platforms to the AS/400.

What about the AS/400 compared to those hot RISC MIPS burners? Well, word is beginning to leak out in the trade press that UNIX/RISC machines require approximately five times as many processor cycles to complete RAMP-C and TCP-A transactions as do AS/400s. [7] It would seem that the efficient compilers haven't quite caught up with the RISC architecture yet. Although we have serious reservations about the reported numbers in Computerworld, it does makes one wonder just how the two systems would compare in a real commercial application.

So, while the jury is still out on computer systems architectures, it is probable there is a right place for all of them—including the "downsizing" of some CISC, RISC, and HLL processor functions to application-specific integrated circuits (ASICs). (See Exhibit III-1.)

G

Conversion, Restructuring, Re-engineering

Although there is great complexity involved in selecting applications to be downsized and their target hardware/software platforms, IS management is confronted with additional difficult decisions concerning how downsizing should be accomplished.

- There are those who advocate a quick conversion of the application in order to take immediate advantage of the potential cost savings (or perhaps just to keep the end users quiet). This sometimes takes the form of letting the end-user department develop the application and then just dumping the data on it. In other cases, it could mean that a mainframe is rolled out and the new platform is rolled in in its place.

- Then there are others who recommend that applications be restructured so that certain functions and/or data are distributed and the application is then processed "cooperatively."

- Finally, some feel that applications should be completely re-engineered to make effective use of new information technology, and to maximize return on investment.

While it is easy to visualize cases where any one of these approaches might be best, it is INPUT's opinion that re-engineering is the best strategy for most applications. Downsizing is an appropriate time to improve the systems development process (and the resulting application), by:

- Making a commitment to quality

- Getting user involvement in the development process

- Getting a broad spectrum of management involved and committed to the downsizing effort

- Assuring that effective personnel are involved in downsizing effort

For those with a long memory, these four elements are the most important ones in INPUT's "productivity pyramid" that was developed during a major multiclient study on "Improving the Productivity of Systems and Software Implementation" in 1980. INPUT's emphasis on "commitment to quality" is based on its belief that "quick and dirty" systems seldom pay off, but they do stay around to haunt us for a long time. Many mainframe applications that are candidates for downsizing fall into this category.

They have been maintained in a state of deteriorating quality for years and even decades. They should not be foisted on end users in this condition, and users should not be encouraged to do a quick and dirty version of an old quick and dirty application.

H

Implemention Strategies and Tactics?

Even after it has been decided what general approach is going to be taken in implementing a downsizing program, there remains the question of selecting the right tools to do the job. Selecting the "right tools" sat at the top of the productivity pyramid, and the point was made that selecting the right tools was only important if the base of the pyramid was built on the solid foundation outlined above.

It was also pointed out that an abnormal amount of effort was spent in selecting and using tools without consideration of the more important elements that contribute to improved productivity in the system development process. The emphasis upon tools (and the search for magical solutions) has only gotten worse since INPUT's 1980 study on productivity. Today, it is practically impossible to hire a consulting firm that does not have its own set of tools that are supposed to solve the problem regardless of what the problem happens to be.

In most cases, we do not believe that an acceptable way to downsize an application is to run it through a set of CASE tools (upper or lower) and generate code for another hardware/software architecture—regardless of target platform. Proper downsizing requires an applications architecture (lower case, not necessarily SAA) that takes into account the distribution of both processing and data over the network.

Detailed analysis of various implementation strategies and tactics is beyond the scope of this study. However, INPUT does plan a report on *Methodologies for Information Technology Downsizing* as part of its Downsizing Program.

V

Downsizing, Productivity and Effectiveness

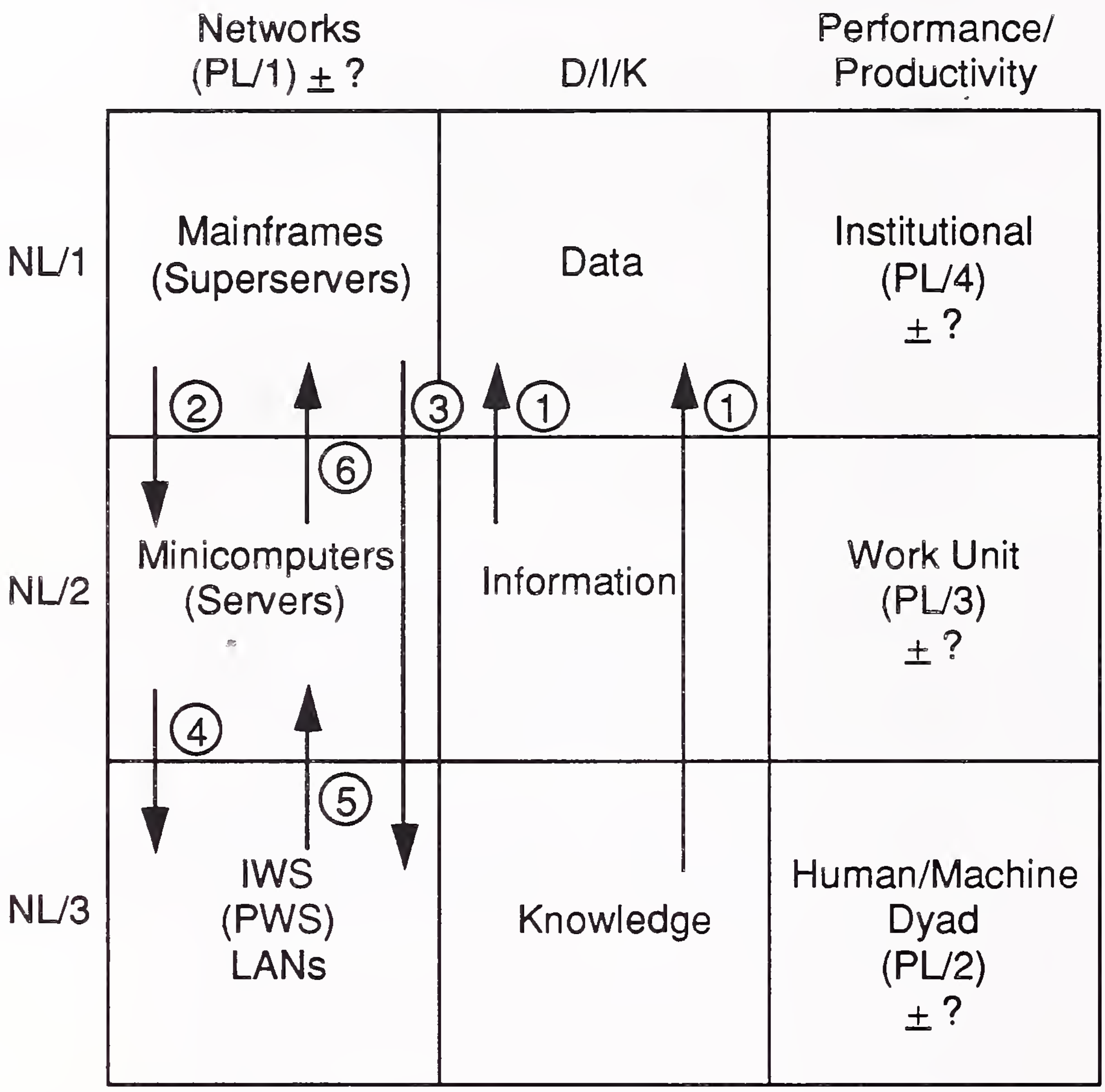
The previous chapter discussed competing architectural concepts behind and at the screen. INPUT believes that the management concepts and motivation for downsizing are substantially more important than those technical considerations.

In *Putting Downsizing in Perspective*, we used a simple 3X3 matrix to depict network architecture and a set of "performance levels" that encompass technical and management concerns. The fact that the matrix is simple does not mean that it cannot be used to depict extremely complex relationships.

Exhibit V-1 summarizes the major architectural trends of the 1990s and also provides a structure for measuring the effective application of information technology.

EXHIBIT V-1

Architectural Trends of the 1990s



1. Integration of Information & Knowledge with Data
2. Differentiation of Mainframes → Minicomputers
3. Differentiation & Mechanization of Mainframes → IWS
4. Differentiation & Mechanization of Minicomputers → IWS
5. Integration & Centralization of IWS with Minicomputers
6. Integration & Centralization of Minicomputers → Mainframes

A

Major Architectural Trends

- The major architectural trend of the 1990s will be the integration of information and knowledge with data. [1] What this means is:
  - Most business information is currently communicated and stored on paper. During the 1990s, there will be a significant shift away from paper media in business processes and toward electronic data.
  - Most knowledge is currently communicated by human beings and stored in human brains. During the 1990s, the trend toward the capture (and communication) of human knowledge by means of electronic media (data) will accelerate.
  - Image processing and knowledge-based systems are the tools for implementing the integration of information and knowledge with data, and INPUT believes downsizing is necessary for effective implementation of such systems.
- The trend toward downsizing business applications, which has been identified by our research, is from large mainframes to client/server networks. It is our belief that the servers associated with most of these downsized applications will fall into what INPUT defines as the mini-computer category. (2) The process of downsizing has been identified as one of differentiation through which a part of the system (network) becomes more specialized (i.e., the human resources department now has its own computer system). We use the term differentiation as it is defined in General System Theory [8]; it is important to understand what that implies.
  - Ludwig von Bertalanffy (the author of General System Theory) describes the process of differentiation in a living organism as follows [9]:
    - "...during differentiation an organism passes from states of lower to higher heterogeneity.
    - "...the transition is towards ever more improbable configurations, towards systems of higher order and organization."
  - If we view the network as an "organism," this tells us that the differentiation process (downsizing) will result in more complexity, and the need for applying more human and/or machine "energy" to maintain the "improbable configurations" and higher order systems associated with the resulting network. This will be a key factor in determining the cost effectiveness of downsizing (differentiation).

- Differentiation obviously does not stop at the minicomputer level. In fact, the primary technological trend is toward finer and finer network granularity.

  - Downsizing from mainframes will result in some applications (or functions) being differentiated directly down to the IWS level. (3)

  - Minicomputer applications (and functions) will tend to gravitate toward the workstation level as part of the general differentiation process. (4)

  - There are limits and a paradox associated with the differentiation process.

    - The limits are imposed by the increased complexity of network and data base management necessary to maintain order among these "improbable configurations."

    - The paradox is that much of the lure of downsizing has to do with the "simplicity" of the new platforms compared to the complexity of the mainframe operating environment.

- Associated with the natural tendency to differentiate is the parallel trend of mechanization, in which parts of the system perform a single function. This tendency is identified along with differentiation to IWSs in Exhibit V-1 [3 and 4]. The downsizing of IWS functions to ASICs (Exhibit III-1) is an even clearer example of mechanization. A few words about mechanization are necessary at this point.

  - Mechanization is reductionists' ultimate answer to productivity problems; the best example is an industrial engineer counting "therbligs" in an attempt to improve worker performance.

  - Though there remains serious doubt whether reductionist techniques such as time and motion studies can measure (much less improve) the productivity of knowledge workers, downsizing will provide the ability to measure what knowledge workers are doing at increasing levels of detail. For example, once tied into a network, it will be possible to measure each keystroke and mouse click that an employee produces, but this does not measure the quality of what is being produced.

  - It has been our experience that what can be counted will be counted—regardless of how accurate these measures may be of true performance (lines of code is a good example).

  - General System Theory has its foundations in the following:

- The Aristotelian dictum of the whole being more than its parts

- Bertalanffy's profound observation that: "...in order to understand an organized whole we must know both the parts, *and the relations between them.*" (our emphasis) [9]

- The need to know the relations between (and among) the parts of a system lead to the necessity for integration of these parts. Whether we start from the bottom or reach it as a result of downsizing is immaterial. The need to integrate IWSs will manifest itself in the "upsizing" (integration) to client/server (minicomputer) environments. (5)

- In addition, General System Theory tells us that *centralization*, in which a "leading part" develops, will also occur. The need to integrate what has been differentiated into "systems of higher order and organization" will manifest itself in the growth of a server(s) into a superserver(s). (6)

Therefore, we can conclude that differentiation and mechanization (downsizing) have the inevitable result of creating more complex systems that require integration and centralization (upsizing). That is the inherent paradox associated with both long-range architectural trends and organization theory: downsizing will lead to upsizing, and decentralization will lead to centralization—it is written in the stars.

This pulsating network architecture (and management philosophy) also makes it extremely difficult to determine how downsizing will impact performance/productivity at all four performance levels (see Exhibit V-1).

B

Downsizing and Performance Levels

The only purpose of applying computers to business systems is to either "save money" or "make money"—in other words, to either cut costs or to gain competitive advantage by providing better products and/or services. Sometimes the "save money" school prefers to talk in terms of improved productivity, but that does not obscure the fact that improved productivity means fewer workers.

In the factory environment, it is rather simple to measure productivity by counting the number of widgets produced per time period or per worker. When dealing with office workers the task becomes considerably more complex; especially since information technology, human beings and organizational structures interact in highly unpredictable ways. A number of years ago, INPUT adopted the four performance levels proposed by James H. Bair [10] for purposes of analyzing productivity in the office environment. These four performance levels—Computer/Communications Network, Human/Machine Dyad, Work Unit, and Institutional—are identified in Exhibit V-1.

It is obvious that when management invests in information technology (PL/1) some return on that investment is expected from improved productivity or performance at the other performance levels. During the 1980s, substantial investment was made in computer technology for offices with the following results:

- It has been impossible to identify any significant correlation between investment in information technology and improved white-collar productivity at either the human/machine dyad (PL/2) or work unit (PL/3) levels.

- It has been impossible to identify any significant correlation between investment in information technology and improved institutional performance (PL/4) as measured by the "bottom line."

- In addition, since many American business institutions appeared to lose competitive advantage during the 1980s despite investing heavily in information technology, some business executives and theorists are even suggesting that the investment in IT could have been more effectively applied elsewhere.

