COMPUTER – COMMUNICATIONS NETWORKS

INPUT

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OFFICES

UNITED STAT

2180 Sand Hil
Suite 320
Menlo Park, C
(415) 854-342

15 Bond Stree
Great Neck, N
(516) 482-417

JAPAN

Overseas Dat
Shugetsu Buil
3-Chome Min
Tokyo, 107
Japan
(03) 400-7090

EUROPE

67A High Street
Sutton SM1 1DT
England

ECONOMICS OF COMPUTER/COMMUNICATIONS NETWORKS AND THEIR FUTURE IMPACT

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INPUT
701 Welch Road
Suite 1119
Palo Alto, Ca. 94304
(415) 854-3422

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I. INTRODUCTION AND GENERAL ENVIRONMENTAL DESCRIPTION

Current computer, communications and software technologies can be structured into networks the economics and impact of which are not fully understood by even the most sophisticated computer users of today. In addition, these technologies are changing rapidly and interacting in unpredictable ways. One thing is clear, it is becoming difficult to distinguish between communications and data processing functions in a network environment, and this has a significant impact on overall systems design. Decisions concerning information systems design can, in turn, influence an enterprise's organization and function. A wrong decision can result in the installation of a system which becomes economically or functionally obsolete and may have adverse effects on an organizations overall performance relative to competition.

The confusion surrounding computer/communications networking is not merely an extension of the computer mistique. Network technology will have a substantially greater impact on computer users, hardware manufacturers, communications carriers, legislative and regulatory activity, and private citizens than the development of computer technology has had to date, and the time frame will be much shorter.

It is critical to develop a meaningful information systems plan in such an environment. However, knowledgeable users who are confronted with making substantial technical and financial commitments are becoming increasingly apprehensive because of the uncertainties involved. These concerns are legitimate since systems installed during the next five years will not be easily replaced.

The purpose of this report will be to provide an overview of the economics of computer/communications networks, their future development, and the impact they may have. The emphasis will be on putting these developments

into proper perspective in a simple understandable manner from an overall point of view. It will provide an environmental framework and guidelines to assist users involved in information systems planning. Subsequent reports will explore specific areas in detail and be intended to complement in-house research efforts.

II. CURRENT TECHNOLOGY

Current computer/communications technology and costs support the establishment of hierarchical networks which consolidate small and medium scale computer installations into large scale centers. There are numerous advantages of such centralization:

1) Cost savings due to economies of scale resulting from the replacement of small and medium scale computers with larger systems.
2) Lower operational costs in terms of operations personnel and physical facilities.
3) Concentration and conservation of highly skilled personnel such as systems programmers, user consultants, and operations managers.
4) Elimination of duplication of program products and consequent lowering of software costs.
5) Improved service in terms of software availability, user assistance, and system responsiveness (turn-around).
6) Standardization and control of programming conventions and applications systems.
7) More effective use of computer hardware and peripheral devices.
8) Smoothing of workload due to a better mix of scheduled and high response jobs, and because of geographic distribution where time differences are involved.

Fundamental to the economics of hierarchical networks are the economies of scale associated with computer systems. It is important that past, current and projected price-performance relationships be understood in order to analyze the economics and impact of computer/communications networks.

It has been observed that there is a quadratic effect of computer system scale which assumes a "four-fold increase in effectiveness for a doubling of cost." This effect is shown in Exhibit II-1, and is based on historical observation. Unfortunately, it tends to get distorted in certain cases today because of planned systems performance controls and technological changes. Nevertheless, it is interesting and still appears in relationships which will be explored later.

We prefer to look at economy of scale on a somewhat different basis in order to observe possible impacts from developments outside of IBM's product line. Although the use of internal speed has traditionally been frowned upon as a meaningful measure of price-performance, we have selected it for the following reasons:

1) CPU capacity is an absolute limitation on systems performance. If a system is truly CPU bound the only alternative is to upgrade.
2) For better or for worse, IBM System /370 operating systems tend to operate at a high percentage of CPU capacity.
3) Internal performance becomes critical in a network environment.
4) Relative CPU speeds are a convenient measure of performance of IBM systems against competition.

Exhibit II-2 shows the internal price-performance of the middle and high end of the IBM System /370 computer line. The internal speed of the 135 is used as a base of 1 and the 145, 158 and 168 (Model 1) are rated relative to that base. Price-performance is determined by plotting relative internal speed against the cost of an average configuration. Interestingly enough, the 135, 145 and 158 have roughly equivalent internal price-performance. Significant improvement occurs only on the 168 which has approximately 1.5 times the internal price-performance of the middle of the line. Based on this advantage alone, it is apparently possible to replace 12 135's, 3 158's or any combination adding up to 12 with a single 168 and save 30-35% on total hardware costs. (In actual practice, we shall find this to be a conservative estimate of actual savings). Of course, this is partially off-set by the costs of communications and terminal equipment, but $60-70,000 per month provides more than adequate savings to cover these expenses and the other