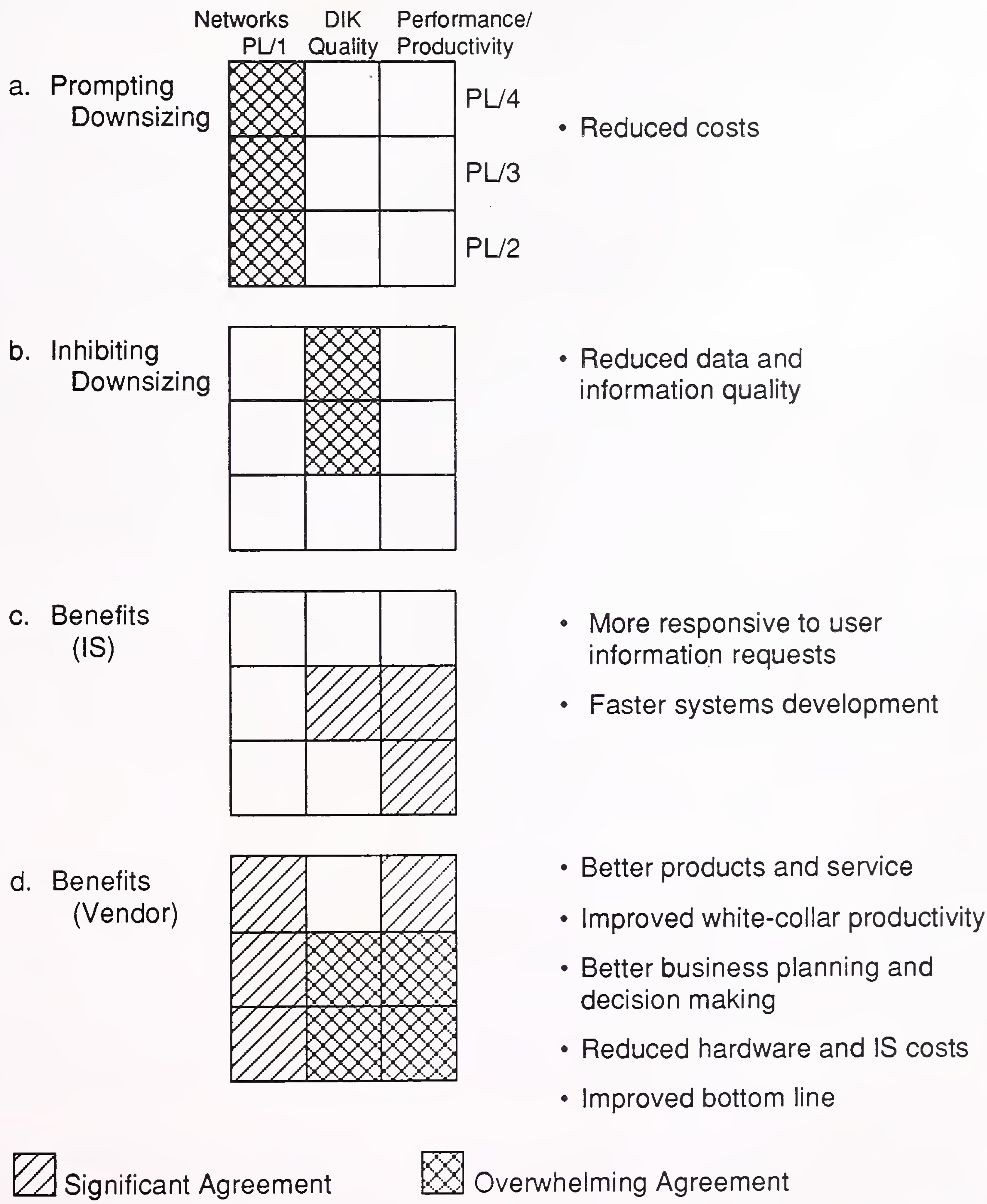
It is important to recognize these general environmental factors, which resulted from the experience of the 1980s, when trying to understand the trend toward downsizing during the 1990s.

1. Anticipated Benefits and Consequences of Downsizing

Exhibit V-2 uses the 3X3 matrix to graphically present the anticipated benefits and consequences of downsizing.

EXHIBIT V-2

The Benefits and Consequences of Downsizing (Performance/Productivity)



a. Factors Prompting Downsizing

Both IS management and vendors agreed that the primary factors prompting downsizing were "lower information systems costs" and "better price/performance of hardware" (see Exhibit V-2a). Both of these factors are obviously related to Performance Level/1, and they indicate a "save money" attitude on the part of management that may or may not be directly related to the experience of the 1980s.

- IS management rankings of relative importance dropped fairly sharply after these two factors, leaving cost savings alone as the most important reason for downsizing. It can be assumed that IS management's interest in cutting back (or controlling) investment in information systems is motivated, in no small part, by the attitude of corporate management. It can also be assumed that corporate management would not be interested in cutting back investment in information technology if it was felt that it could significantly improve productivity/performance at other levels.

- Vendors, while ranking "lower IS costs" as the most important factor, considered two additional factors more important than improved hardware price/performance even though that factor had a relative importance of 88%. The other two factors were "improved user service"—99%, and "user control"—95%. Both of these factors indicate dissatisfaction with the performance of the IS function as an organization, and indicate a management issue that is equally important to the technical issue.

In other words, there is the implication that the failure has not been in technology, but rather in the centralized IS function that has grown up around the mainframes. This is an important consideration that should not be ignored by IS management. However, there is something just a little perverse about this conclusion, and we shall examine that later.

b. Factors Inhibiting Downsizing

Both IS management and vendors agreed that the two most important factors inhibiting downsizing were "data quality problems" and the "cost of reprogramming." The former was clearly the top-ranked concern (see Exhibit V-2b). Though these potential problems of data base integrity, synchronization and security (that is the way the questionnaire was phrased) have not prevented IS management from pursuing downsizing in some form, these potential problems will determine how effective the downsizing effort will be in improving performance/productivity at other levels.

In other words, it is possible that cost savings at the IS and network performance levels could be more than offset by deterioration of data and information quality within the organization. The fact that both IS management and vendors agree on the importance of this factor in inhibiting downsizing does not mean that they are equally concerned about the severity of the potential consequences. For example, the attitude of the vendors could be that IS is creating a big problem about data quality because IS wants to inhibit downsizing.

It is important that the real nature of the data quality problem be understood when downsizing is being planned; discovering the data quality problems after downsizing could be disastrous. The importance of data quality varies considerably from organization to organization, and will be a major factor in determining the architecture of the resulting information system.

It should also be pointed out that deteriorating data and information quality inevitably has an adverse impact on both individual and organizational knowledge, and knowledge is key to institutional success.

c. Benefits Anticipated by IS Management

After being asked about specific downsizing efforts they (or their clients) had under way, respondents were asked what they anticipated the primary benefits would be. The questionnaire was designed to determine what percent of respondents agreed with certain benefits and consequences. "Significant" agreement is considered to be above 75%, and "overwhelming" agreement is above 85%.

IS management was not in "overwhelming" agreement that any of the benefits would occur as the result of downsizing, and did not "significantly" agree that IS or hardware costs would be reduced even though these were the primary factors prompting downsizing (see Exhibit V-2c). The only items on which they were in significant agreement were:

- Improved responsiveness to user information requirements
- Broader range of choices (products and services)
- Faster, easier systems development

None of these benefits or consequences can be directly related to improved performance/productivity at any of the performance levels. It is a passive response to an important question. One does not sense any enthusiasm on the part of IS management for downsizing.

d. Benefits Anticipated by Vendors

Even discounting the natural enthusiasm of vendors, their responses were in striking contrast to IS management's. In addition to endorsing the passive responses of IS management, vendors overwhelmingly supported specific statements concerned with improved performance/productivity at all performance levels (Exhibit V-2d). By a ratio of over 5 to 1, vendors are in agreement that the following benefits will result from downsizing:

- Improved process, product, service (PL/3)
- Improved white-collar productivity (PL/4)
- Better business planning and decisions (PL/3, PL/4)
- More effective use of information technology (PL/1)
- Improved responsiveness to user information requirements
- Broader range of choices (products and services)

In addition, there is significant agreement that the following additional benefits or consequences will result:

- Substantially reduced hardware costs (PL/1)
- Diminished role and expense of the central IS department (PL/1)

The fact is that INPUT's research shows agreement that there will be a radical change in information systems (and technology) architecture during the 1990s, but there seems to be little consensus among IS management and vendors as to what the benefits and consequences will be at the various performance levels of the organization.

C
The Innovation Process

Innovation has become a popular term lately; and it is difficult to argue with the fact that downsizing, as a predominant architectural trend of the 1990s, will play an increasingly important role in both the rate and nature of information systems innovation. However, the specific course that IS innovation will take is exceptionally complex and far from settled.

Before taking a look at the IS innovation process, a few profound observations about innovation from the past seem especially appropriate.[11]

> "An important scientific innovation rarely makes its way by gradually winning over and converting its opponents: it rarely happens that Saul becomes Paul. What does happen is that its opponents gradually die out and that the growing generation is familiarized with the idea from the beginning."
>
> Max Planck

> "The new always carries with it the sense of violation, of sacrilege. What is dead is sacred; what is new, that is, different, is evil, dangerous, or subversive."
>
> Henry Miller

> "A 'new thinker,' when studied closely, is merely a man who does not know what other people have thought."
>
> F.M. Colby

> "Sir, we must beware of needless innovation, especially when guided by logic."
>
> Sir Winston Churchill

The current advocates of downsizing would certainly agree with the wisdom of the first two quotations as they apply to mainframe-oriented, central IS departments. However, they might have some difficulty acknowledging the wisdom of the other two. Therefore, let us point out:

- There is little new thinking associated with the tools and architectural constructs of downsizing—even superficial study reveals that such concepts have been around for two decades or more. It is important to recognize and understand why mainframe applications have been so resistant to change; that deserves close study.

- Sir Winston's statement is more than a dictum of: "If it works, don't fix it." The wisdom comes in the qualifier of "...especially when guided by logic." It is "logical" to assume that more processing power, at a cheaper price, distributed directly to its point of use, will result in the most cost-effective application solutions. This is classic reductionist thinking, and it is wise to "beware" of such thinking before blindly pursuing unnecessary (and perhaps unworkable) innovations in network architecture.

With that said, let's take a look at the IS innovation process.

1. The Innovation Process Model

Innovation processes, from hybrid corn to diesel locomotives, have been an area of study for years. Everett M. Rogers produced a synthesis of more than 1,500 such studies and came up with the innovation process model presented in Exhibit V-3a. [12] It will serve as a starting point and general framework for our analysis of downsizing. Simply stated, practically all innovations proceed through the following stages:

1. There is need or problem identification, which prompts innovation.

2. Potential solutions for the need/problem are researched (both basic and applied). And, Rogers points out that most innovations researched have

been technological innovations, and these practically always contain both "material" (hardware) and "software" aspects.

3. There is a development stage where the actual innovation occurs in the form of a working prototype. Both research and development are characterized by uncertainty, and Rogers makes a point that is worth quoting:

> "If the adopter of an innovation is faced with a high degree of uncertainty, the inventor-developer of a new idea must cope with even greater uncertainty. The inventor-developer must understand not just his or her problems (as an innovation-adopter must do), but also the problems of various other individuals and organizations who will be the ultimate adopters of the innovation that he/she is creating."

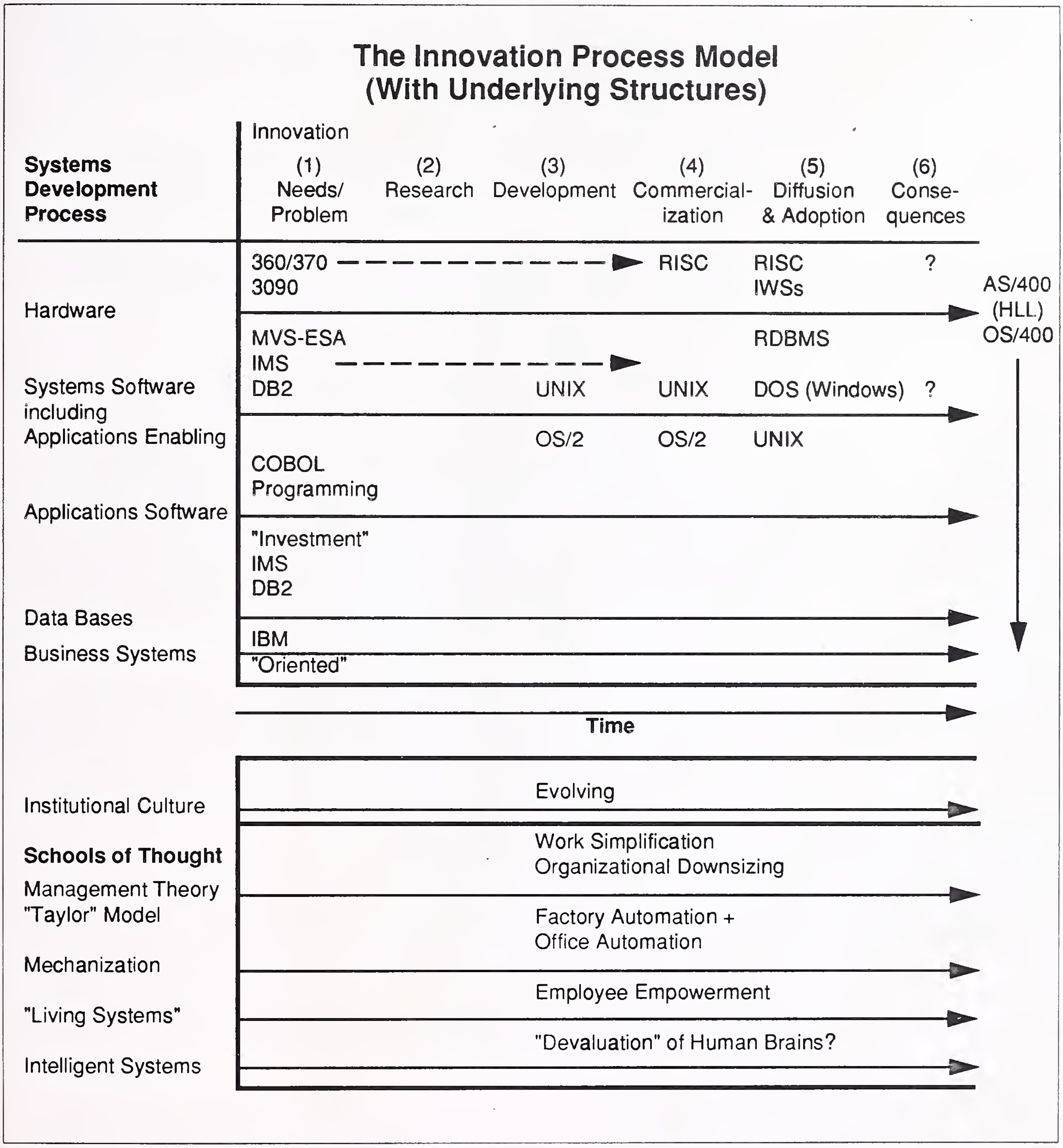
4. There is the commercialization of the innovation, which consists of the production, manufacturing, packaging, marketing and distribution of a product (or service) that embodies the innovation.

5. Then there is the diffusion and adoption process. The decision to diffuse an innovation extends back to the R&D processes; adoption can begin even before full commercialization (beta testing, for example). However, the decision to diffuse and the rate of adoption obviously span the commercialization process and are critical to its success.

6. The final phase of Rogers' innovation process model is the consequences of the innovation. The original need/problem may or may not be solved by the innovation; and the innovation may create new needs/ problems, which prompt a new innovation cycle.

All of this makes a lot of sense and works very well for mechanical tomato harvesters, but when we start tampering with existing business information systems (as downsizing does) we open up a virtual Pandora's box of underlying, interdependent, innovation cycles, starting with the IS development cycle itself, which adds another dimension to the Innovation Process Model (Exhibit V-3b).

EXHIBIT V-3


The Innovation Process Model
(With Underlying Structures)
Systems Development Process
Innovation
(1) Needs/ Problem
(2) Research
(3) Development
(4) Commercial-ization
(5) Diffusion & Adoption
(6) Conse-quences
Hardware
360/370
3090
RISC
RISC
IWSs
?
AS/400
(HLL)
OS/400
Systems Software including Applications Enabling
MVS-ESA
IMS
DB2
RDBMS
UNIX
UNIX
DOS (Windows)
?
OS/2
OS/2
UNIX
Applications Software
COBOL
Programming
Data Bases
"Investment"
IMS
DB2
Business Systems
IBM
"Oriented"
Time
Institutional Culture
Evolving
Schools of Thought
Management Theory "Taylor" Model
Work Simplification
Organizational Downsizing
Mechanization
Factory Automation +
Office Automation
"Living Systems"
Employee Empowerment
Intelligent Systems
"Devaluation" of Human Brains?

2. The Systems Development Process

Without going into a great deal of detail, let us present some well-known symptoms of the problems associated with the IS development process. These were summarized quite succinctly in a paper by Kalle Lyytinen published in *ACM Computing Surveys*. [13]

> "There are many indications that IS development is fraught with recurrent problems caused by poor, undisciplined, and incomplete development practices. According to a recent survey ...75 percent of all systems development undertaken was never completed or, if completed, not used. In a similar vein, ...the inordinate amount of total life-cycle costs (70%) spent on systems "maintenance" is a symptom of poor development practice...."

These problems with major IS development projects have been around for decades, and despite the expenditure of enormous human and machine resources they remain with us today. We have watched the magic solutions to improved productivity in the software systems development process fall short of the mark for over thirty years—COBOL, DBMSs, 4GLs, structured programming, methodologies, prototyping...they have all had their share of outrageous claims and failed to solve the fundamental problems identified by Lyytinen. Indeed, these fundamental problems are what have made the IS department vulnerable to attack for being unresponsive to user needs and problems.

It is the height of optimism, bordering on folly, to believe that the relational model, CASE, object-oriented programming and GUIs are going to fare any better when applied to major development projects of any complexity. In fact, the analysis, selection and integration of new tools, and the time required to make effective use of them, may further delay and complicate the development process.

It is also a fact that the journey from hardware innovation to adoption for real business applications can be a slow and tortuous one. One has only to track the continuing development of the PS/2 through operating systems, applications enabling tools, "real" applications, and data base development, down to the current integration and downsizing efforts, to realize that effective application of information technology can be a daunting task indeed.

However, since business systems are composed of both computers and human beings, there are additional complexities involved in the adoption and consequences of downsizing as it pertains to the overall business systems architecture.

3. Institutional Culture

Sociologists have long been familiar with problems of cultural lag. Something as simple as human resistance to the use of a keyboard (or mouse) and the preference for paper documents can slow adoption of new business systems. The Planck and Miller quotes above apply not only to the IS department's reaction to downsizing, but to the end users who are confronted with a substantial dose of "newness" as downsizing is implemented. However, downsizing does, in fact, seem to be changing institutional culture.

Organizations once prided themselves on the fact that executives answered their own phones. Now humans in the business world are spending more time "relating" to their computers than they are with other human beings, and it is now practically impossible to reach another human being on the telephone at the office.

On the other hand, downsizing will permit offices without walls—airlines are planning to install telephones and fax machines for business travelers, and with the physical downsizing of staff there may be fewer people, but they are working longer hours. Telecommuting is becoming increasingly popular (and accepted), because it is possible to buy a board with modem, voice mail, and fax for a few hundred dollars at your local computer store.

Downsizing has forced cultural changes in some businesses that would have been unthinkable only a few years ago. But, many of the basic business systems have remained essentially the same, and both employee and management thinking has not necessarily changed all that much.

4. Schools of Management Thought

There are various management schools of thought about the effective use of information technology, and these will determine how downsizing proceeds in the 1990s. These schools of thought will be used in the next section to analyze the potential impacts of downsizing on the human architectural structure of business systems—at Performance Levels II and III. They can be briefly characterized as follows [14]:

- The Management Theory School of Thought emphasizes "scientific" management as introduced by Frederick Taylor. It features emphasis upon work simplification and cost control that has characterized industrial engineering in the factory. Technological downsizing will facilitate the application of this school of thought to the office environment. This will permit the reduction of staff by increasing productivity of individual workers.

- The Mechanization School of Thought emphasizes the automation of processes using the tools of both operations research and industrial engineering. The routing and scheduling of work is automated wherever possible. Downsizing is a major step toward the cost-effective substitution of electronic for paper media in business processes—an innovation of major proportions in the office environment.

- The Living Systems School of Thought believes the empowerment of workers with information will result in increased productivity in terms of improved products and services. Such empowerment has been a consistent theme since the development of personal computers. Downsizing and improved access to corporate data are viewed as essential to stimulate the untapped creativity and potential of the work force.

- The Intelligent Systems School of Thought is based on Simon's concept of an "intelligent artifact" capable of performing many functions at, or beyond, the capability of human beings. This has been a highly controversial school of thought since the early days of computers, feared by many to result in the "devaluation of the human brain." Downsizing holds the promise of cost effectively exploring both the potential and limitations of artificial intelligence as a substitute for human knowledge and decision making.

Downsizing is an important architectural innovation for all of the schools of thought. However, the school of thought that predominates in giving impetus to current downsizing efforts is the Management Theory School. It emphasizes cost control of the investment in both information technology and information systems themselves (PL/1). Therefore, the initial measure of success of downsizing in most companies will be perceived reduced costs of information systems.

For that reason it is important to understand the cost factors associated with downsizing.

D

Cost Factors To Be Considered

Regardless of whether the stated objective of downsizing is to reduce IS costs, the fact remains that the emphasis upon hardware price/performance and the advantages of "open systems" imply that substantial cost benefits will result. And, as long as the focus remains on the central IS function, it may be possible to demonstrate cost savings. Downsizing to more cost-effective platforms should reduce mainframe workload (or, at the very least, control traditional growth). In addition, the decentralization of some IS responsibilities should lower central IS department budgets.

Unfortunately, there is currently little reason to believe that the total investment in information technology will decrease if the overall costs of downsizing are considered. This should be cause for concern regardless of what is prompting the downsizing effort.

For example, one organization that had already decentralized IS development and maintenance responsibilities, but continued to provide processing and data base services from a highly centralized, mainframe-oriented, data center decided to develop an "information architecture" for the 21st century. Based on its knowledge and experience with downsizing technologies (an extensive network of minicomputers and workstations is installed), IS management made two fundamental assumptions:

1. That the overall architecture would be built on the "client/server" model

2. That better applications development tools (including off-the-shelf applications) would be available, and used, in the client/server environment

The primary objective was not to save money, because this was a long-range plan. However, even for a long-range plan, the question of funding arose. It was a simple question of how do we get from where we are to where we want to be? A "cost and funding task force" was established which came up with a comprehensive framework for analyzing the relative costs of client/server technologies as compared to mainframe technology (see Exhibit V-4).

EXHIBIT V-4

Downsizing Cost Factors (Client/Server versus Mainframe)

Cost Factors	Data Center	Network	Application Custodian	End User
Application Support				
Development	neutral	neutral	minus	neutral
Maintenance	neutral	neutral	minus	neutral
Documentation	neutral	plus	neutral	neutral
Training	neutral	neutral	plus	neutral
Hardware				
LANs	neutral	neutral	neutral	plus
Workstations	neutral	neutral	neutral	plus
Servers	minus	neutral	neutral	neutral
Network Backbone	neutral	plus	neutral	neutral
Environmentals	minus	neutral	neutral	plus
Systems Support				
Data Quality	plus	plus	plus	neutral
Standards	minus	minus	minus	minus
Systems Software	plus	neutral	plus	neutral
Staffing				
Staffing Levels	neutral	plus	minus	minus
Local Expertise	neutral	neutral	neutral	plus
Transition Costs	plus	plus	plus	plus

The cost factors and organizational entities form a matrix that was used by the cost and funding task force to take a rough cut at determining whether costs would go up or down in specific cells. These results are presented for demonstration purposes only since they are relatively meaningless without detailed knowledge concerning the current information systems infrastructure. (While such detailed analysis is beyond the scope of this study, INPUT is in the process of preparing a set of case studies that will be published in a separate report, and this organization will be included in that report.) However, a few observations will be made in order to clarify the use of the matrix.

- The "Application Custodian" refers to the specific organization having responsibility for the development and maintenance of the applications. Although IS was decentralized several years ago, and analysts and programmers were transferred to user departments, there are certain applications that remain the responsibility of the central IS function (which is associated with the data center).

- The central mainframes are viewed as (super) servers for purposes of planning the information systems architecture, and it will be noticed that costs of Data Center "servers" and environmentals (space, air conditioning, power, etc.) are projected to decline.

- It should also be noted that costs of application development and maintenance are projected to decline based on the assumption of improved tools and packages programs.

- On the other hand, costs for systems software and maintaining data quality are projected to increase, partially because standards activities have been weakened by decentralization. (The subject organization had standardized on a specific central data base system, and with downsizing they will have new DBMSs to support.)

- The task force has not yet determined whether the net cost of moving to the client/server environment will be positive or negative on continuing operations, but it was observed that—for this particular organization—downsizing transition costs, alone, may be high enough to preclude any possibility of cost recovery over the life of the applications.

The problems associated with transition costs were described as being a "one-time cost extending over many years" during which "we will need to support and operate in a dual architecture environment, both mainframe and client/server..."

It appears that downsizing may not result in decreased costs at PL/1, and that funding from the downsizing effort may have to be justified based on the other performance levels (see Exhibits V-1 and V-2). This could require a substantial change of management mind-set in many organiza-

tions where concentration on the bottom-line and quarterly results seems to be the predominant management style.
In fact, it appears that downsizing may result in substantial one-time costs that can increase and extend over many years, and even more patient management may find this unpalatable.

When planning a significant information systems architectural innovation, it is important to minimize the risk of getting caught in the "dual architecture environment" for an extended period of time—especially when the cost advantages of the new architecture are questionable (or not easily quantifiable).

It appears to us that the risks associated with downsizing are most critical at the data base server (minicomputer) level, where competing solutions are at various stages of the innovation process and various levels of the systems development process. (Exhibit V-3.)

E

Downsizing Risk Analysis

The Innovation Process model (Exhibit V-3a) can be used to put downsizing in general perspective, and the underlying Systems Development model (Exhibit V-3b) can be helpful in evaluating the risk associated with major downsizing efforts.

1. The Needs/Problems Prompting Downsizing

The needs/problems giving impetus to downsizing are as follows:

- IBM's mainframe hardware architecture is old, tired and expensive in terms of price/performance. It was not designed to operate in a complex network environment, and it has evolved through several cycles of the innovation process—never quite catching up with customer networking requirements.

- IBM systems software and applications enabling subsystems (DBMSs) are complex and expensive in terms of both cost and systems overhead. This means that the mainline operating system and DBMSs cannot be "downsized" to more cost-effective platforms at the departmental (work unit) level. IBM systems software has been through even more innovation cycles than the hardware—slowly evolving to increasing levels of complexity which are beyond customer understanding and control. Enormous customer resources must be expended to trudge the unhappy, uphill road that is IBM systems software.

- Customers' investment in programming for IBM mainframes (predominantly COBOL) has resulted in applications that have been difficult to develop because of the complexity of the hardware/software platform, and expensive to maintain because of the constant struggle to remain current with the latest systems software. These (COBOL) application programs are expensive, inflexible, and unstructured. They also happen to be indispensable—a source of power, and a barrier to change, for the IS department.

- As if the systems software and applications programming investment weren't enough to tie the customer to IBM mainframes, customer data bases implemented using IMS are expensive, inflexible, and so structured that they bind the entire customer enterprise to their hierarchy in a deadly embrace. Relational data bases (using DB2), on the other hand, manage to give the customer a certain degree of freedom, but the ransom is extremely high, and the freedom is illusory—even in peer-to-peer relationships the peer that possesses the data is more equal than any requester.

- For all of the above reasons, most business systems are "IBM oriented"—minor satellites circling around the Big Blue Data Source.

This celestial architecture is comfortable for many IBM customers who feel secure in their orbits because of the reliability of the central data source. For others, the Big Blue Data Source is more like a black hole that swallows up resources without possibility of return. It is these IBM customers—frequently end users—who want "choices" and the freedom of controlling the data and information necessary to run their portion of the enterprise.

They are beginning to be heard, and they even managed to get IBM's attention. SAA was the direct result of IBM customers demanding that what goes up—data, computer size, IS expense—should at least have the possibility of coming down! SAA is now muddling through another innovation process cycle—not nearly fast enough for many IBM customers.

2. Where the Downsizing "Solutions" Stand

Though SAA may be proceeding with less than due speed toward the objective of permitting applications and data to seek their most cost-effective level over the IBM processing hierarchy, SAA does provide architectural goals and objectives that have been reasonably well stated. Other downsizing "solutions" leave open some rather serious questions at both the hardware and systems software levels of the systems development process (see Exhibit V-3).

- RISC technology as an alternative to CISC for commercial applications (or as distributed data base servers) has certainly reached the commercialization stage of the innovation process model, and the decision to diffuse this technology has obviously been made. However, despite everything you read in the press, this technology has not yet been adopted with any enthusiasm as a platform for downsizing major commercial applications, and INPUT's research indicates that IS management does not view this technology with nearly as much enthusiasm as do vendors.

- At the operating system level, UNIX is in much the same situation as RISC is at the hardware level. However, the situation with UNIX as a downsizing solution is even further complicated by the following facts:

  - It does not have proven functionality or robustness to replace mainframe operating systems.

  - It is still under development by any number of competing sources to make it an industrial-strength product in the commercial market, and it obviously has gone through the commercialization stage of the innovation process model to the accompaniment of more sound and fury than anything since COBOL. However, there is little substantive data indicating it is being adopted with any great enthusiasm by the rank and file of commercial users.

  - Proprietary systems from major computer vendors (DEC and HP as well as IBM) continue to sell well in the minicomputer market; DOS Windows currently controls the desktop; and, OS/2 EE may leapfrog UNIX for serious commercial applications.

- The point is that not enough RISC/UNIX systems have penetrated the current IBM-driven business systems market, so it is impossible to understand what the consequences of downsizing mainframe applications to such platforms would be—especially in terms of the downsizing cost model presented in Exhibit V-4.

In the meantime, while all of the sound and fury about RISC, UNIX and open systems has been going on, the AS/400—an HLL (higher-level language) system with a proprietary operating system—has been quietly taking over the midrange commercial market. During the research for this study, IBM announced the AS/400 E-Series, which extends down into the IWS price range and well up into the mainframe price range (prices range from a little over $10,000 to approximately $900,000). We have no intention of reviewing that announcement here, but we would like to make the following points about the AS/400, which most competitors (including those within IBM) either don't understand or choose to ignore:

- The statement was made that if IBM were to spin off the AS/400 as a separate company it would have revenue of nearly $15 billion per year, and would be the second largest computer company in the world (after its parent obviously).

- The AS/400 currently absorbs 11% of IBM's resources, and produces:
  - 29% of its revenue, and
  - 33% of its profit (we don't know how this applied to 1991)
- Fifteen percent of the AS/400s are being sold into accounts other than those that already have IBM System/3X or AS/400 equipment installed.
- It has been found that the AS/400 requires approximately one-fifth the staff (systems programmers, data base administrators, operations, etc.) that an IBM mainframe installation does to support a comparable size data base and number of users. (The actual numbers were for 400 users, the mainframe staff required was between 20 to 50, and the AS/400 requirements were from 4 to 10.)