EXHIBIT II-1

QUADRATIC EFFECT OF
COMPUTER SYSTEM SCALE

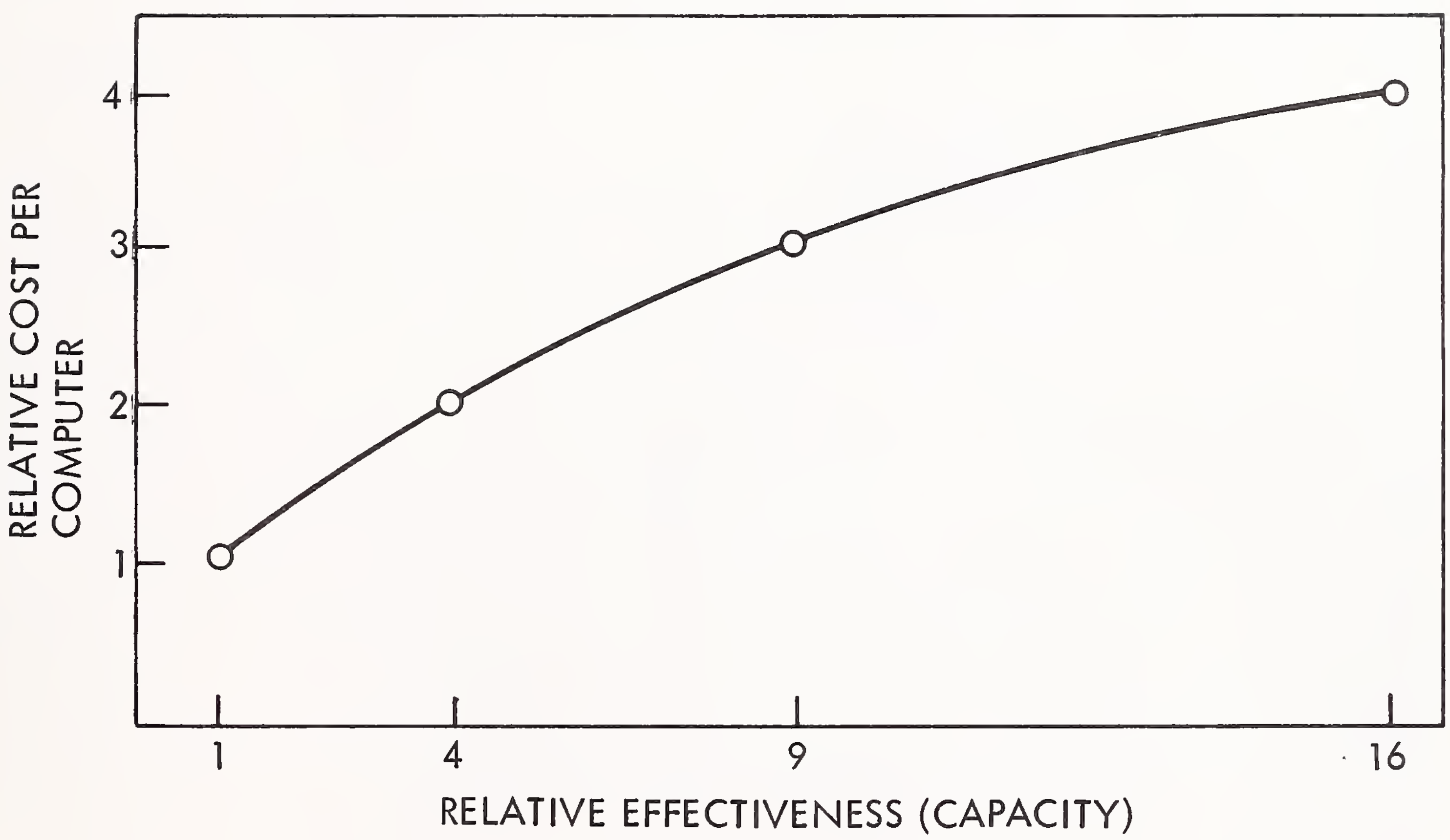
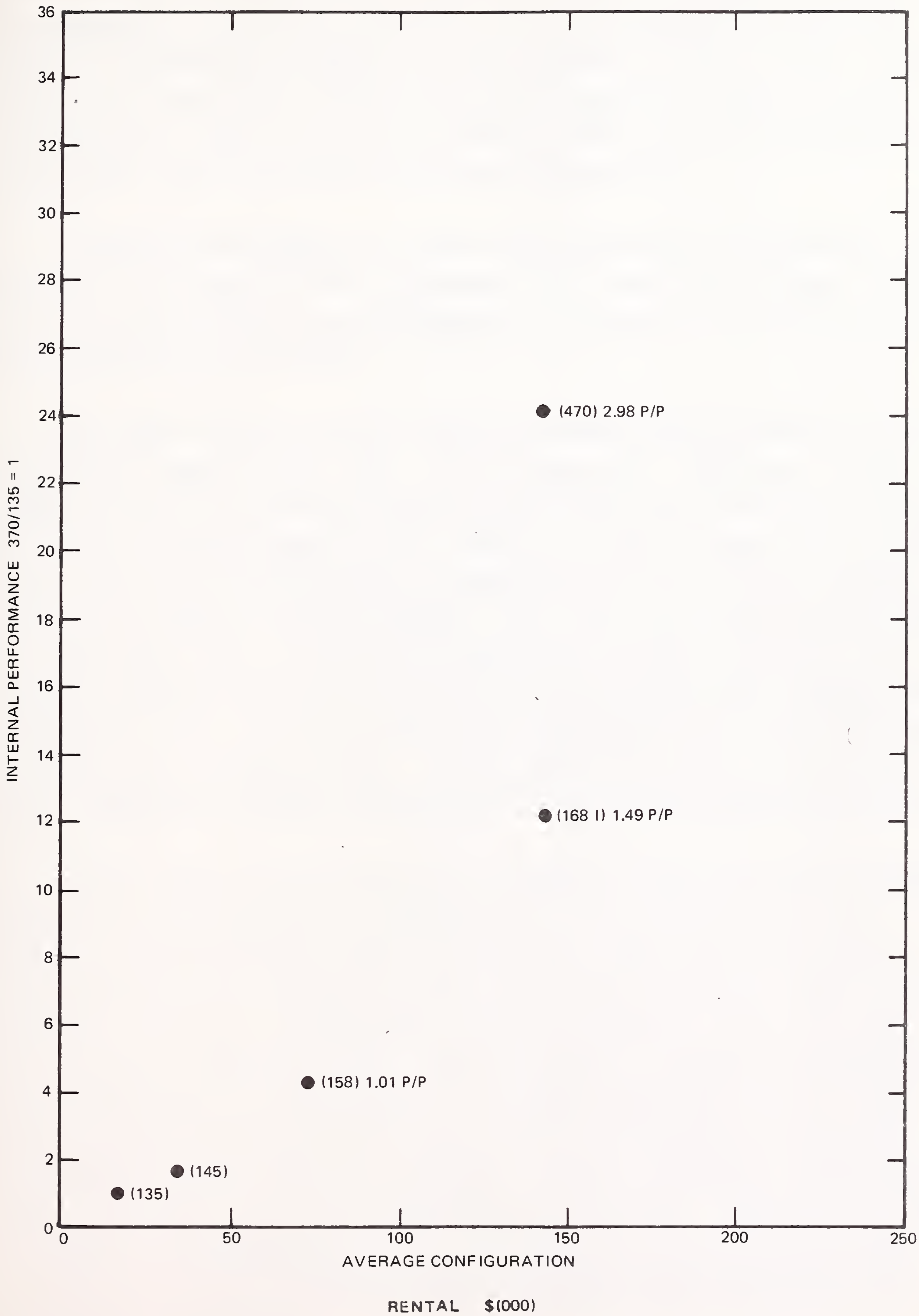


EXHIBIT II-2

IBM SYSTEM 370 INTERNAL PRICE-PERFORMANCE



advantages of centralization can also be realized. It should be noted that the doubling of cost when going from a 158 to a 168 results in only three times the potential performance and defies quadratic effect of scale. Nevertheless, the theoretical economics are still attractive enough to warrant consideration. Thus even within the IBM 370 line, the effect of economy of scale argues for centralization on large scale systems.

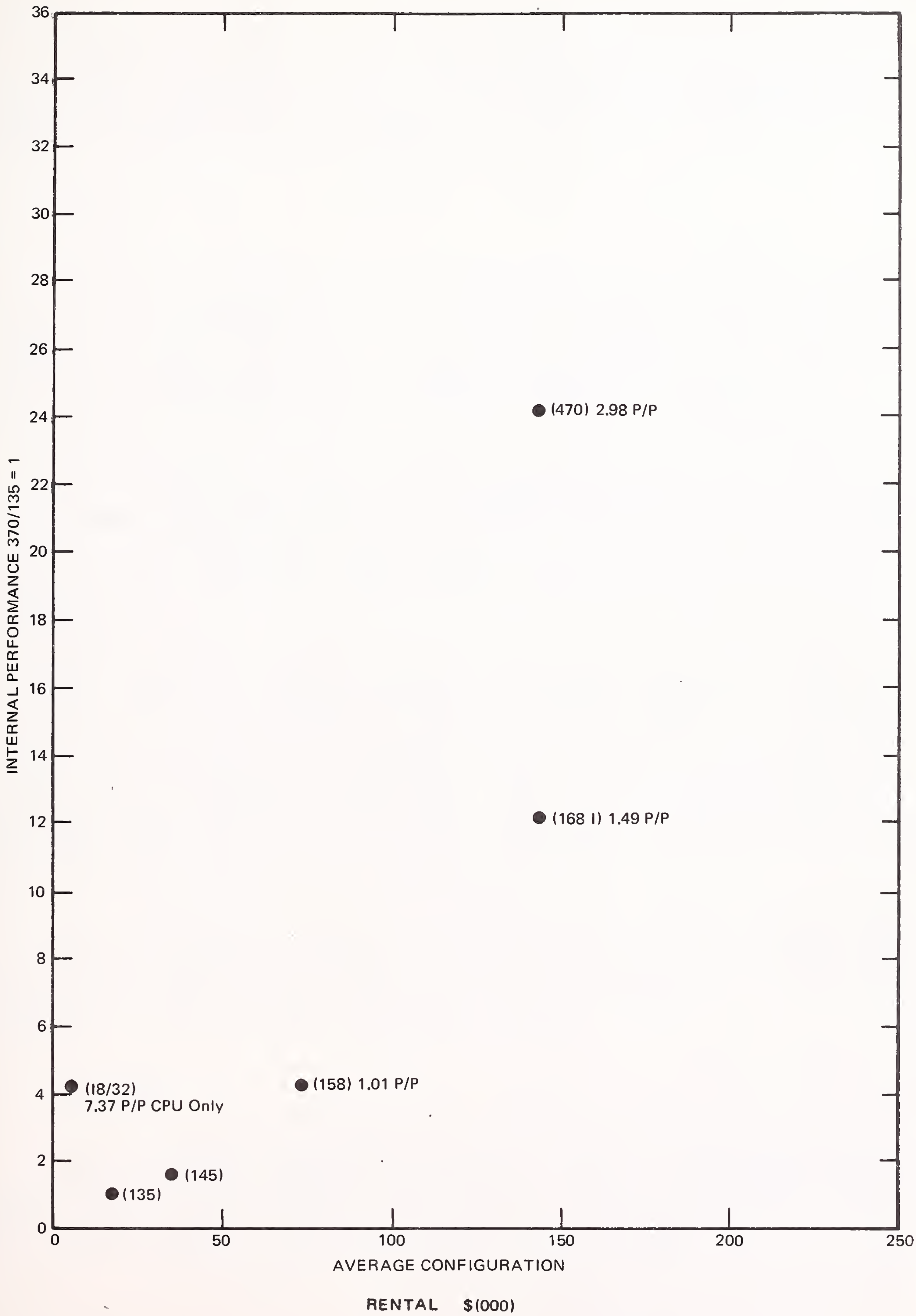
Competitive developments in large scale systems and minicomputers pose even more of a threat to small and medium scale stand-alone systems. Exhibit II-3 shows the internal price-performance of the Amdahl 470 V/6 and Interdata 8/32 compared to the 370 line.