In addition, the announcement contained the following hardware/software components that are especially pertinent to downsizing:

- IBM announced that a version of CICS would be made available on the AS/400. Current AS/400 users have neither the need nor the desire for CISC (verified by a show of hands in the audience). The only purpose would be to make it easier for IBM mainframe customers to write (or port) transaction processing applications from mainframes to AS/400s, and to facilitate cooperative processing among CICS/ESA, CICS/400 and CICS/OS2. (However, delivery for CICS/400 is about a year off.)
- A WORM (write once, read many) optical library is available on all but the smallest model (E02).
- The Turbo 3 1/2 Disk Unit for the low-end systems (read LAN servers) has extraordinary reliability (400,000 hours Mean Time Between Failures).
- In addition, it was announced that, though the OS/400 kernel would remain closed, IBM was now emphasizing "openness" around the kernel in order to:
  - "Enable IBM and non-IBM extensions" to OS/400
  - Permit "interoperability among heterogeneous systems"
  - Facilitate "portability"
  - Provide the following benefits for the AS/400 and its users:

- More tools and applications
- Industry standards compliance
- "Enterprise integration"

The AS/400 will be four years old this summer. It has been selling at a rate slightly over $1 billion a month in the business systems market. That means an installed base of about $50 billion. The AS/400 has already been through the innovation process and has been adopted with enthusiasm in the commercial market. The consequences are that its satisfied customer base continues to grow.

3. Downsizing Risk Report Card

Commercial users looking for a distributed data base server when they are downsizing (and INPUT obviously feels this is the key to successful downsizing) would seem to be presented with a "no-brainer" in selecting among the various competing platforms. They can either sort through a hodge-podge of relatively unproven hardware/software technologies and try to piece together a solution for themselves, or they can select a high-quality, proven product that can even be "gift-wrapped" as a Total System Package (TSP) including everything down to media such as blank tapes for backup and paper for the printer.

Exhibit V-5 is a "Risk Report Card" for rating competing hardware/software platforms as distributed data base servers when downsizing commercial applications. The "grades" are based on past performance, and only the AS/400 has taken "finals" and been fully accepted in the commercial (office) environment.

- Everyone, including Microsoft, recognizes that the inadequacies of DOS can't be hidden behind Windows; and Apple has thrown a $4 billion rock that could shatter even that fragile advantage on the client side of the client/server environment. DOS-Windows just doesn't pass muster as a distributed data base server. It was not rated on applications software, because much of the shrink-wrapped commercial applications (as opposed to tools) are of questionable value for implementing industrial-strength commercial applications.

- Neither UNIX nor RISC was developed with the commercial market in mind, and both are a step backwards from mainframe hardware/software technology. This platform was not graded on DBMS because the quality of DBMSs for this platform varies considerably and will be a primary factor in determining whether this platform passes its final commercial examination. However, even if it does pass, the operating system, the hardware technology, and the availability of commercial applications places it in a position of playing catch-up with a major front-runner.

EXHIBIT V-5

Risk Report Card
(As Distributed Data Server)

System Components	UNIX/RISC	DOS-Windows	OS/2 EE	OS/400
Hardware	C	C	C	A
Operating System				
Process	B	D	B	A
Memory Management	B	D	B	A
Data Protection/Security	D	D	C	B
Scheduling/Resource Management	C	D	B	A
Systems Structure	C	D	B	B
Technology	D	D	B	A
Data Base Management System	not graded	D	B	B
Connectivity	C+	D	C	A
Applications Enabling	C+	C	B	B
Applications (Commercial)	C+	not graded	not graded	A

- OS/2 EE is unproven and has been so slow out of the starting blocks that it is at a serious disadvantage as either a client or server. However, it has been architected to work closely with both MVS/ESA and OS/400 on the SAA side of the house. Though OS/2 EE promises to be better than UNIX as a distributed data base server, it falls far short of the AS/400 as a distributed data base server or as an applications engine in the downsized environment. OS/2 EE was not graded on commercial applications availability for the same reason that DOS-Windows wasn't—industrial-strength commercial applications are not readily available, and those that are available vary widely in quality.

- The AS/400 (OS/400) is vastly superior architecturally to either RISC (UNIX) or PS/2 (OS/2) as a distributed data base server and commercial applications engine. In addition, an extensive amount of proven applications software is available for the system, and it has an enormous installed base of satisfied customers. The primary impediment to its success as a downsizing platform is IBM's longstanding commitment to mainframe technology, SNA and customer hardware/software "growth."

The secondary impediment is the low profile of the AS/400 in the computer industry; practically everyone seems to believe that if it is just ignored it will go away. For example, the *San Francisco Chronicle* ran an article with the headline "IBM Takes Lead on New Memory Chip" which described the new memory technology being employed in newly announced AS/400 E-series, and never mentioned the AS/400 at all—much less the fact that it has continued to prosper through several miserable years for the U.S. economy.

However, one of the consequences of the success of the innovative architecture of the AS/400 is that it can no longer be ignored. With $50 billion worth of AS/400 technology out there it is going to make its presence felt—within IBM, among its competitors, and perhaps even in the press. It is somewhat like having an elephant in the living room: if you don't know it is there you probably won't trip over it, but you may get badly trampled.

Does the fact that the AS/400 has clear superiority as a distributed data base server mean that there is no place for its competitors? Of course not—there are applications (and portions of applications) that could benefit from both RISC technology and UNIX. In fact, IBM made a point that there was no reason a RISC engine could not be put under the covers of an AS/400 if it was needed in some applications (such as image processing).

RISC and UNIX have an important role to play in new applications and as old applications are re-engineered during the 1990s to incorporate artificial intelligence, complex algorithms of operations research, and new compute-intensive mathematics into commercial information systems. However, the degree to which such concepts are actually incorporated into business systems will depend upon major innovations in the "human architectures" associated with information systems—including changes in management mind-set.

The availability of OS/2 EE, vastly improved price/performance, improved user interfaces, and ready access to high-quality data promise to fulfill expectations of improved white-collar productivity as business application functions reach the desktop. Not only will the system be an excellent client in the client/server architecture, but it should be adequate as a server in small work units. The PS/2 and compatibles are the means of empowering employees, and they are absolutely essential to reaching the objectives of management initiatives in organizational downsizing, where span of control increases as management levels are eliminated.

VI

Organization and Management Implications of Downsizing

It is difficult to know whether downsizing is a phenomenon of technology-push or technology-pull. In other words, is the availability of technology pushing management toward new organizations and management concepts, or are new management concepts and organizations pulling technology toward new architectures? It is a moot point under the best of circumstances.

However, the observation of Shoshana Zuboff in her excellent book In the Age of the Smart Machine is not; here is what she had to say:

> "Technological developments, in the absence of organizational innovation, will be assimilated into the status quo." [15]

Ms. Zuboff is quite correct, and she goes on to describe a new type of workplace that centers around the "smart machine." Unfortunately, she uses the term "informated" to describe this new environment; but it is, nonetheless, an insightful description, and we shall use it later.

The trouble with the centralization of power that has accompanied mainframe computing and corporate data bases is not that the computer becomes the focal point of the organization, but that the concept of a Chief Information Officer (CIO) has tended to put the IS department in a hierarchical relationship with the rest of the organization and remove it from the mainstream of the enterprise. It makes little difference whether the computer "pushed" this centralization or was "pulled" along by the latest thinking of the nation's prestigious business schools that have prospered without let-up since the end of World War II. Centralized planning and control, and computers, have formed an unholy alliance that is currently under attack from both advanced technological developments and management theory.

Highly centralized information systems result in several problems one of which has been described as the "chimney problem."

A

The "Chimney Problem"

Ford Motor Company described its organizational structure as consisting of tall chimneys with the only outlet for information flow and problem resolution being at the top (Exhibit VI-1). When Ford nearly went bankrupt in the early 1980s, it was forced to make far-reaching management changes throughout the organization; this set of initiatives has been labeled "chimney breaking."

Regardless of terminology, deep hierarchical organization structures, upward information flow to feed corporate data bases, and rigid financial controls exercised through computerized business plans were beginning to cause serious problems for American business in the early 1980s—just at the time when personal computers were starting to appear on desktops.

- Users saw themselves supplying endless reports and data to corporate management; and receiving, in return, more requests for data interspersed with budgets and "plans."

- The control mentality of corporate management trickled down to lower level management, and peer-to-peer professional contact was practically unheard of in a continuing game of one-upmanship across organizational lines and between organizational layers.

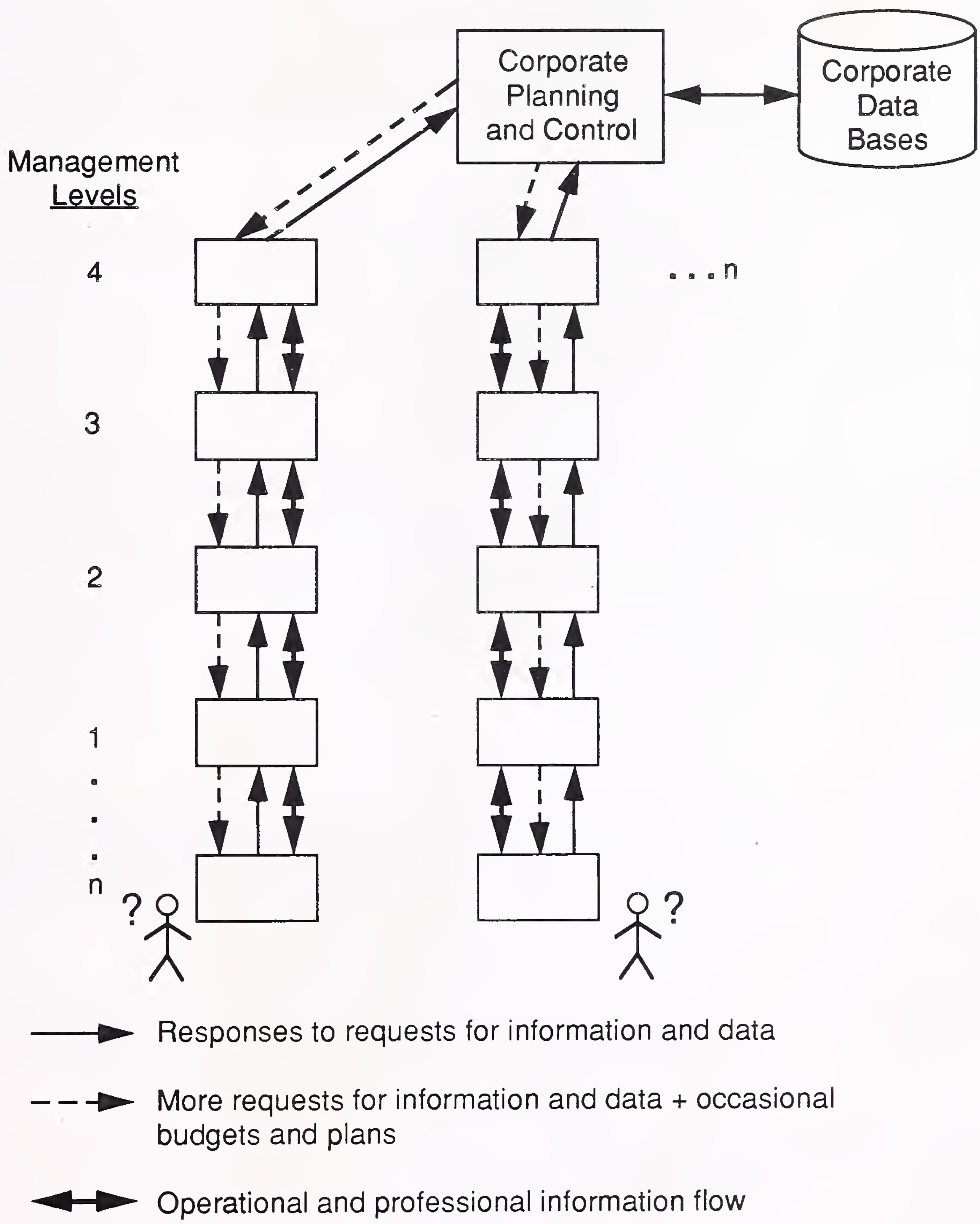
- Design, engineering, manufacturing and customer service personnel hardly talked to each other at Ford except at the highest levels. Everyone kept feeding data into the "system," but each level felt that nothing of value ever came back except tighter controls and rejection of anything new.

- This attitude was not peculiar to Ford—the same chafing under corporate control and planning was expressed at GE, which had been dominated by a financial elite and where auditors were the "elite of the elite."

Both Ford and GE transformed themselves in the 1980s.

EXHIBIT VI-1

The "Chimney Problem"



B

The Ford Transformation

Ford fought its way back from the brink of bankruptcy under the leadership of Donald Peterson, who managed to elicit the support of all employees by placing quality above cost and breaking down the chimneys. In the interest of quality, a worker could stop the line; and a UAW representive actually presented a union jacket to Peterson when he visited a plant. Ford still doesn't know exactly how it accomplished its transformation—it was so desperate that initiatives occurred at six distinct levels in the organization and proceeded in parallel and were not documented as they occurred. However, it is certain that the corporate financial reins were loosened, and Ford started making innovations that would have been unthinkable in better times. Among the initiatives were:

1. Strategic Repositioning

- The product line was repositioned in 1980 when the Detroit Design Center was assured that new corporate management would be receptive to new ideas. The key product was Taurus (which was viewed as the biggest gamble since Edsall), and the plan proceeded despite the fact that in 1982 Ford's cash reserves dropped to 45 days.
- Quality was established as the number-one priority for the company in 1981.

2. Employee Involvement

- Beginning with quality circles, employee involvement (including regular meetings with assembly line employees) was extended throughout the company in the early 1980s, and resulted in the replacement of several senior management personnel who just couldn't adjust to the changes taking place.
- Profit sharing was initiated with the UAW in 1983, and an employee education fund was financed through a 5-cent-per-hour-worked contribution by the company. (So many good ideas were developed that the employee involvement system became overloaded.)
- By the mid-1980s, employee involvement was described as "a way of life" at Ford.

3. Synchronization of the Organization

- During 1983 a "Change Task Force" audited Ford as a "system" and identified the "disconnects." Then 100 workshops were conducted worldwide to address these disconnects.

- By 1984 "less onerous" financial systems had been developed and the functions decentralized; shortly thereafter, the budgeting system was applied in a more discretionary fashion.

- By 1987, new performance appraisals included a bonus system that weighted "teamwork" at 33%.

4. Team Taurus

- The Taurus prototype was the basis for strategic repositioning. Ford made a decision to invest $3.5 billion during 1980-85 despite enormous losses during the years from 1979 through 1981.

- Team Taurus was created, and in late 1981, it was directed to redesign because of lower fuel prices. In the old "chimney environment" this would have resulted in starting all over and going through all of the internal political wrangling across organizational lines. Team Taurus was able to take it in stride and maintain momentum.

- Input from hourly workers, insurance companies and repair shops was fed into the development process during 1982. (Customer inputs were obtained during the design phase.)

- Taurus was introduced on schedule and under budget in 1986 despite the redesign (which had been dictated from above), and 80% of the key components met or exceeded "best in class."

5. Chimney Breaking

- In 1981, Ford started to focus on "conflict management" across functional lines, and started to conduct training sessions.

- A "Blue Ribbon Committee" of executives—which cut across the chimneys—was formed, which was literally sequestered until the members came up with a plan for how they could work together. (It later evolved into an ad hoc committee to address specific issues, and resulted in task groups to resolve problems at the engineering/manufacturing interface and in the design approval process.)

- The management style that developed from breaking down the chimneys was one of contention management—letting the problems surface at the working level and providing a means of resolution.

- By 1986 an "aggressive plan" to rotate managers across functional disciplines had been developed, and executive "re-education" became the watchword.

- By 1987 the various committees and task forces had evolved into a "Concept to Customer Committee"—and that is how the chimneys crumbled.

6. Vision and Values

- In 1979, Ford was rated worst in quality and styling in the auto industry. In the early 1980s, based on the strategic redirection toward quality (and in the middle of some very bad financial results), Ford closed an entire plant (Mahwah, N.J.) because of quality problems—establishing proof of commitment to quality and a change of values for the company.

- By 1981, white-collar "chimney breaking" activities and the employee involvement program were generating confusion about corporate values. The old "rules" no longer applied—Ford was at the beginning of a cultural revolution.

- In 1982 and 1983, Donald Peterson worked on Ford policy and how to articulate the company's new values, and Henry Ford II presented the Mission, Values and Guiding Principles of the company at a public meeting. The values, simply stated were:

  - People—Our people are the source of our strength. They provide our corporate intelligence and determine our reputation and vitality. Involvement and teamwork are our core human values.

  - Products—Our products are the end result of our efforts, and they should be the best in serving customers worldwide. As our products are viewed, so are we viewed.

  - Profits—Profits are the ultimate measure of how efficiently we provide customers with the best products for their needs. Profits are required to survive and grow.

- By 1986, Peterson had added "Continuous Learning" as a value—a step that was obviously necessary to support the original three values.

INPUT suggests that downsizing is a major innovation that is taking place during critical times for many business enterprises, and that one of the major purposes is to break down the walls between the IS function and operating departments. There are many lessons to be learned from Ford's experience that can be applied directly to current downsizing efforts.

C
The GE Transformation

Unlike Ford, GE accomplished its transformation primarily through the sheer will of Jack Welch, who had successfully managed several GE business units despite the burdensome financial controls. When he became CEO, he cut the corporate staff back drastically. Here is what he has to say about organization:

"We took out management layers. Layers hide weaknesses. Layers mask mediocrity. I firmly believe that an overburdened, overstretched executive is the best executive because he or she doesn't have the time to meddle, to deal in trivia, to bother people. Remember the theory that a manager should have no more than six or seven direct reports? I say the right number is closer to ten or fifteen. This way you have no choice but to let people flex their muscles, let them grow and mature. With ten or fifteen reports, a leader can focus only on the big important issues, not on minutiae.

"We also reduced the corporate staff. Headquarters can be the bane of corporate America. It can strangle, choke, delay, and create insecurity.... We don't need the questioners and the checkers, the nitpickers who bog down the process, people whose only role is to second guess and kibitz, the people who clog communication inside the company. This is a mind-set change: staff essentially reports to the field rather than the other way around." [16]

It is INPUT's belief that Jack Welch's attitude is prevalent in American business today, and that the problems Welch deplored existed before the current recession. Centralized planning and control, organizational "chimneys" and layers of management that stifle the free flow of information are seen as the "problem." To the degree that the central IS function is associated with the corporate hierarchy, it has been designated as part of the problem. In fact, since the term "information" has been bandied about so freely, and IS hasn't been responsive to end-user demands for information, the IS department may be burdened with the lion's share of the responsibility for the communication problems.

At any rate, there is downsizing going on in corporate America that has little to do with the availability of more MIPS on a chip. The impact on the role of the IS department is already beginning to be felt. A recent issue of *Computerworld* had an article titled: "When The CIO Becomes Expendable." It lists four companies in which IS "chiefs" (CIOs) have been downgraded from the Vice President level to Director or Manager. [17]

With that in mind, let's return to Dr. Zuboff and her observations concerning the management and organization changes that may occur in "the age of the smart machine."

D

Concentric Ring Management and Organization

Though we deplore some of Dr. Zuboff's terminology, her conclusions are based on actual case studies (she teaches at Harvard Business School) and they are extremely perceptive of some of the changes that are going on "beyond the screen" of technology. Her book was selected as one of the

10 Best Business Books in 1988 by Business Week. It provides some important insights into both management and organization in the "informated" organization, and also defines the future role of what we now call the IS department.

Dr. Zuboff believes that organization in the "informated" business enterprise can best be pictured as a set of concentric circles rather than as classic lines and boxes. This alone can be enough to startle an IS professional who has been dealing with classic flow charts and the hierarchical data model, or a corporate controller who is concerned with establishing an audit trail and tight cost controls. Here is how Dr. Zuboff describes it:

> "As the intellective skill base becomes the organization's most precious resource, managerial roles must function to enhance its quality. Members can be thought of as being arrayed in concentric circles around a central core, which is the electronic data base. The skills required by those at the core do not differ in kind from those required at a greater distance from the core. Instead of striking phenomenological differences in the work that people do, the distance of any given role from the center denotes the range and comprehensiveness of responsibilities, the time frame of those responsibilities, and the degree of accountability for cross-functional integration attached to the role. The data base may be accessed from any ring in the circle, though data can be formatted and analyzed in ways that are most appropriate to the information needs of any particular ring of responsibility."

We interpret the "intellective skill base" to be the combination of information and knowledge that has been captured in the electronic data base, and the unique and uncaptured knowledge of the humans at the human/machine dyad.

The rings around the core (Exhibit VI-2) can be described as follows:

1. Closest to the core are the workers who work directly with "information" (data) on a real-time basis. They are the daily production workers (at all levels) who input, organize and administer the central electronic data base. Zuboff states: "Because intellective skill is relevant to the work of each ring of responsibility, the skills of those who manage daily operations form an appropriate basis for their progression into roles with more comprehensive responsibilities." The operator at the human/machine dyad is considered a "manager" of the core data base.

2. The next ring of management responsibility is concerned with "intellective skill development." This implies both "high-order analysis and conceptualization, as well as in promoting learning and skill development among those with operational responsibilities." This goes beyond the classic training function, and can be viewed as knowledge base manage-

ment. It looks "beyond the screen" to promote not only an improved data base interaction, but an improved distributed knowledge base among the humans at the human/machine dyad. Zuboff puts it this way: "In this domain, managers are responsible for task-related learning, for learning about learning, and for educating others in each of the other three domains."

3. Beyond the intellective skill development ring is the "technology development" ring, which will sound familiar to those in IS departments. Zuboff states: "This managerial domain of technology-related activity comprises a hierarchy of responsibilities in addition to those tasks normally associated with systems engineering, development, and maintenance. It includes maintaining the reliability of the data base while improving its breadth and quality, developing approaches to system design that support an informating strategy, and scanning technical innovations that can lead to new informating opportunities. Members with the responsibility for the development of technology must be concerned with the use of technology...Technology develops as a reflection of the informating strategy and provides the material infrastructure of the learning environment."

4. The "learning environment" created, maintained and extended by the inner rings of the organization support "strategy formulation" and "social system development" rings. At this point, it becomes clear that what Zuboff is describing is the "Living System" School of Thought. Here is what she has to say:

> "For an organization to pursue an informating strategy, it must maximize its own ability to learn and explore the implications of that learning for its long-range plans with respect to markets, product development, new sources of comparative advantage, et cetera. A division of learning that supports an informating strategy results in a distribution of knowledge and authority that enables a wide range of members to contribute to these activities. Still, some members will need to guide and coordinate learning efforts in order to lead an assessment of strategic alternatives and to focus organizational intelligence in areas of strategic value. These managers lead the organization in a way that allows members to participate in defining purpose and in supporting the direction of long-range planning."

It is obvious that the "Living System" envisioned by Zuboff breaks down the conventional hierarchical model of management, and that the creation of a learning environment (organization) that empowers all employees provides for both horizontal and vertical organizational integration—without clear lines between the concentric circles.

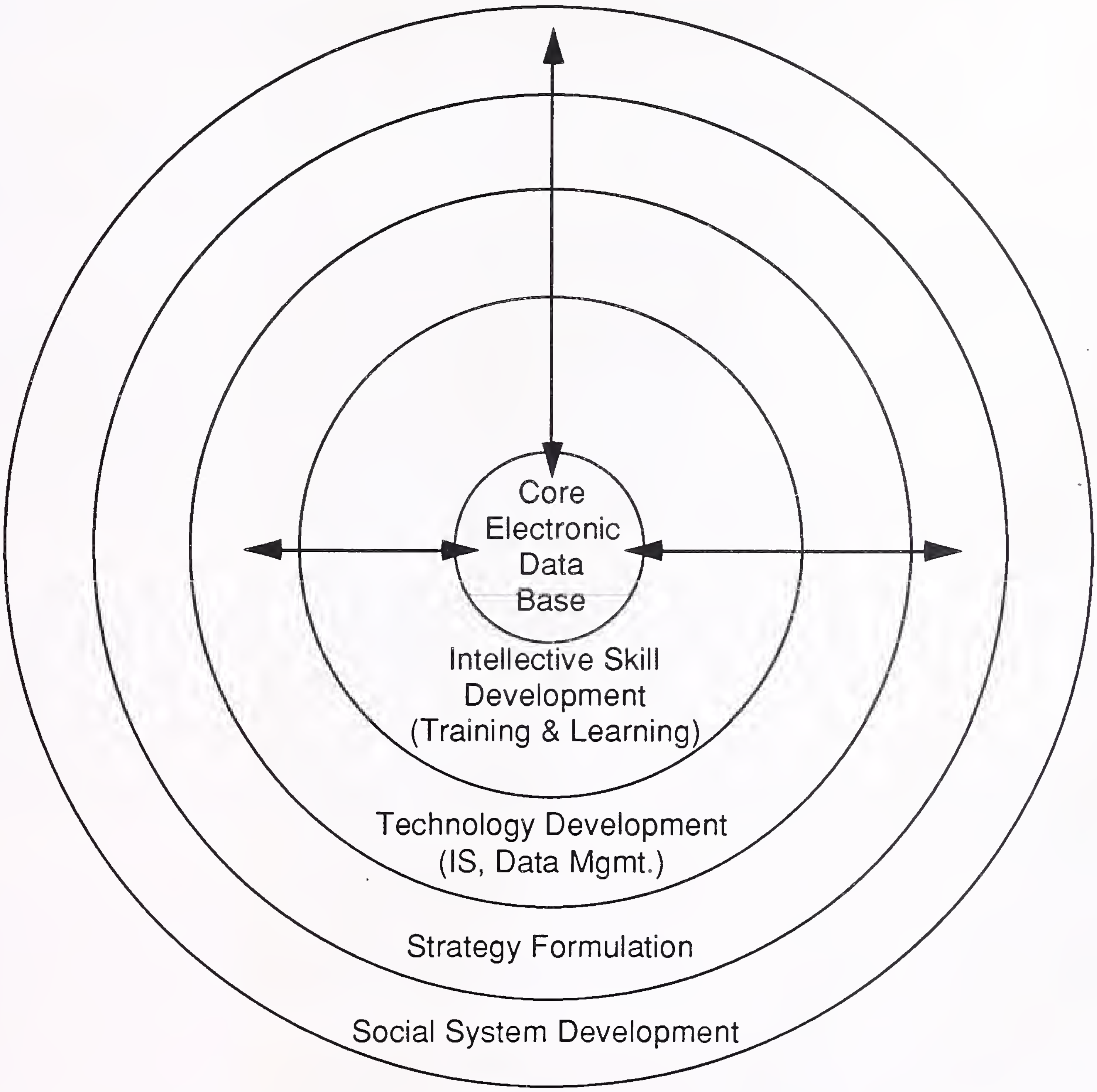
It seems obvious that the Ford transformation during the 1980s headed toward the Zuboff concept of concentric rings of management. The statement of values issued by Petersen and Henry Ford II late in the 1980s is a very clear example of the outer ring of "social system development." While it is probable that Zuboff was well aware of Ford's experience, it does not appear that Ford was one of the case-study companies upon which she based her book.

Zuboff's contribution is in placing the central data base at the core of the organization, and in depicting the fluid management structure as one of concentric circles rather than as a hierarchical structure or even a matrix. See Exhibit VI-2.

The implied flexibility of such an organization and management style does not lend itself to either highly structured data bases or slow response times from central IS to effect what appear to be modest changes in direction. For example, imagine the furor at Ford if the great ideas formulated through Employee Involvement could not be processed or implemented because information was not available, or Team Taurus could not be formed because the hierarchical data base could not be changed to account for it.

EXHIBIT VI-2

The Shape of the Future? ("Intellective" Skill Base)



E

Downsizing and the "Intellective" Skill Base

The core of the "intellective" skill base is assumed to be a reliable electronic data base (including all of the data types previously mentioned), and its importance to the new management directions cannot be overstated.

It matters not whether this is the infamous corporate data base that users are demanding access to for purposes of "strategy formulation" or "social system development" or whether it is the network distributed data base that appears to be the inevitable result of these demands. The data base must have integrity, and be secure against intrusion (or sabotage) if it is to be the core of the "intellective" skill base.

As we have so carefully pointed out during the course of our analysis of downsizing, there are problems of distributed data base management inherent in downsizing that have not been solved by any vendor or set of vendors. Where downsizing is proceeding without awareness of (or sensitivity to) these problems, systems integrators are left with the daunting task of scheduling inventions to mitigate the consequences of management demands for quality data and information.

Whether the management mind-set prompting downsizing is cost reduction through the elimination of management layers or establishing a learning environment on the road to the "informated organization," there are going to be substantial demands made on the "technology development" ring of the concentric management structure. That is true regardless of whether the CIO is demoted to manager, or whether those responsible for "strategy formulation" must spend a substantial portion of their time on technology development.

The dispersing of the central IS function out into the rings of the new organization could have the effect of being an excellent learning experience, or it could lead to some unfortunate consequences. For example, the organization that developed the cost model in Exhibit V-4 decentralized the IS function a number of years ago, and user departments are finding that "their IS employees" have considerably less time to devote to development activities because they are directly exposed to ad hoc reporting requests and consulting assignments with end users.

The impacts of both technological and management downsizing on IS departments, user departments and vendors are highly unpredictable.