The Amdahl 470 V/6 is a 370 compatible system with approximately twice the internal speed of the 168 at the same cost. Therefore, if you double the cost of a 168 and install 2 470's you get four times the power and the quadratic effect appears again. However, it does not apply when compared to the rest of the 370 line where a doubling of cost can obtain a six-fold increase in internal price-performance. Thus, the 470 V/6 has the potential for replacing 6 158's or any other combination of systems adding up to 24. Computer hardware savings in excess of 50% are indicated when replacing combinations of 135's, 145's, and 158's, and replacement of two 168's would save more than 25% on hardware costs. It would appear that large scale systems have a significant economic advantage over medium scale stand-alone systems.

However, the classic concepts of economies of scale are being seriously disrupted by developments in "minicomputers." The Interdata 8/32 has internal price-performance which is more than 7 times that of the middle of the 370 line, and there are numerous other mini's which have similar performance characteristics. The 8/32 has internal performance which approaches the 158 at approximately 10% of the cost. The full impact of such price-performance is just beginning to be felt because of software limitations, but it will become increasingly difficult to justify the use of medium (or even large) scale systems for scientific time-sharing, program development, simple transaction processing, and communications control functions. If classic concepts of internal price-performance have been disrupted by minis, they will soon be destroyed by microprocessors, which will be discussed in the section on Technological Projections.

EXHIBIT II-3

AMDAHL 470V/6 AND INTERDATA 8/32
INTERNAL PRICE-PERFORMANCE RELATING RELATIVE TO IBM SYSTEM



III. CURRENT NETWORK ARCHITECTURE AND ECONOMICS

Exhibit III-1 shows a hierarchical network which can be constructed using today's computer and communications technology and operating under available software (either OS or VS).

Level I

Based on the economies of scale mentioned in the previous section, a Level I by definition should be an IBM 168 or larger system. Its proper functions are heavy computation, transaction processing against large data bases, and RJE replacement of smaller stand-alone systems.

Even if a mini has better internal price-performance than a large scale system, it is seldom practical to take a job which could be completed in an hour on a large scale system and have it run for a shift or a day on a smaller system. Therefore, large scale systems are required for heavy computation.

While there are probably very few really large data bases which could not be more effectively distributed over the network, today's software technology does not support distributed data bases and Level I's are left with a great deal of transaction processing. (Even with the simple transaction processing distributed to a lower level, there will be some legitimate large data bases which will require a large scale central facility)

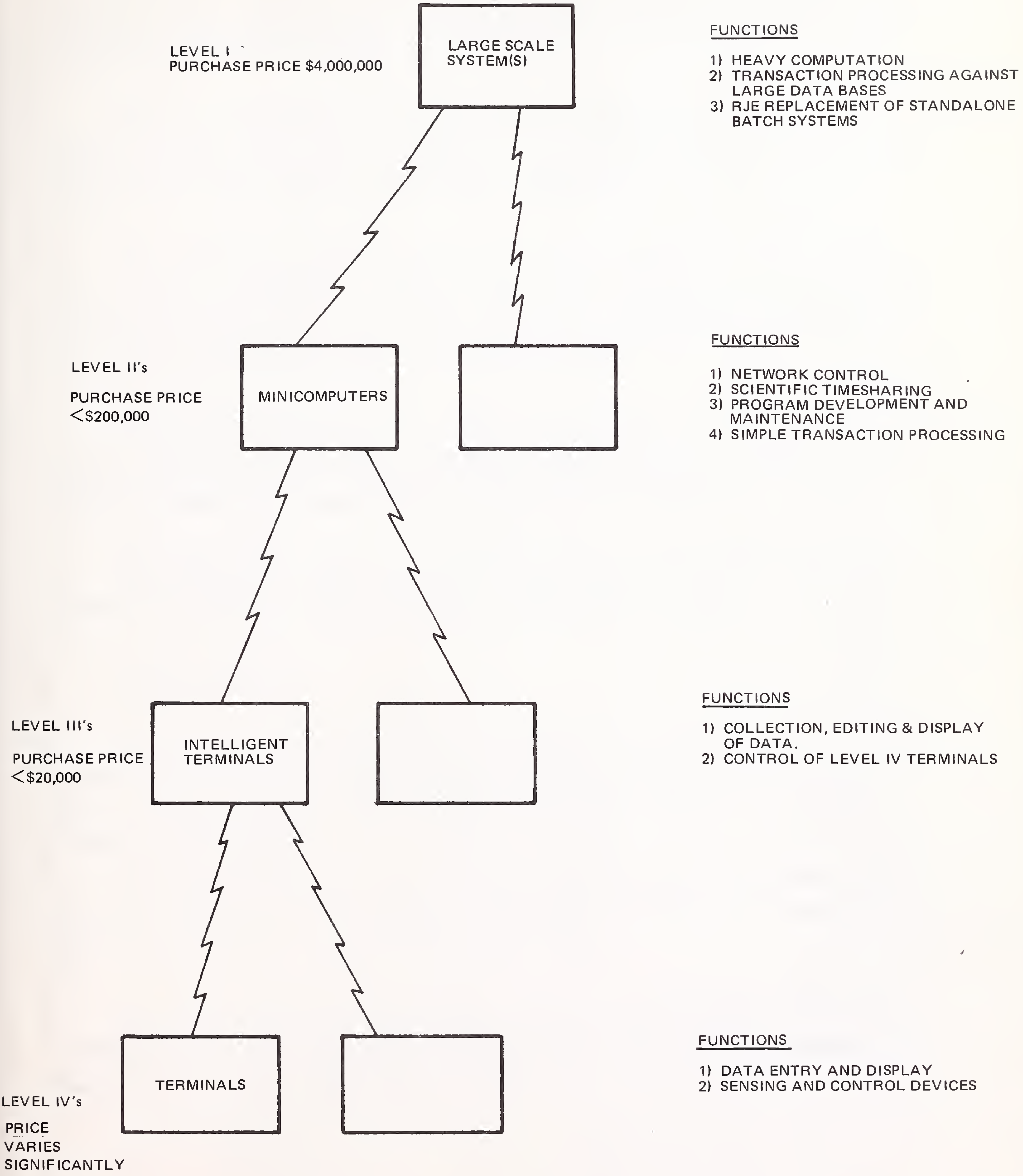
The replacement of smaller systems with Level I's is a primary reason for the establishment of networks using current technology. In the future there will be other and more compelling reasons to do so.

Level II

Due to software limitations the true potential of Level II's in a network environment has seldom been realized. However, where they have been properly applied, the results have been outstanding.

EXHIBIT III-1

HIERARCHICAL NETWORK



Because of superior internal price-performance mini's are ideally suited for many communications control functions which are currently shared by larger systems and terminal control units.

There are substantial cost savings to be achieved by servicing slow speed scientific time-sharing terminals from minis and using the same systems to communicate with Level I's for heavy computation.

The servicing of terminals used for program development and maintenance can best be handled by minis. Simple text editors can be used for the entry and maintenance of source code and the development of job streams for remote job entry to Level I's is also possible.

Transaction processing at a local level includes: data collection, editing, display, local report preparation, and forwarding of either individual or batches of transactions to a Level I data center.

All of the above uses of Level II's have economic benefits based on superior internal price-performance and communications costs.

Levels III & IV

Intelligent terminals come in a wide range of prices and may be either special purpose such as point-of-sale terminals or general purpose terminals which, in some instances, have internal processing capability approaching a Level II minicomputer.

The primary function of intelligent terminals is the collection, editing, and display of data. However, substantial processing and computation can be accomplished in specific application areas.

The other function of intelligent terminals is to control Level IV terminals which can be keyboards, printers, card readers, badge readers, CRT's, sensors and any other input/output devices.

At the present time, many Level III's and IV's are serviced directly from Level I's (or medium scale systems) primarily because of software availability and limited technical resources to install the type of hierarchical network which has been described. An additional reason such networks are not more prevalent is because data processing management has resisted centralization of resources in the mistaken belief that responsibility (and compensation) can best be measured by the type of hardware installed - - the latest and largest obviously being the best.

We do not feel the reasons mentioned above can any longer delay the development of computer/communications networks using current technology -- there are too many more compelling reasons for their development.

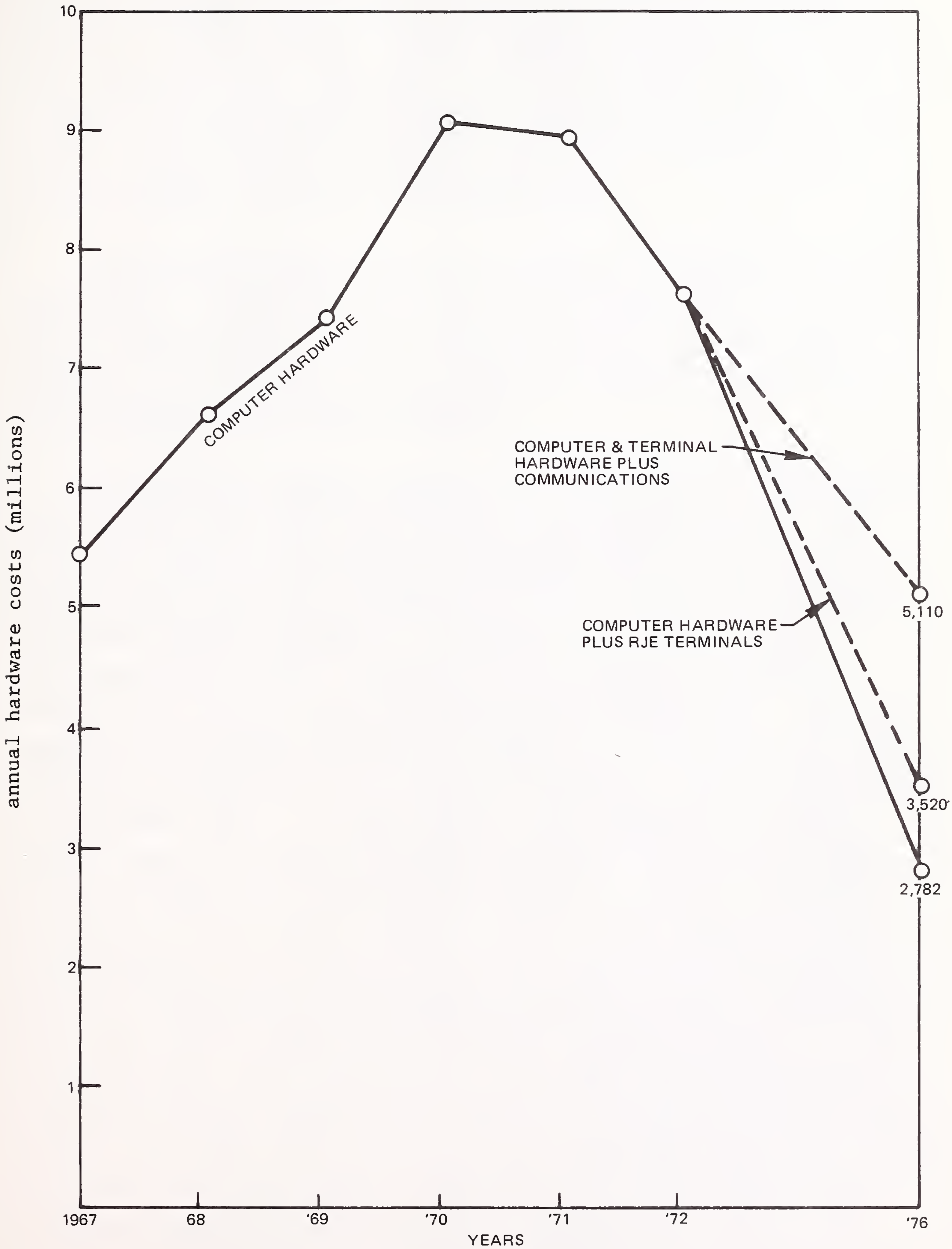
Exhibit III-2 plots the historical hardware costs of a company which consolidated more than 20 stand-alone systems into a single Level I center. Between 1967 and 1970 computer hardware costs on an annual basis increased from $5.484 million to $9.072 million -- an increase of 65% over a three year period. During this same period, the company's sales increased by only 17% and its profits by only 11%. The dramatic increase in costs was accomplished by upgrading the numerous stand-alone systems which were geographically dispersed throughout the United States; the situation was an extremely attractive one for computer hardware salesmen.

In 1970 and 1971, the consolidation of these stand-alone locations was begun into four regional centers and a leveling off of cost is apparent. By year end 1972, the impact is clearly apparent as the hardware costs have started to drop significantly. One regional center was closed at the end of 1972 since it became apparent regional centers were not required.

The budgeted costs for computer hardware, communications, and terminal equipment for the United States in 1976 will be $5.110 million down by 44% from the peak in 1970, and lower than it was ten years ago in 1967. All of the processing for the United States will be done from a single center, and the consolidation of European locations into that center has already begun, but the figures are not included on the chart.

EXHIBIT III-2

HISTORICAL HARDWARE COSTS - STAND ALONE VS. NETWORK



An even more dramatic decline can be seen in the cost of computer systems since virtually all of the $9 million expenditure in 1970 was for such equipment. That number is now down to $2.782; a decline of 69% over a six year period. In fact, computers represent only 54% of the 1976 'hardware' costs. This shift in cost from computer hardware to terminals and communications services in a network environment has significant implications for the entire structure of the information processing industry. This will be discussed later.

Exhibit III-3 presents an overall comparison of network versus stand-alone costs. The network can be operated for approximately 52% of the cost of doing the same work on a stand-alone basis, and with annual savings of $7.757 million. It is difficult to justify multiple stand-alone systems in view of such economics.

The equivalent replaced systems listed in Exhibit III-3 were derived based on each node's actual utilization of the central facility. The equivalent usage of each model was established based on experience obtained during the actual consolidation effort, and then checked against previously installed hardware. The results are interesting from a technical point of view. The Level I center hardware configuration consists of an IBM 165 and 168 operating under OS/MVT HASP. This configuration has combined internal performance of 20-22 (based on the chart contained in Exhibit II-2), and could be expected to replace systems with an equivalent total. In actual practice, the configuration replaced systems with total internal performance of 45.4 -- approximately twice as much as would have been logically projected. This can be directly attributed to both network technology and the better control of costs. This particular network had both Level II's and Level III's as RJE terminals and processing was distributed to the nodes because the users of the network could clearly see the economic advantage of doing so. The other factor was that users could see their data processing costs drop immediately if they improved their systems or optimized their use of the network. The fixed costs associated with a stand-alone system give little incentive to make improvements to existing applications systems since the hardware capacity remains under any circumstances. Once cost is based on actual usage of the central facility there is incentive to make such improvements.

EXHIBIT III-3

NETWORK VS. STANDALONE COST COMPARISON $(000)

LEVEL I COSTS	CONSOLIDATED		STANDALONE
HARDWARE	2,782		
COMMUNICATIONS	1,590		
PERSONNEL	1,126		
OTHER	1,126		
TOTAL		6.624	

TERMINAL OPERATING COSTS (INCLUDING HARDWARE

NODE	CONSOLIDATED		EQUIVALENT REPLACED SYSTEM	STANDALONE COSTS
1	78.		370/125	276.
2	78.		370/115	178.
3	34.8		370/115	178.
4	61.5		370/135	480.
5	78.		S/3	115.
6	118.8		370/145	804.
7	52.8		370/125	350.
8	349.		370/168	3408.
9	88.8		370/145	804.
10	164.7		370/168	3408.
11	34.8		370/125	276.
12	175.8		370/158	1800.
13	73.5		370/125	350.
14	34.8		370/135	480.
15	114.		370/158	1740.
16	26.7		370/125	216.
17	49.5		370/145	804.
18	34.8		370/115	179.
19	26.7		370/125	240.
TOTAL		1,705.		
TOTAL CONSOLIDATED		8,329.	TOTAL STANDALONE	16,086.

Data processing operations managers are then measured on their ability to cut costs rather than on how much hardware they have installed. Thus, the raw economies of scale associated with internal performance are enhanced substantially in actual practice.

Exhibit III-4 provides a node by node comparison of the estimated stand-alone costs contained in Exhibit III-3 against the total costs of operating within the network (including actual billing from the Level I center to the node). It should now be pointed out that communications costs are billed out by the Level I center as part of the network operational costs rather than being borne directly by the individual users -- thus, geographic distance does not penalize users of the network. Even so, the consolidated cost as a percentage of stand-alone cost varies considerably from node to node, but tend to cluster in the 40-60% range regardless of system size. The really noticeable exception occurs with the two 158 replacement nodes (12 & 15). Node 15 is operating at 30% of stand-alone and node 12 is operating at 80%. The explanation for this is interesting: node 15 was consolidated early in 1972, and node 12 was consolidated in mid-1975 (less than 6 months before these operating results were obtained). Experience has shown that significant reductions in billing from the Level I center occur approximately 6 months to 1 year after consolidation. This is due primarily to the fact that it takes the new user this long to optimize his programs to take advantage of the central facilities hardware, software and billing practices.