VII

The Challenges and Opportunities of Downsizing

In this section, we will explore briefly the challenges and opportunities that downsizing presents for corporate executives, IS management, IS users and IS vendors. We will start with a challenge attributed to the late Konosuke Matsushita (founder of Matsushita Electric, Ltd.) by Richard Tanner Pascale in his excellent book Managing on the Edge [16]:

> "We are going to win and the industrial West is going to lose out; there's not much you can do about it because the reasons for your failure are within yourselves. Your firms are built on the Taylor model. Even worse, so are your heads. With your bosses doing the thinking while the workers wield the screwdrivers, you're convinced deep down that this is the right way to run a business. For you the essence of management is getting the ideas out of the heads of the bosses and into the hands of labor.
>
> We are beyond your mindset. Business, we know, is now so complex and difficult, the survival of firms so hazardous in an environment increasingly unpredictable, competitive and fraught with danger, that their continued existence depends on the day-to-day mobilization of every ounce of intelligence."

The "Taylor model" Matsushita referred to is based on Taylor's expressed opinion, over sixty years ago, that:

> "Hardly a competent workman can be found who does not devote a considerable amount of time to studying just how slowly he can work and still convince his employer that he is going at a good pace. Under our system (Scientific Management) a worker is told just what he is to do and how he is to do it. Any improvement he makes upon the orders given him is fatal to his success." [18]

We do not intend to argue whether or not Matsushita is correct in his analysis of the mind-set of the industrial West (much less get embroiled in current controversies concerning worker quality and executive compensation). However, we will say that technological downsizing supports both the Matsushita and the Taylor management philosophies.

- Microprocessor technology can *theoretically* provide workers with ready access to information, encourage active participation in knowledge-based systems, and create an environment of continuous learning. Each employee can contribute and be recognized and rewarded on the basis of individual merit by an objective, and perhaps even sympathetic, "system" that rewards performance and learning without regard to race, sex, age, national origin, educational credentials, personal appearance, physical handicaps, political orientation, family connections, or position in any remaining organizational hierarchy.

- Or, on the other hand, the "easy to use" personal computer, complete with GUI, can be used to tell the worker what to do in the simplest possible terms, monitor exactly how he/she is doing it, and tolerate no deviation from prescribed procedures. In fact, notebook computers, cellular phones and beepers (two way) can be used to track and monitor employees outside the office and even into their homes. Downsizing carried to extremes can mean system architectures that serve as electronic chains to bind workers to their employers 24 hours a day, every day, until they have been sucked dry of all their physical and mental energy. At which time, their electronic personnel folders can be "dragged" over to the garbage can icon. (A scenario beyond the dreams of either Frederick Taylor or George Orwell.)

These best and worst of all possible world scenarios have been around since the early days of computing. No one said it any earlier or any better than Norbert Wiener as he worried about the relationship at the human/machine dyad in the early days of computers.

> "This new development has unbounded possibilities for good and for evil...The first industrial revolution, the revolution of the 'dark satanic mills,' was the devaluation of the human arm by the competition of machinery...The modern industrial revolution is similarly bound to devalue the human brain at least in its simpler and more routine decisions." [19]

Wiener's concern was not restricted to fear of management mind-set and intent; it also focused on the inadvertent loss of control: "By the very slowness of our human actions, effective control of our machines may be nullified...." [19]

While the technical challenge of getting heterogeneous computer systems to talk with each other occupies a great deal of our attention in the downsizing environment, the human side provides even more of a challenge. Here is the type of finger-snapping advice that is being given to business organizations by the financial community (in this case a Silicon Valley venture capitalist).

> "The virtual corporation will eliminate middle management and replace it with trained workers operating computers to provide information links and help make decisions." [20]

It is doubtful whether the venture capitalist either understands or cares about problems of distributed data base management, decision support systems, management mind-sets, "informated" organizations, or the long tortuous history of artificial intelligence—much less Norbert Wiener's concerns about "devaluing the human brain." He has a vision of "virtual corporations" that can produce an infinite variety of custom products to meet fluctuating demands and competition all around the global village.

Those associated with the computer industry have consistently overrated the benefits of technology, underestimated difficulties of implementation, and failed to consider the possible adverse consequences of new technology. To visualize the architecture of a virtual corporation is one thing, but to build virtual corporations without regard for the realities of technological and human capabilities and limitations would be the height of folly.

The primary challenge of the 1990s—for everyone—is to assure that a proper balance is achieved (or maintained) between the human and machine sides of the information systems architecture. This requires an objective and realistic appraisal of the capabilities of both technology and human beings. Those who are not capable of understanding and evaluating both sides of the architectural equation will not be able to take advantage of the potential opportunities afforded by downsizing, and they may be subject to disastrous consequences.

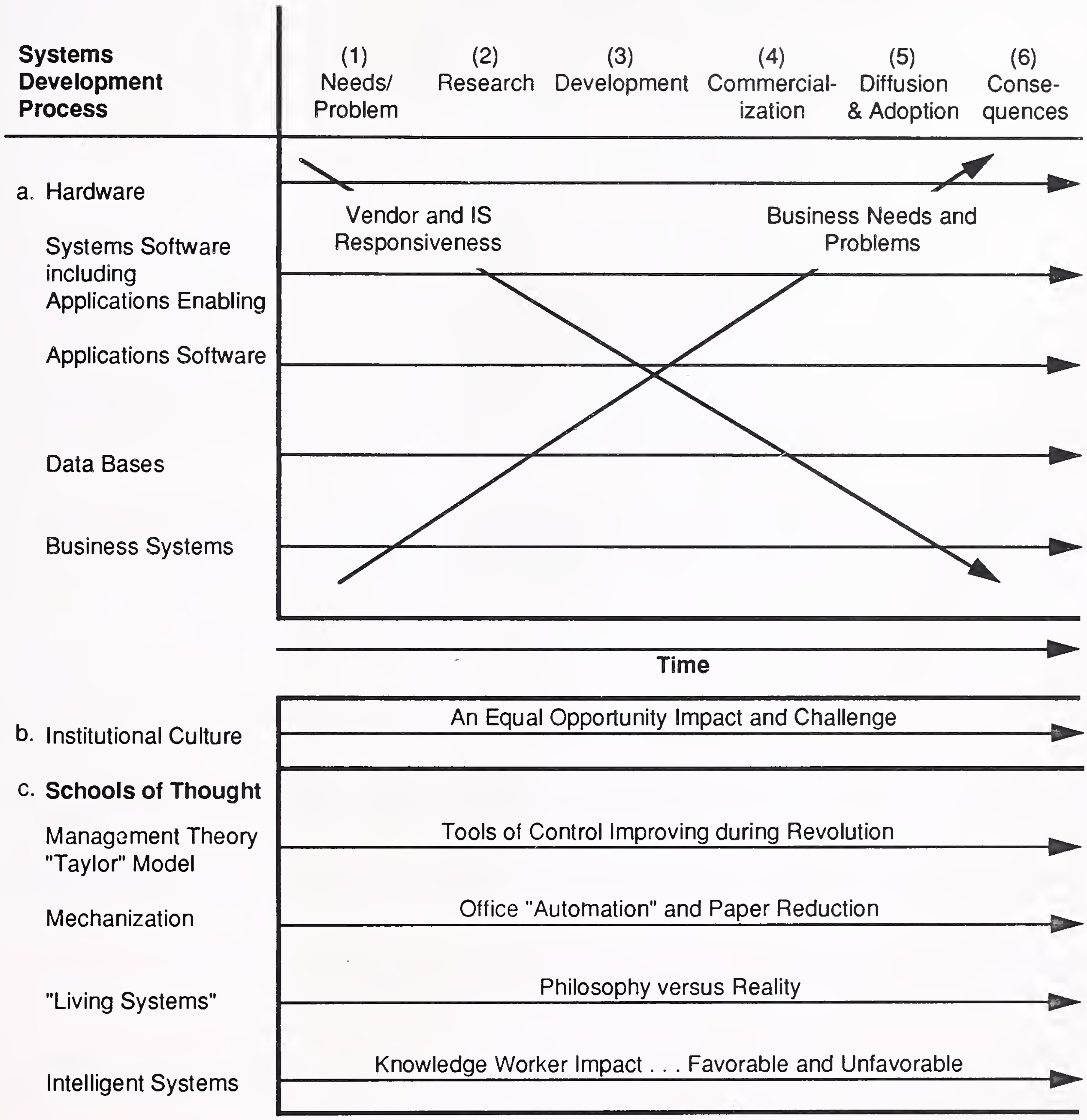
The general challenge and opportunity of the 1990s is depicted in Exhibit VII-1a. The challenge, simply stated, is to realize the benefits of new technology in the workplace before business needs/problems change and before the technology itself becomes obsolete and causes adverse consequences. Opportunities exist for anyone (or everyone) who can make effective use of available technology that is already in the business environment—not after the next release of the operating system or after the distributed data base problem has been solved, but today—right now!

Underlying this relatively understandable (if not simple) challenge and opportunity are the human considerations that will determine not only how effective the application of new technology will be, but the definition of effectiveness itself. This will depend on the culture of the organization and the changes that are either causing, or will result from, downsizing. As we have already pointed out, downsizing is an equal opportunity impact and challenge in that it will affect the institutional culture at all levels (Exhibit VII-1b). This has been amply demonstrated by the general experience at Ford during the 1980s, and by the recent demise of the CIOs in some organizations.

Giving direction to the cultural changes is the responsibility of management, and the mind-set of individual managers will be more important than the organizational structure in which they operate or the type of business they are engaged in. These management mind-sets are represented by the various schools of thought, previously defined, and shown in Exhibit VII-1c. These schools of thought will be referred to as examples of the management challenges and opportunities facing corporate executives, IS, users and vendors.

EXHIBIT VII-1

Management, IS, User and Vendor Challenges and Opportunities



A
Corporate Executives

The personal computer revolution was born out of the troubled times of the 1960s and among its initial objectives was the stated intent to distribute computer power to the people and overthrow the establishment. The fact that the technology, and many of the early PC pioneers, have been integrated into the establishment makes no difference. Information is now viewed as power, and all indications are that downsizing is as much a result of a power struggle as it is a technological phenomenon.

Corporate executives are being promised cost savings and increased flexibility through the distribution of processing power and data to the working level. On the other hand, they are being threatened with loss of control. Their experience tells them that investment in information technology has neither improved white-collar productivity nor improved bottom-line performance. However, many of them are now too young to recognize that many of the promises being made for the new technology are practically identical to the promises of the giant "electronic brains" of thirty years ago.

The challenge for corporate executives is to steer a course between overrating and undervaluing technology. This requires the ability to pose intelligent questions about certain fundamental issues such as:

- What is the value associated with corporate data bases?
- What did the "investment" in COBOL programming buy the organization and what is the value of that investment now?
- How have corporate information systems improved our competitive position in the market, and how will downsizing impact these systems?
- Will downsizing improve the ability to reach out and take advantage of the organization's human resources, or will it "devalue" human brains?
- What can computers do better than people in our organization and what can people do better than computers?
- What are the limitations of mathematics in using all of these accumulated data, and what are the limitations of computers in processing these data?
- Is there really a danger that we will lose control of computers because humans cannot possibly keep up with the speed of communication and the volume of information?

- Who is right among all of the intelligent human beings who can't agree among themselves about the potential and impact of artificial intelligence?

- What are the probable long-range social and general economic impacts of all these new technologies?

- Will downsizing permit us to attract and hold better quality people, or will it drive them away?

- Do we run the risk of getting in a deadly embrace of technology for technology's sake?

- Are we really considering all of the costs of downsizing?

- Will downsizing really give the organization more flexibility or will there be no turning back once we start in that direction regardless of consequences?

- How much trust do I personally have in the information provided by the computer network when I make a query?

- Who will be responsible for the quality of information I receive when data bases are distributed and middle management is "eliminated"?

- If no computer and no human can answer questions like these for me, what do I do?

- If my computer can answer questions like these for me, why do I need any humans?

- How would I feel about depending more on computers than I do on human beings?

- If my computer can ever answer questions like these for me, am I needed?

All humans, even corporate executives, must look behind the screen, at the screen, beyond the screen and then within themselves when determining their role in the emerging technological environment.

Corporate executives, while they will function primarily in the two outer rings (Strategy Formulation and Social System Development) of Zuboff's concentric circles of responsibility, will also have to understand and work directly with the inner rings (Technology Development and Intellective Skill Development) and interface personally with the core electronic data base. Depending upon the accuracy of Zuboff's observations, that is what life will be like "in the age of the smart machine"—and downsizing is pointing us in that direction.

Some corporate executives will find this extremely challenging to their capabilities and mind-set; others will consider it a wonderful opportunity for self-fulfillment and corporate transformation.

B IS Management

Downsizing is placing IS management in an unenviable position. Perceived IS failures, expense and unresponsiveness all helped weaken the position of corporate planning, and the corporate controller used IS to exercise the tight fiscal controls that are now being blamed for the weakened competitive position of U.S. corporations in global markets. Now IS is responsible for making downsizing work. The IS department will receive little credit if downsizing is successful, but all of the blame if it fails.

We have mentioned the fact that some CIOs are already beginning to "downsize" themselves out of a job. A more likely scenario is as follows:

- The easy applications will be downsized and turned over to end users who will remain dependent upon the IS function as their primary source of data.

- Visible use of mainframe services (report generation) will decrease much more rapidly than the costs of maintaining central data bases. Budgeting (or cost recovery) for the central IS department will come under increasing pressure from operating departments that now have their own IS expenses and want to cut back their expenses for central services.

- Some IS personnel, who feel bigger is better, will be disappointed that growth possibilities are becoming limited. It is much easier to find "managers" who can manage in a growth environment than it is to find those who can manage when times get tough. Finding and keeping good IS personnel in this environment will be a challenge.

- Network complexity will grow much more rapidly than the capability of the central IS function's ability to handle it, and it will be necessary to seek outside assistance in systems integration efforts.

- It will be found that many COBOL programmers (and data base administration personnel) have become glorified clerks with weak qualifications (or even aptitude) for the more complex programming and analysis tasks associated with re-engineering existing applications to take advantage of new technology such as image processing and knowledge-based systems, or for designing and maintaining the distributed data bases that will be required.

- Outsourcing will become an increasingly attractive alternative for many of the processing, maintenance and other systems support functions that have traditionally resided in the central IS department.

The challenge of distributing and sharing IS responsibilities with end users certainly may prove to be the undoing of IS management—especially those who have not looked up from their screens for the last ten years as management mind-sets have begun to change. However, for those who have been looking beyond the screen (or who now answer the downsizing wake-up call), the opportunities are obviously there.

If the Zuboff model is even roughly accurate, those who have been close to the core in building corporate data bases should be better qualified than any others in the age of the smart machine. The inner two rings of responsibility (Intellective Skill Development and Technical Development) can be preempted by personnel with an IS background, and the outer rings of management responsibility will increasingly require the "intellective skills" that can only be acquired by passage through the inner rings and knowledge of the core data bases.

Downsizing is an excellent opportunity to apply information technology in a more effective manner. In many companies this will mean a shift from an accounting mentality, which views the IS department as a tool for maintaining control, to one that emphasizes a continual learning environment throughout the organization. Essentially, this is a shift from the Management Theory School of Thought, which was taught when many of the corporate MBAs were in business school, to the "Living System" school that is now emerging. This can be viewed as the first step in a continual learning environment for corporate management.

It may be difficult for some of those who have been "counting beans" for years to move out into the fields and start growing them, but that may be precisely what is required. There can be considerable satisfaction in being directly involved in producing something.