Exhibit III-4 also presents the approximate costs of obtaining comparable service from a computer services company. These figures were obtained by running one month's actual data against the published billing algorithms of several service companies and selecting the one which seemed most representative. While there are significant variations from node to node, the service organizations rates are generally lower than stand-alone (-14% overall) and higher than network costs (+65% overall). Considering the flexibility of pricing on major contracts in the computer services industry, discounts in excess of 25% are not uncommon. A 40% discount would be required to bring service company charges into line with the networks costs in this particular case.

EXHIBIT III-4

COST COMPARISONS BY NODE $(000)

NODE NO.	STANDALONE	CONSOLIDATED (INCL. TERMINAL COST)	% OF STANDALONE	COMPUTER SERVICES COMPANY
1	276	150	54%	302
2	178	111	62%	96
3	178	69.8	39%	172
4	480	232.5	48%	672
5	115	96	83%	66
6	804	443.8	55%	776
7	350	109.8	31%	318
8	3408	1814.0	53%	2156
9	804	331.8	41%	818
10	3408	1706.7	50%	2580
11	276	184.8	67%	420
12	1800	1446.8	80%	1844
13	350	170.3*	49%	323
14	480	208.8	44%	506
15	1740	519.0	30%	1558
16	216	101.7	47%	197
17	804	478.5	60%	652
18	179	84.8	47%	142
19	240	87.7	37%	130
TOTALS	16,086	8347.8	52%	13,799

*ESTIMATED NOT INCLUDED IN TOTAL

Exhibit III-5 presents a cost breakdown of physical facilities in the network case study compared with those prevailing in various industries at the present time. The dramatic shift from computer equipment cost to communications and terminal costs in a network environment is clearly illustrated.

In summary, the economics of today's technology in computer hardware and communications permit the establishment of hierarchical computer/communications networks which can result in substantial savings to any user of multiple stand-alone systems. The case study network resulted in saving approximately 50% of the total operating cost of the computer facility, and currently available hardware could reduce the actual numbers in the study. For example, the substitution of an Amdahl 470 V/6 for the IBM 165-168 configuration would result in an additional 10% reduction in total cost.

Considering the other benefits of centralization, networks have not developed as rapidly as would seem to be indicated. However, the benefits (once understood) will dictate the rapid development of networks and a significant structural change in the information processing industry where the costs will shift away from general purpose computer hardware and towards communications services and terminal equipment.

IV. NETWORK IMPACT

The current state of computer/communications technology and economics as described in the previous sections of this report can be ignored only at great risk by computer users, hardware manufacturers, communications carriers, and computer service companies. The possible ramifications of network technology are as follows:

Users

It is apparent that the potential for a substantial reduction in data processing costs will be attractive to informed users with multiple installations. Those who have not already embarked on a centralization

EXHIBIT III-5

COST COMPARISONS — PHYSICAL FACILITIES (COMPUTER EQUIPMENT, TERMINALS & COMMUNICATIONS)

	COMPUTERS	TERMINALS	COMMUNICATIONS
NETWORK	54%	15%	31%
BANKING	79%	8%	13%
EDUCATION (UNIVERSITIES)	91%	4%	5%
INSURANCE	79%	10%	11%
MANUFACTURING (ELECTRICAL & DP EQUIPMENT)	84%	9%	7%

effort are currently either: a) conducting feasibility studies, or b) attempting to recruit the necessary managerial and technical talent to implement such an effort. The less knowledgable users will follow current trends quite rapidly as is customary. As data processing users gain network experience, the following can be anticipated:

1) There will be less concern about computer hardware since it will be less visible. The model and age will not be significant. This is borne out by many remote computing vendors which have continued to supply competitive service with equipment which would normally be considered obsolete. The extended life of computer equipment has significant benefits for users who can take advantage of it.
2) Attention will be focused on service levels and costs since the centralized service will be held responsible and users will receive immediate cost benefits for decreased volumes or improved systems.
3) The management of the centralized facility will generally be of higher calibre than that of the individual installations, and technical support services will also be improved. Specialists will be available for user consultation, performance measurement, and communications services.
4) Data processing personnel in the user organizations will be able to concentrate on the implementation and improvement of information systems rather than on the operational aspects of computer hardware and supporting software.
5) Computer power will be made more readily available to users who are not data processing oriented. The primary concern of these people will be for easy-to-use systems and equipment. Therefore the human factors involved in languages, protocols, and terminal design will be of primary importance.

Computer Equipment Manufacturers

The development of computer networks and large centralized facilities has significant ramifications for hardware manufacturers. Some of the considerations are as follows:

1) The price-performance characteristics of large scale systems and minicomputers combined with communications make stand-alone small and medium scale systems extremely difficult to justify. Any manufacturer who does not anticipate the impact of computer/communications technology on the sale of small and medium scale systems will have some severe adjustments to make in the not-too-distant future.

2) As centralization occurs hardware and computer services sales representatives will be dealing with better informed customer personnel. Cost and service levels will be primary considerations for the management of the computer utility since this will be the basis on which effectivness will be measured.

3) Communications services and hardware will compete directly with data processing equipment in a network environment.

4) Computer service organizations will be able to compete more effectively for data processing hardware dollars.

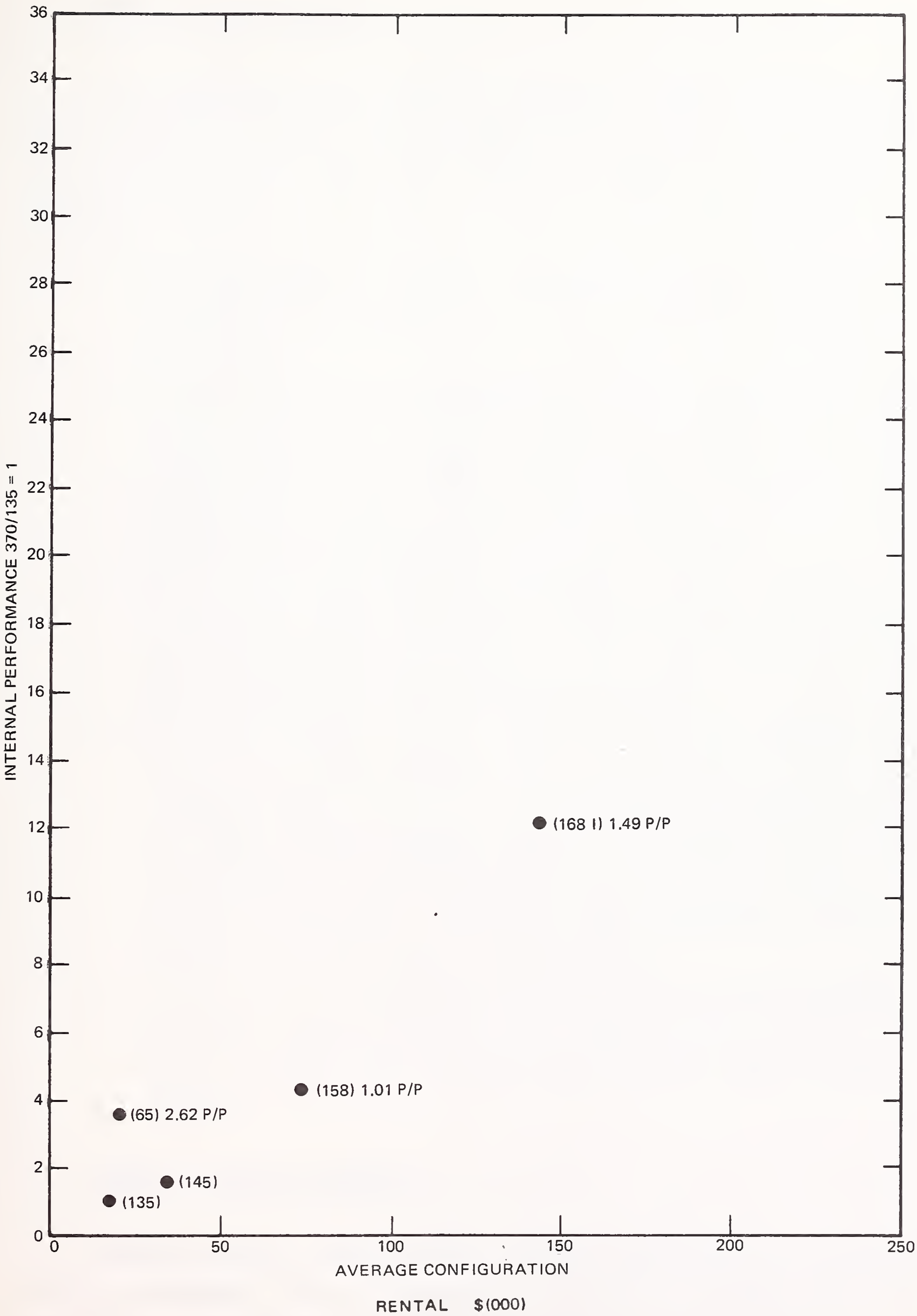
5) Used computers will have extended life and value in a network environment (and even on a stand-alone basis). The used computer market and its impact is worth additional consideration at this time. Exhibit IV-1 shows the familiar price-performance chart with the addition of a 360/65 which was only recently installed by a computer services company for high speed RJE using OS/MVT HASP. The actual cost of that system gives it price-performance which is quite competitive with the top of the IBM 370 line and clearly superior to 370 systems of its approximate power.