The challenge and opportunity for IS management remain the same as they have over the years. Those who identify with their companies' goals and objectives rather than those of technology, for the sake of technology, are in an excellent position to progress to senior management in their companies. Those who identify primarily with technology will continue to bounce from company to company in a shrinking market for corporate information systems "experts."

C
User Management

Just as IS management is faced with a shrinking market for CIOs, operating management is faced with the "elimination" (or at least reduction) of middle management. There are going to be fewer layers in the management hierarchy as downsizing proceeds, and user departments will have to become familiar with the new technology as part of the initiation rites to the continual learning environment.

Practically all office and administrative work now requires some familiarity with the personal productivity tools of personal computers. The client/server environment, which results from either downsizing or upsizing, is going to require knowledge of, and participation in, distributed data base and network management. This presents the following challenges to user management:

- The technical challenges of becoming familiar with systems concepts and network operation that go far beyond familiarity with spreadsheet packages, and how to reboot a PC if something goes wrong

- The inevitable requirement of becoming involved on a real-time basis with the core electronic data base (regardless of who has responsibility for data quality as downsizing proceeds)

- Depending on, or competing with, the IS "experts" for positions of leadership and responsibility in the first two rings of Zuboff's concentric ring model

The "winners" in the PC revolution are now confronted with all the problems of what to do with the power they have wrested from the central IS department. Regardless of how bad things were perceived as being before, user management is going to be confronted with the responsibility for solving some of those problems themselves. This can be a sobering experience.

In many ways, downsizing is similar to what is happening in the Soviet Union.

- The central authority can be brought to its knees, and all of the tools of power can be seized, but underlying structural (architectural) problems in the economy (business) may become worse before they can be improved. (There are economies of scale associated with the centralized data centers, which make it probable that IS costs will increase—at least temporarily—as downsizing proceeds.)

- There is also the danger that parts of the organization may go their separate ways and actually engage in power struggles among themselves. (Early leaders in distributed processing in the 1970s sometimes found that little "data-fiefdoms" developed as competing organizations tried to build their own power bases.)

- Some workers may not want to be empowered. They are perfectly happy having a job and receiving a paycheck and they don't want to compete. (Zuboff found precisely this situation in one of her case studies; empowered workers accused one of their peers of "intellectual rate busting" when he made suggestions about improving operations. Peer pressure was so strong that the worker stated he would be reluctant to make such suggestions again.)

In addition to all of the other challenges to line managers, they do not have the luxury of theorizing about new schools of thought about management. They are confronted with the day-to-day problems of the business, and integrating new technology into business processes will be difficult under the best of circumstances. It will be difficult to take a long-range view incorporating "intellective skill development" in either themselves or their employees.

However, though the challenges to line managers are formidable, the fact remains that they have the practical experience with business processes that is absolutely essential for the effective application of information technology. It is our opinion that the technical challenges of information technology will be easier for many of them to master than will the realities of the business for information systems professionals.

D

Vendor Management

Vendor management, at all levels, is confronted with all of the challenges and opportunities presented for the general business community. However, vendors have some peculiar problems all their own.

- Many are confronted with severe technical and structural shifts in their product lines. (The fact that the AS/400 represents 11% of IBM's resources, contributes 29% of the revenue, and 33% of income may seem like a simple management decision to those outside of IBM, but understanding why this is so, and determining what to do about it is considerably more complex.)

- There is a serious problem of product differentiation associated with downsizing hardware and software, which has led to a MIPS race that threatens both product profitability and vendor credibility. Hardware prices are dropping so fast there isn't even any pretense of being able to integrate the new technologies into existing business systems before they become obsolete.

- Many vendors are being confronted with systems software complexity that makes it extremely difficult to develop industrial-strength products for the downsizing market—especially fast enough to take advantage of rapidly changing hardware technologies.

- There looms the threat of end user resistance to increasingly complex and expensive hardware and software tools without quantifiable payoff in applications that address real business problems. There will be increasing awareness that tools are not solutions as downsizing of mainframe applications proceeds.

- Downsizing is going to expose customers directly to the consequences of investment in information technology. The impact of this exposure on the markets for information technology is highly speculative. There are already those who are beginning to question whether the investment in information technology in the 1980s could not have been better applied in product research and investment in improving the quality of human resources. It is probable that such questioning will increase as downsizing proceeds.

- The challenge for vendors is to facilitate the shortening of the innovation cycles at all levels of the systems development process so that information technology is effectively employed in business systems as rapidly as possible. This is a formidable task that has defied simple solution over the long history of the computer industry, and it is unlikely to be solved by wrapping the information technology package in another layer of pretty wrapping paper in the form of a GUI. Downsizing is going to make that clear in a hurry!

All of these questions require additional market analysis that is beyond the scope of this study, but INPUT intends to include a report on *The Impact of Downsizing on IT Vendors* as part of this report series.

Although there is a formidable array of problems facing information technology vendors, there is unlimited potential for those who solve real-world problems. Just as with the "bean counters," the toolmakers are confronted with rolling up their sleeves and going out to labor in the fields of integration. This integration is not the integration of tools (box A to box B, and network X to network Y—although these are necessary), it is the integration of information technology with the "human architecture" of the business enterprise.

In summary, it is the responsibility of corporate executives, IS management, users and vendors to fulfill the promises of information technology to contribute to both the economy and the general well-being of human beings. The opportunities for those who can literally make effective use of information technology for these purposes are unlimited. Downsizing and the 1990s are going to be "roll-up the sleeves" time for all of us. The die has already been cast, we are entering the long-awaited "information age" and there is no turning back.

VIII

Conclusions and Recommendations

Compute-intensive applications tend to seek their most cost-effective platform in the processor hierarchy because the benefits are obvious and easily obtainable. Commercial applications, on the other hand, have tended to remain close to their data sources because the benefits are not so obvious, and they are not so easily downsized.

In addition, IBM's System Network Architecture (SNA) is essentially host oriented. This has resulted in many commercial applications remaining on large host mainframes that do not require the functionality, and burden, of mainframe systems software. The burden of this top-heavy architecture is not only unnecessary expense, but complexity that inhibits responsiveness to changing business needs. These are the applications that are currently the target of downsizing.

In some cases, more cost-effective application solutions have been available for a long time. INPUT has recommended the "orderly distribution" of processing and data from mainframe computers for over 15 years, but little progress has been made during that time. IBM's System Application Architecture (SAA) has been around now for four years, and not a great deal of progress toward "rightsizing" has been made under that architecture. It is important for each individual organization to understand why this has been so, because the current trend toward downsizing is not an orderly process, and mistakes in determining what can and should be downsized could be extremely costly.

We started this study with the metaphor of a human sitting at the computer screen. We have looked behind the screen at hardware and software architecture; we have looked at the screen in terms of the systems development process; we have looked beyond the screen in terms of the "human architecture" of management and organization; and we have viewed all of this in terms of the innovation process.

One major conclusion we have reached is that "downsizing" is occurring in both the technological architecture and in the human architecture it supports. If either is to be effective in accomplishing its purposes, it is necessary for the other to succeed. Therefore, it behooves IS management to understand what is going on beyond the screen, and it behooves corporate executives to have some understanding of what is going on behind the screen. It behooves everyone to understand what is going on at the screen, because the relationship at the human/machine dyad will determine "the future of work and power in the age of the smart machine."

However, this report is directed to IS management, and our conclusions and recommendations will focus on the impact of downsizing on technological architecture and the role of the information systems function.

A
Conclusions

1. General

Some IS personnel have concentrated on looking behind the screen of mainframe hardware/software technology so intently they have lost sight of technological innovations that have occurred over the past twenty years. While concentrating on what has been going on in the IBM world, they completely missed minicomputers, language developments other than COBOL, network architectures other than SNA, operating systems developments other than the evolution of OS/VS/MVS, and they even labeled personal computers as "toys" well into the 1980s.

IS management has been so busy minding the data store they don't know what has been going on in the technological marketplace. During that time the IS function has become closely aligned with the corporate planning and control functions. Those functions have come under increasing attack by operating management, and corporate executives are downsizing organizationally by:

- Cutting corporate planning staffs and loosening corporate financial controls
- Eliminating (or reducing) layers of middle management

Although the stated goals of technological downsizing are to reduce IS cost, the management initiatives being taken require even more investment in IS technology at the local level, with little assurance of significantly reduced costs at the mainframe level. We say this for the following reasons:

- Even the most vociferous advocates of "client/server" architecture and open systems acknowledge that most downsized applications will continue to rely on "back room" or "glass house" mainframes for their data.
- It is possible (and perhaps even probable) that activity on mainframe data bases will actually increase rather than decrease as downsizing

proceeds. This is especially true during any transition period—and that period will be measured in years in many large installations.

- This problem becomes especially acute when "excessive downsizing" occurs. By excessive downsizing we mean an architecture that distributes data directly to intelligent workstations (and there are those who advocate this). Where this is done the dependency on the mainframe is extended until the need for integration at the local area is recognized—at which time it is discovered that what goes down must come up, and work unit servers are installed. Mainframe dependency will continue until this cycle is completed.

- We do not believe that "lights-out operation" will be available for very many mainframe installations. Those data base administrators and systems programmers don't work very well in the dark, and while these may be viewed as custodial functions, mainframes and central data bases do require a great deal of tender loving care, as do the more complex SNA networks that will continue to grow even as downsizing proceeds.

IS, which is viewed by practically everyone as being part of the problem, will probably be held responsible for making both technological and organizational downsizing work by assuring that data quality is maintained while trying to integrate unproven hardware/software technologies and user-developed "applications" into reliable (and secure) networks of systems. This is an unenviable position to be placed in under the best of circumstances, but it is especially onerous when it requires taking all the blame if it doesn't work, and receiving little credit if it does.

It is our opinion that organizations that fragment their information systems, and virtually eliminate the central IS function (and the CIO), will suffer the following consequences:

- Increased information systems expense as the result of downsizing (even if these IS expenses are hidden in departmental budgets)

- The eventual necessity to re-establish central responsibility for IS technology development, information architecture, enterprise data base management, "intellective skill development," and (heaven forbid) standards

- And, those two consequences are the best-case scenario, which assumes that the enterprise will survive.

Since downsizing is not proceeding on an orderly basis, it would be prudent for IS to adopt a course that minimizes technological risk in pursuing management's objectives.

2. Technological Architecture

Since concerns about data base integrity, synchronization and security are the primary factors inhibiting downsizing, we conclude that distributed data base management is of critical importance if downsizing is to be effective in achieving both technological and management objectives.

Since a high percentage of all commercial data bases reside on proprietary IBM systems, and since the key element in IBM's Systems Application Architecture is distributed data base management, we conclude that SAA platforms must be considered when downsizing. This is necessary if only for the reason that interfacing with SAA is inevitable for other proprietary and open systems that are data dependent.

The problems of distributed data base management in a two-tiered network of large mainframes and intelligent workstations become intractable if significant portions of the data base are distributed. In addition, there are currently no proven operating systems for IWSs that make any pretense of supporting anything more than relatively simple file transfer systems. Therefore, it is our opinion that downsizing from mainframes should initially be to minicomputer distributed data servers.

UNIX or UNIX-like systems (which really become proprietary systems in their specific implementations) do not have any proven track record as distributed data base servers. They are high risk if used in that environment. Therefore, proprietary minicomputer systems are the safest choice as DDB servers.

It is our opinion that IBM's AS/400 is currently the best DDB server. It dominates the midrange commercial market and has a superior architecture for distributed data base management. It has a proven track record of:

- Easy installability
- Low operating and support expense (operations, systems support, training, and data base administration)
- Superior connectivity and network management facilities
- Ready availability of a wide variety of applications
- High reliability, availability and serviceability
- Excellent architectural scalability
- About the only thing lacking is enthusiastic vendor support for downsizing from System/370 architecture mainframes to AS/400s under the SAA umbrella.

The fact that IWSs have been ruled out as distributed data base servers, does not mean they have no role to play in the downsized environment. A number of applications functions will "pass through" the distributed data base server directly to IWSs if downsized applications are properly re-engineered. Even more important is the fact that new applications development in support of organizational downsizing will be concentrated at the IWS level.

Exhibit VIII-1 presents downsized applications and functions in a "proper" hierarchical network for the 1990s. It is our opinion that this type of network will evolve even if it starts with bottom-up system development (or if excessive downsizing occurs), but our specific concern is an architecture for applications that minimizes the risks inherent in downsizing.

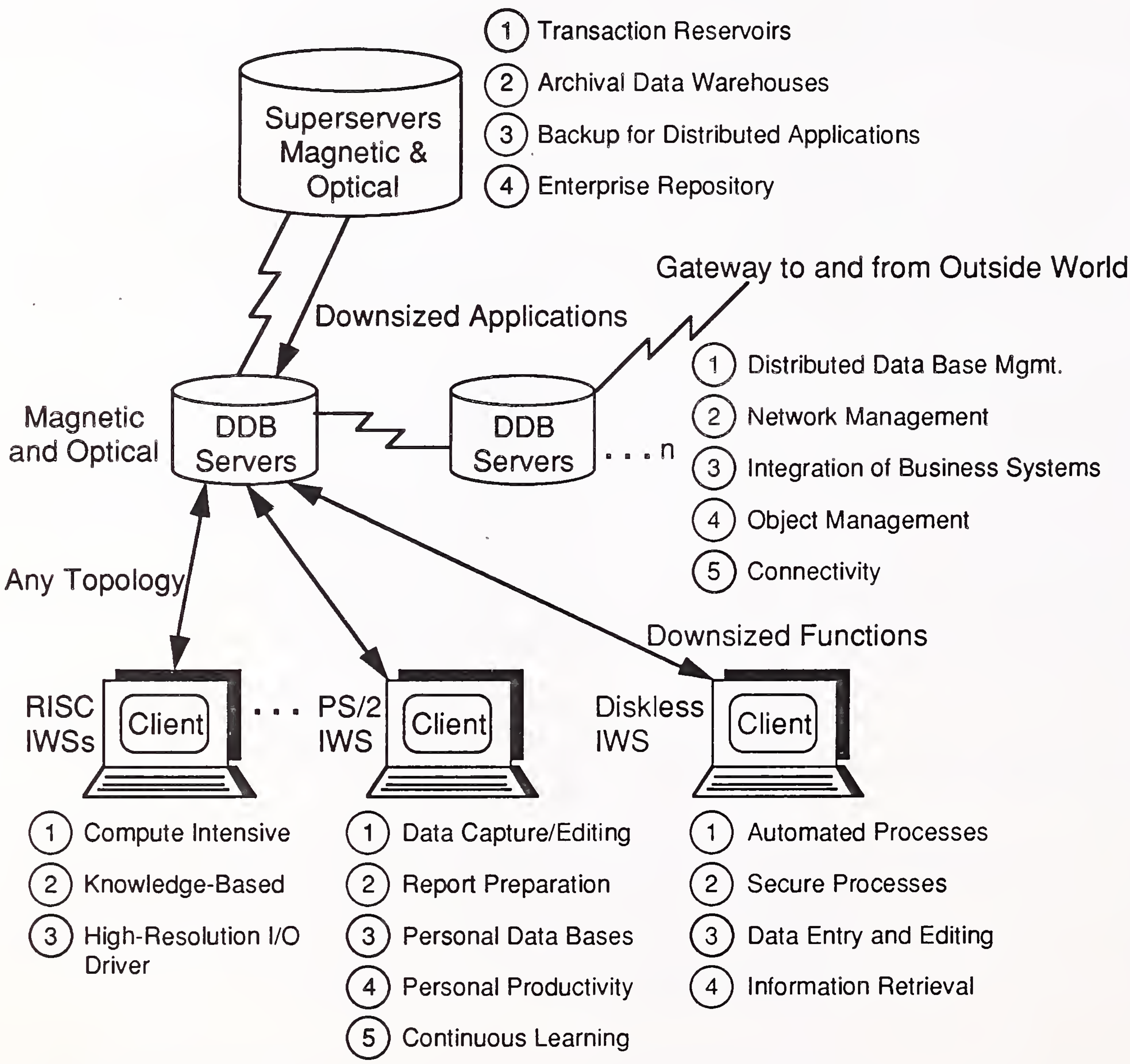
- The mainframe becomes a superserver that is fundamentally burst (or batch) oriented. The systems software for mainframes started with a batch orientation, and the amount of sorting that still takes place on large mainframes indicates that the operation hasn't changed all that much despite hanging on terminals for transaction processing. The primary roles of the superserver will be to:
  - Serve as a network transaction and data reservoir—a massive store-and-forward system for transactions and data
  - Provide an archival data warehouse, including "bonded storage" for enterprise data (such as "intellective skills data bases") and a central library of electronic publications on optical disk
  - Provide backup for distributed applications and data in the event of network failure or overload
  - House the enterprise network repository necessary for data base and network management. (Yes, the repository will live on—or will be reincarnated.)
- The DDB servers (by definition) will provide distributed data base and network management among other DDB servers and superservers, and to the clients in their work units. They will also serve as the primary links to the outside world (see also Exhibit IV-1) where they will screen, identify and route calls and "filter" data from outside sources. In addition, they will be:
  - The primary data processing engines for downsized applications, and will serve as back up for applications functions passed through to clients during downsizing
  - The coordination points for office systems and services within the work unit and across the network as required