6) Vendors who can supply proposals for a total service (including communications) will have a definite edge in competing for network business. (This does not imply sole source, but rather, the possible emergence of project managers, 'brokers', or network architects who may use other manufacturers' hardware and services in their proposals) Under any circumstances vendors approaching 'full service' capabilities will have an advantage.

EXHIBIT IV-1

USED IBM SYSTEM 360/65 INTERNAL PRICE-PERFORMANCE

RELATIVE TO IBM SYSTEM /370



Communications Carriers

The communications and terminal portions of computer/communications networks present the most interesting and dynamic area of the technology. Since communications carriers are subject to regulation, it is difficult to predict exactly what may occur, but the following would seem to be probable:

1) The development of networks will present significant growth prospects for communications carriers (as demonstrated in the case study).
2) There will be severe competition for this extremely attractive market within and outside the regulatory framework. This will include not only the common carriers, specialized carriers, and value added carriers; but also joint ventures, network sharing schemes, and new entrants such as CATV operators.
3) Many computer/communications networks, both services and private, will carry a high percentage of message traffic replacing not only mail and telex, but voice as well. This impact may become more significant than is currently realized.
4) We should consider the U.S. Postal Service as a communications carrier for these purposes, and first class mail could be severely impacted since over 75% of it is currently transaction oriented. At current packet switching rates, it is possible to send over 12,500 bytes of information anywhere in the United States for the cost of a 13¢ stamp. An average retail statement does not contain 1/10 this amount of information.
5) There will be considerable confusion over what is communications and what is data processing, and communications carriers will tend to extend their activities and provide a more complete service.

Computer Service Companies

Computer services companies are especially sensitive to the economics of data processing and must therefore be effected by network technology more severely and immediately than either users or other vendors. Some of

the possible impacts are as follows:

1) As demonstrated in the case study, effective use of large scale computers in networks can reduce data processing costs substantially below those of comparable stand-alone systems. It will be difficult for computer services companies to show significant savings when they must compete against large companies which have established an internal network.

2) However, large scale systems have so much capacity that only the largest companies will have sufficient internal work to justify such systems. For example, the company in the case study is in the top one hundred of the Fortune 500 and could do all of its data processing on a single Amdahl 470 V/6 system. Only the largest industrial companies and computer services companies can afford to take advantage of the economy of scale represented by very large scale systems. The replacement of small and medium scale systems in smaller companies can, therefore, be an extremely attractive market.

3) The economics of minicomputers indicates that providing "time-sharing" service from large computers will not be an attractive market, where the service adds little value to the hardware.

4) In order to survive and grow, computer services companies must take advantage of network economics. Those companies offering total service from Level I through Level IV terminals will be in the best position to take advantage of the competitive environment.

Summary

The structure of the entire information processing industry is not clear at this time because the situation is extremely dynamic. A new competitive environment is developing among computer equipment manufacturers, communications carriers, and computer service companies. Since the information processing industry may become the world's largest marketplace within the next 10-20 years, the competition will be keen. An additional complicating factor is the confused situation concerning the possible regulation of computer/communications networks in an environment where it is difficult to determine what is communications and what is data processing. The Federal government must play a role in defining and controlling the type of competition which will be either encouraged or permitted - at present, this is an open question.

In order to assist in decision making and planning, it is necessary to anticipate technological change, competitive strategies, and governmental involvement.

V. TECHNOLOGICAL PROJECTIONS

The discussion of current technology made little mention of systems software. This was intentional since the purpose was to explore the economics of networks versus stand-alone systems with both operating under currently available software.

It is not within the scope of this report to present a history of systems software support, but it is necessary to make several comments if we are to project network technology on a 5-10 year time frame.

The case study network was operating under OS/MVT HASP which was designed and implemented for the 360 line. Simply described, it is a multiprogramming operating system supplemented by improved spooling capability. Multiprogramming and spooling were old concepts when 360 was announced and both are aimed at solving the same problem --compensating

for the fundamental imbalance between internal CPU speed and the relatively slow speed of peripheral devices. VS support for the 370 fundamentally corrects many of the deficiencies in OS -- job scheduling, access methods, security, etc. On the other hand, certain other 'advantages' such as memory management and deeper levels of multiprogramming are somewhat questionable since performance considerations dictate the use of more real storage and restricted levels of multiprogramming. However, the fundamental point is quite simple: neither OS nor VS was designed to support computer/communications networks. Both anticipated slow speed terminals connected to large central processors for either time sharing or data base -- data communications systems. SNA was an afterthought and will be discussed later. As far as DB-DC systems are concerned, not much real conceptual progress has been made since GE announced IDS in the early 1960's. Current DB-DC systems were not designed in anticipation of hierarchical computer/communications networks.

The performance of current operating systems in a network environment is unsatisfactory, at the least. Approximately 60-70% of executed CPU cycles are required by the operating systems - leaving 30-40% for problem program execution. When you realize practically all problem program code is generated by higher level languages you can anticipate less than 15-20% effective use of large scale systems. This is the reason hardware performance improvements have not been readily apparent to end users.

Now we shall proceed with what can be expected from technology in the next 5-10 years. At the time Exhibit II-3 was developed in the fall of 1975, another chart was prepared in an effort to anticipate possible IBM reaction to the 470 V/6, see Exhibit V-1. The original projections contained only the 178-I and 178-II, and 178-II was effectively ruled out because IBM has traditionally kept its 'super-computers' incompatible with the rest of its line. The 168 IV was added later because of price-performance improvements at the low end of the 370 line. What actually happened was the 168 V which is shown in Exhibit V-2. It came in with price-performance of 2.27 compared to 2.38 predicted for the '178-I'. Unfortunately, this is not an example of a technological projection, it is an example of a compe-