- The repository for work unit objects, and the library for work unit reference documents and archives

- The connectivity and routing engines for intra- and internetwork communications for work unit clients

EXHIBIT VIII-1

Downsized Applications and Functions



- A variety of local and remote clients will be supported by DDB servers. One of the primary purposes of DDB servers is to break down the walls of the work unit and permit flexibility in bringing together appropriate "intellective skills" work units regardless of geographic location. Clients are then located as close to the source of the transaction, skill, knowledge or data source/destination as possible. Representative clients and their functions are shown in the diagram, but they are not intended to be definitive or restrictive. Those shown are:

- RISC workstations being used for compute intensive applications such as CAD/CAM, knowledge-based systems, and as the drivers for high-resolution I/O devices; these clients may be either loosely or tightly integrated with the DDB servers (and may even be under the same cover in some configurations).

- Personal computers being tightly integrated with DDBs as the primary clients for downsized applications functions such as data capture and editing, report preparation and information display, personal data bases, and personal productivity tools; in addition, these clients will be the focus and vehicle for "continuous learning."

- Diskless workstations to mechanize clerical processes, data entry, routine information retrieval, and to provide secure processes under direct control of the server; the workstation engine will be determined by the processing requirements of the automated process, but cost will be kept to a minimum.

Walking around this architecture enables us to identify all four schools of thought, and we conclude they will all be served by the downsizing architecture.

- The Management Theory school that represents tight central cost control and planning

- The Mechanization school that emphasizes work simplification and mechanization (and along with the Management Theory school constitutes the Taylor Model referred to by Matsushita)

- The "Living System" school that was explored by Zuboff

- The Intelligent System school, which has come to be associated with Herbert Simon, has been eternally slow in delivering on promised results. However, it seems to be relied upon in some of the downsizing initiatives currently being undertaken by management. The purpose of intelligent systems is to capture human knowledge and skills and move the interface of the human/machine dyad.

Though all of the management schools of thought are served by the architecture that has been depicted, this does not mean that the management mind-set of either corporate or IS executives has changed to embrace all of these schools. Management mind-set will determine where emphasis will be placed in the architecture and how effective it will be in implementation.

The downsizing architecture also helps in understanding Zuboff's management model as it applies to information systems and the IS function.

3. Organizational Architecture

In order to decentralize planning and control to operating units of the organization and at the same time eliminate layers of middle management, it seems obvious that some combination of the following must occur:

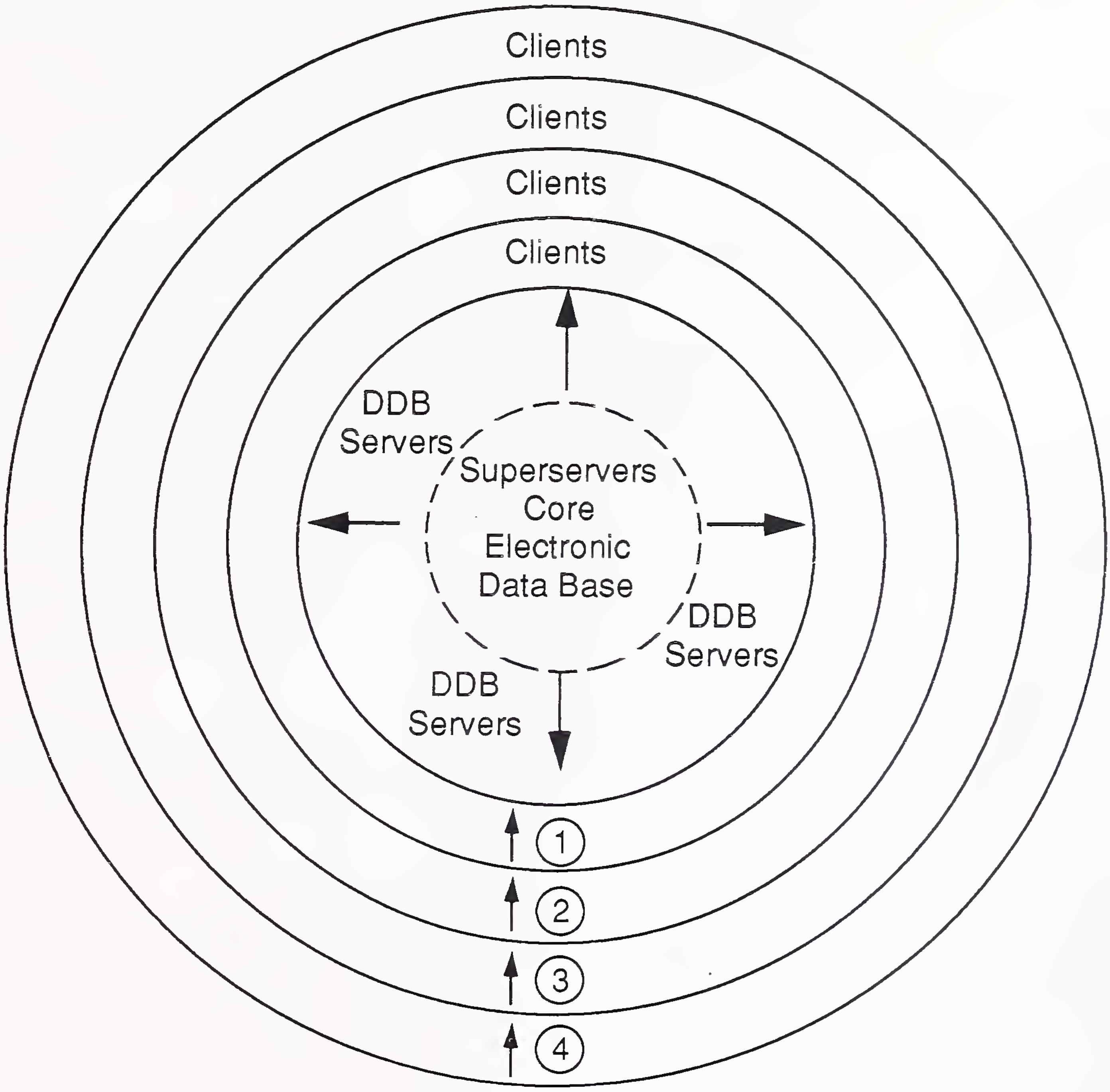
- The remaining employees—whether they are executives, managers, supervisors, project leaders or just plain workers—are going to have to work longer and harder (which already appears to be the case).
- And/or, the remaining employees are going to have to work a lot "smarter."
- And/or, the remaining employees are going to have to be empowered with improved information systems that relieve them of some of the additional burden.
- And/or, the artificial system must become "intelligent" enough to substitute for some of the experience and knowledge that was previously applied to the information flow by middle management.

It is probable that all four of the above will be required, to some degree, if the implementation of the downsizing management initiatives that are currently under way are going to be effective. It is therefore concluded that the remaining employees will be drawn closer to the core electronic data base of the Zuboff management model (in terms of understanding and use), and the core itself must expand significantly as more data are added (especially in terms of experiential decision rules). This will result in compression of the Zuboff concentric rings of management responsibility (Exhibit VIII-2).

The exhibit also clearly shows the importance of the technological model in maintaining (and improving) the quality of the core electronic data base(s). There is a big difference between capturing facts (such as sales, inventory, work in process, etc.), and information pertaining to human interactions and decision making (skills, knowledge, performance and personal characteristics). These more complex data vary in validity and reliability, but they form the most important elements of Zuboff's "intellective skill" core (whether they are in human heads or in data base servers). These raw data should not be stored or distributed to every desktop in the enterprise—or exposed in any way to unauthorized access or contamination.

EXHIBIT VIII-2

Organizational Architecture



1. Intellective Skill Development
2. Technology Development
3. Strategy Formulation
4. Social System Development

Building and maintaining the core electronic data base is a formidable challenge on the leading edge of both computer and mathematical science (to say nothing of artificial intelligence, which cuts across many disciplines). Accessing these data is one thing, understanding their quality and usefulness is going to be quite another, and building the artificial systems that take full advantage of these data is frequently beyond the current state of the art in information systems. This leads to the following conclusions:

- It is apparent that "intellective skill development" in terms of both building and using the core date base will be considerably more difficult than explaining the use of the latest spreadsheet package.

- The task of "technology development" is currently formidable and can only get more complex and challenging during the 1990s.

- It is unreasonable to expect employees in user departments to be of much assistance in either of these areas, much less to provide the necessary leadership in the downsized environment.

We also conclude that "strategy formulation" and "social system development" will be increasingly dependent on the underlying information architecture and technology. The quality of data will determine the quality of strategic decisions, and the quality of information systems (at the screen) will determine to large degree the social system that evolves.

It appears that competent IS employees (at all levels) have little to fear from downsizing. They will be needed and have an even more important role to play in the age of the smart machine.

It seems apparent that lowering IS costs is not necessarily a reasonable objective if organizational downsizing is to be successful. However, the objective of a leaner, more competitive organization may be all the justification that is needed for downsizing.

If reduced costs are necessary to justify management downsizing, these savings must come from improving human information systems of all kinds. Since artificial intelligence and knowledge-based systems remain high risk in terms of both difficulty of implementation and probability of cost savings, it will be necessary to concentrate on improving business processes. (In fact, these will have to change if layers of middle management are to be eliminated.

It will be necessary to re-engineer many downsized applications if existing processes are going to be improved. One of the most attractive opportunities for improving processes is the reduction, or elimination, of paper. The core data base is *electronic*, not paper.

Properly implemented, downsizing affords the opportunity to improve the applications development process. There is broad-based management support for downsizing, and end users can be involved in the application development process. These are two of the elements INPUT has traditionally cited as being necessary to improve productivity in software development.

We conclude that downsizing affords substantial opportunity for improving both IS practice and recognition.

B Recommendations

The first recommendation is that IS management should take downsizing seriously and view it as an opportunity to improve the quality of information systems and their contribution to management objectives. Fears of downsizing the CIO out of a job should be put aside. That isn't going to happen if downsizing is to accomplish management's objectives.

Downsizing should begin with a commitment to quality, and that will usually require re-engineering existing applications.

End users should be involved in the downsizing effort from the beginning—especially those that require improved business processes. End user involvement is a benefit of downsizing if it is approached on a team basis rather than an "us and them" attitude. The most effective personnel should be assigned to projects based on their skills and abilities rather than their organizational affiliation.

IS management should take the leadership in "intellective skill development" at all levels in the organization. It should be pointed out to management that there is an inherent power shift associated with increased reliance on the core electronic data base, even if this is not what they intended.

The question of cost savings should be analyzed on an objective basis. There should be no unpleasant surprises or hidden costs of moving some responsibilities to end-user departments. A thorough cost analysis framework should be established that includes all of the potential costs (see Exhibit V-3).

IS management must do an objective analysis of mainframe applications, and accept responsibility for those that obviously could benefit from downsizing. This requires becoming familiar with existing technologies that could be used for downsizing, and with the business processes associated with those applications. Work with users in defining the best candidates.

INPUT recommends that you do your own report card on the possible alternatives as distributed data base servers. As part of this process, we recommend that you take a careful look at both the AS/400 and UNIX as well as PC-based LAN servers. Do not reject new or unfamiliar technologies that may be of benefit in the downsizing effort. Do this evaluation even if it requires considerable effort. For example:

- It may not be possible to get very good information from an IBM sales representative whose orientation (and compensation) is based on mainframes. You may have to seek other sources of knowledge—including current users.

- It is also difficult to find objective opinions concerning the quality of UNIX (especially in all its various forms). It may be necessary to do some desk and field research.

- At the workstation level there is no substitute for trying various alternatives, if you have not already done so.

We recommend a careful analysis of the need for distributed data bases as downsizing proceeds. If they are really not necessary, you may be able to simplify your architecture considerably. However, as part of this analysis, play a file transfer scenario through to completion and try to visualize the potential integration problems that may develop as downsizing proceeds.

Use Exhibits VIII-1 and VIII-2 as models and analyze any technical or management limitations in implementing such a model in your organization. Give special attention to any discontinuities between management expectations and technological reality—especially in terms of the ability to transfer human knowledge and experience to the core electronic data base.

Develop a long-range information architecture with the cooperation and understanding of both corporate and user management. Put this architecture in the electronic data base so that everyone can have ready access to it even when absorbed in the details behind the screen.

Prepare a downsizing plan that is consonant with this architecture and includes anticipated shifts in IS and management responsibilities that are necessary (or probable) in your organization, and the potential consequences of these shifts.

Work with management and end users in making certain that these consequences are understood and accepted.

Prepare a long-range (10-year) technological forecast and scenario that will expand on the consequences of information technology innovation in the 1990s, and relate this scenario to your company. In other words, look beyond the screen and beyond downsizing to the technological and management architectures of the future. Although there may be many factors beyond the control of any individual or organization, it is important to anticipate the business environment.

Assume your responsibilities for "intellective" skill and technical development. Information technology innovation is the most important fact in the 1990s business environment, and it is INPUT's belief that IS management must accept the responsibility for leadership in the management of these innovations.

A

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