EXHIBIT V-1

PROJECTED IBM RESPONSES TO AMDAHL 470 V/6

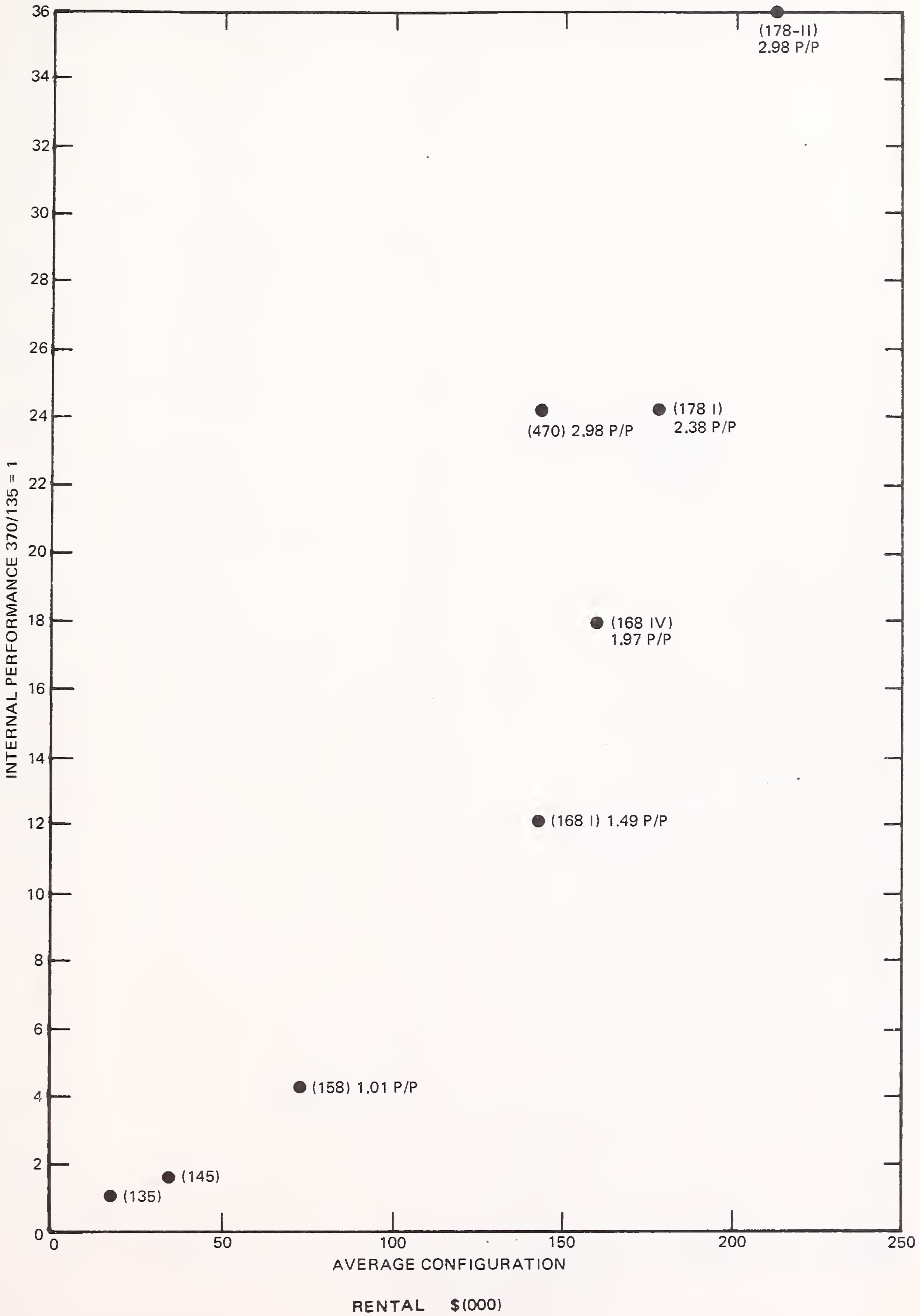
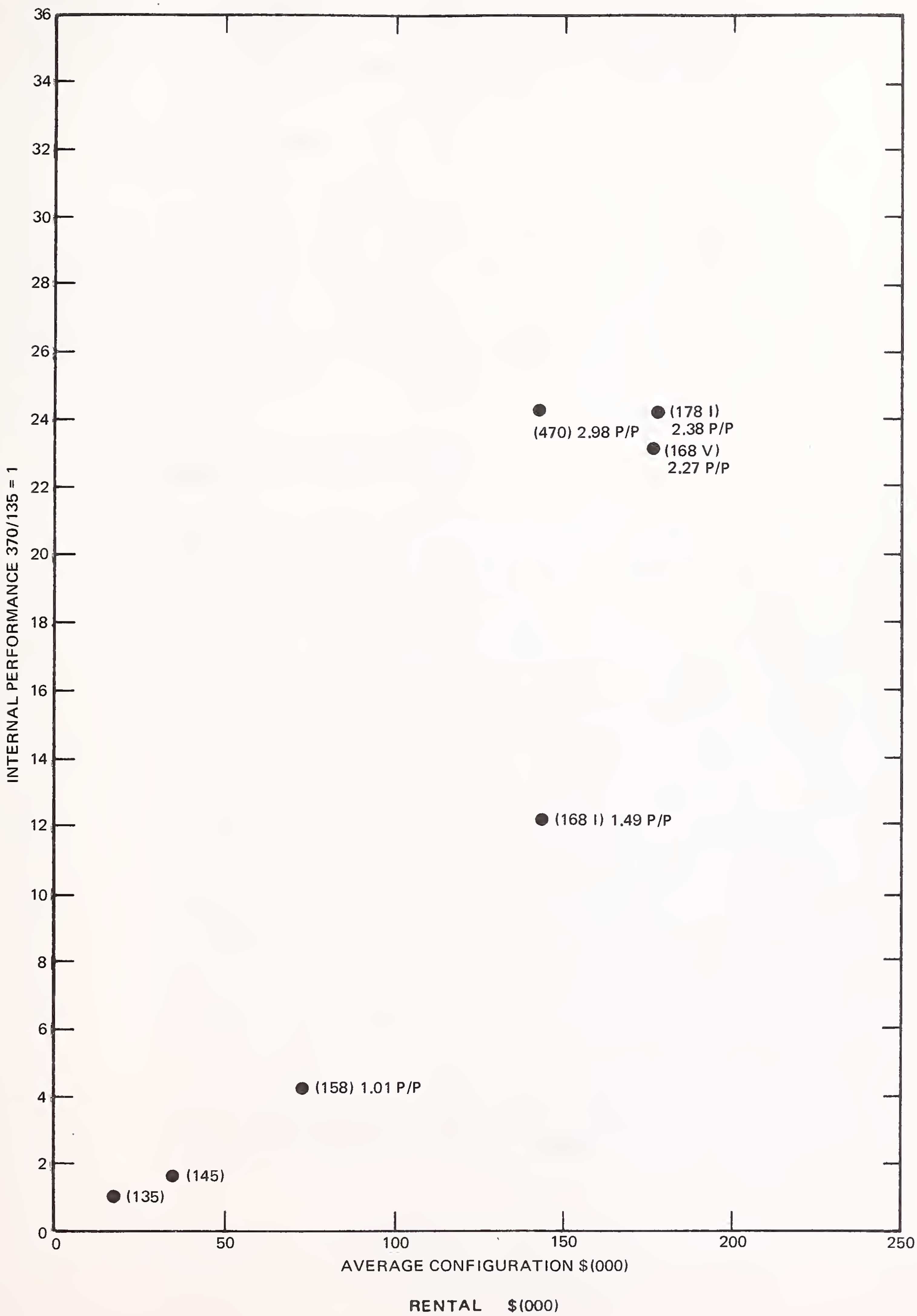


EXHIBIT V-2

IBM SYSTEM /370 MODEL 168 V, RELATIVE INTERNAL PRICE-PERFORMANCE



titive projection based on historical IBM patterns. It is apparent that technological developments are subject to competitive situations which may either delay or improve their actual availability in the marketplace.

Network Performance

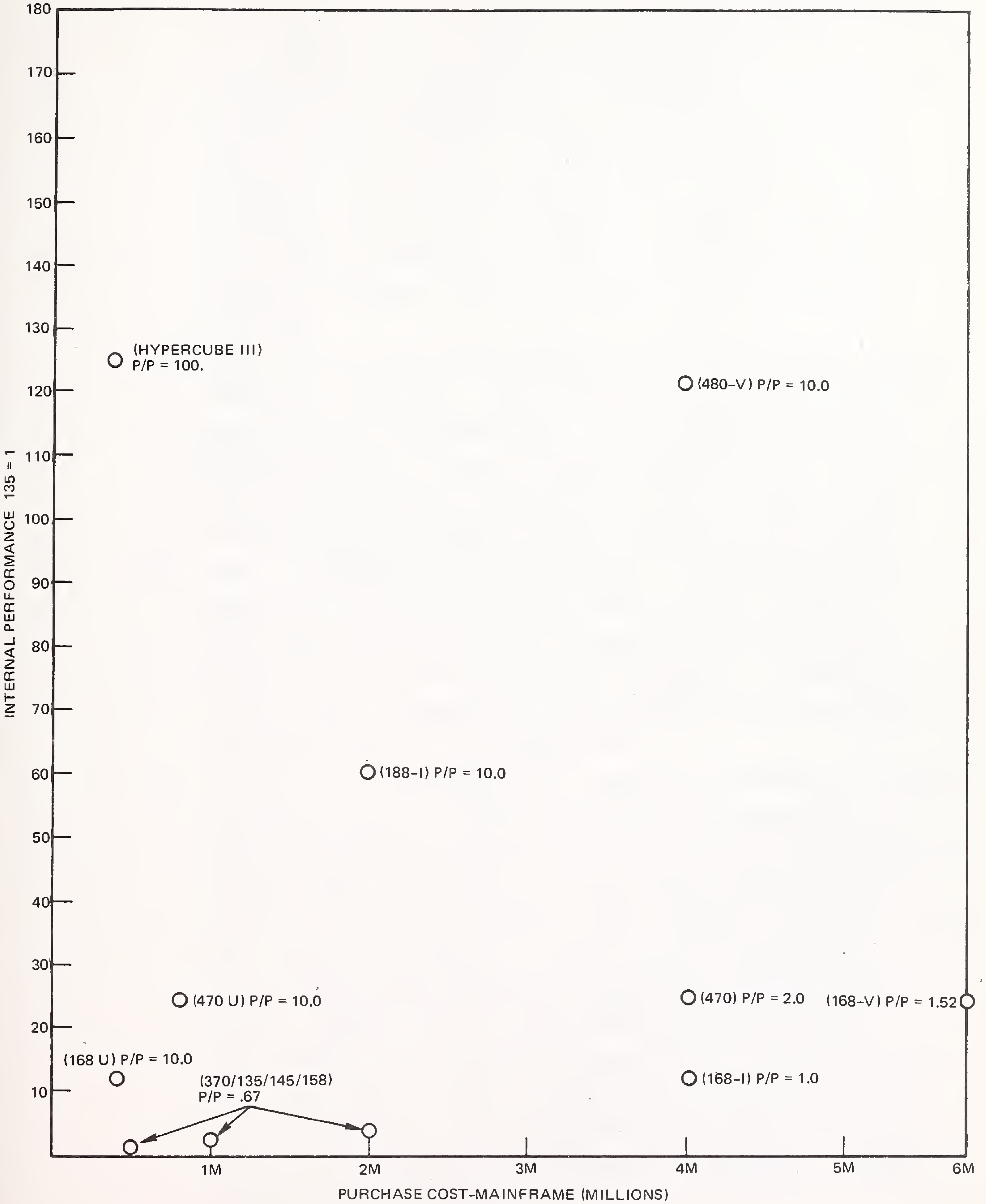
Five to ten years from now, a hierarchical network such as that depicted in Exhibit III-1 should have 7-10 times the effective throughput of those constructed with today's technology. This is measured on a strict price-performance basis which means tasks or applications systems which today cost $100 will then cost in the range of $10-$15 . This estimate is probably conservative and is based on the following:

1) Hardware Price-Performance

a) Improved internal price-performance of Level I systems which should approach 10 times that of the 168-I. Exhibit V-3 gives some possibilities for how this price-performance might be achieved. The chart is similar to those used previously. The internal performance scale has been extended but is still based on the IBM /370 IBM 370/135=1. The cost has been changed from average configuration rental to mainframe purchase price, and all price performance ratios are based on the IBM 370/168=1. The 480-V is a new system with 5 times the performance of the Amdahl 470 V/6 at the same cost. The 188-I is a new system with 5 times the performance of the 168-I at one half the cost (both of the new systems could be multiprocessing systems with multiple CPU's). The 470 U is a used 470 purchased for $800,000 or one-fifth its original cost. The 168 U is a used 168 purchased at one-tenth its original cost. By the mid-eighties none of these possibilities can be ruled out based on advancing technology and extended life of current hardware.

EXHIBIT V-3

POSSIBLE INTERNAL PRICE-PERFORMANCE OF HYPOTHETICAL SYSTEMS IN THE MID-EIGHTIES RELATIVE TO THE IBM 370/168



The Hypercube III is an array of microprocessors announced by IMS Associates, Inc., which potentially has 10 times the performance of the 168 at one-tenth the cost for price-performance of 100 times the 168. (There is also a Hypercube IV with 33 times the performance of the 168 at an increased price which maintains the same price-performance, but it was not plotted because it caused problems of scale.) Even if we have difficulty determining how to use microprocessors (and we will) the potential is such that they cannot be ignored. They only have to achieve 10% of their potential in ten years in order to have impact on network performance - not only at Level I, but throughout the hierarchy.

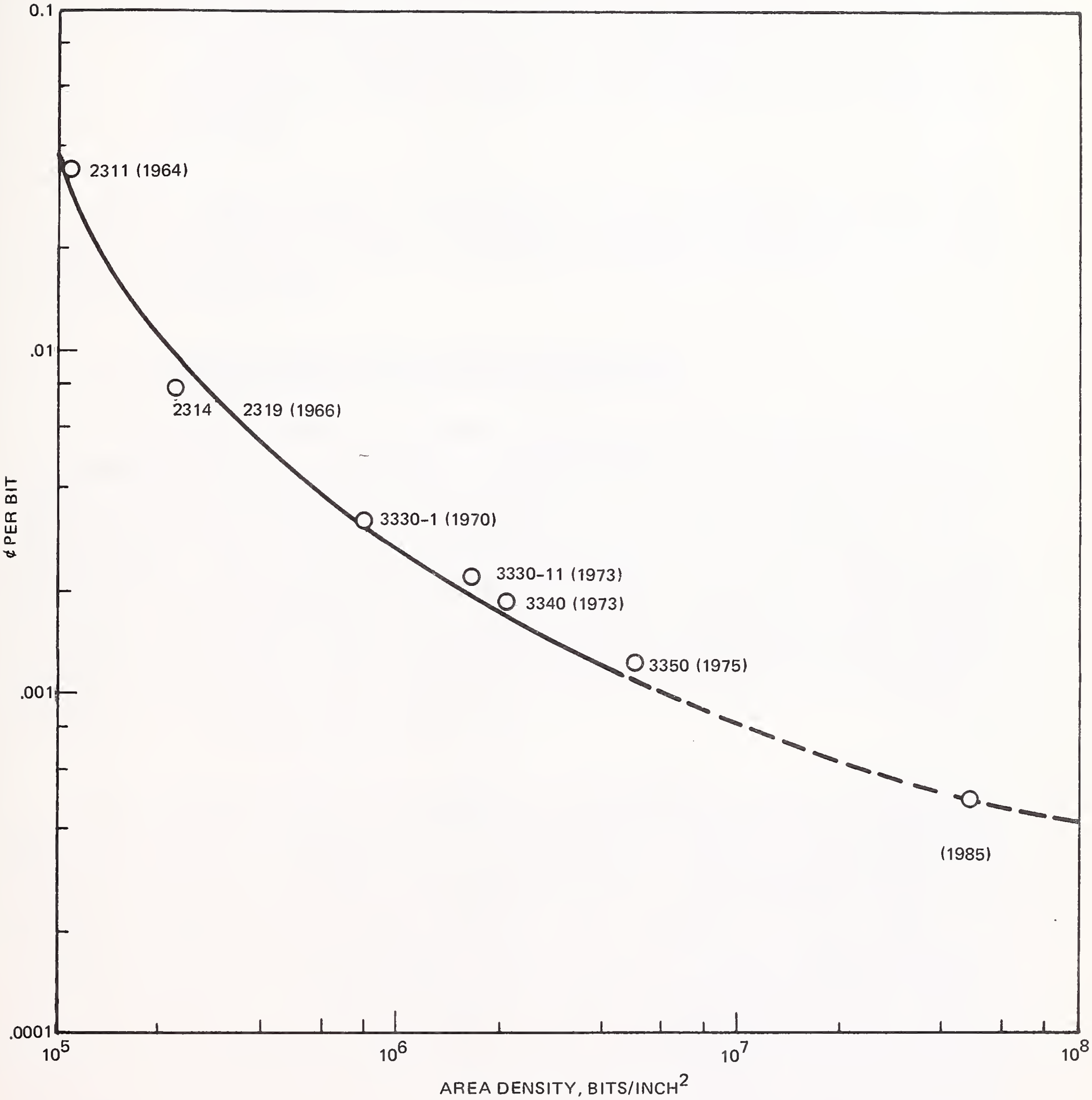
b) Level II's will also have improved internal performance, greater than that of the 168-I. They will perform the functions designated for them in Exhibit III-1. It is estimated that 40% of current workload on Level I's will be distributed to Levels II and III by the mid-1980's in order to take advantage of high internal price-performance and save on communications costs.

c) Level IV terminals will become cheaper as expensive electromechanical devices such as card readers, printers, and hard copy keyboard terminals tend to dissappear in favor of more economical data capture and display terminals. A good CRT will cost less than a typewriter and will tend to replace such hard copy devices even for 'correspondence.'

d) The cost of on-line storage will continue to decrease, with disk storage decreasing to .0005¢ per bit by 1985 (See Exhibit V-4) This is one fifth to one sixth of today's cost and the projection is quite conservative since projections have been made which do not even include disk storage by 1985 because of superior technology in the form of bubble or photo-optitcal memories which will have the additional advantage of being more reliable as well as cheaper. However, even our conservative estimate passes a critical threshold since magnetic storage will be cheaper than paper in most cases. Cheaper storage costs at Levels I, II and III will encourage the distribution of data bases and the distribution of processing against these data bases will improve overall network performance.

EXHIBIT V-4

HISTORICAL AND PROJECTED COST AND DENSITY
OF IBM DISK STORAGE DEVICES



e) In addition, Level V terminals will appear in substantial numbers. Level V terminals are defined as mobile terminals which can connect to the network. These terminals are of two varieties: a) those which are 'on-line' via radio such as the digital terminal systems already appearing in police vehicles and other emergency vehicles, and b) those that have the ability to be carried by an individual to record transactions for later transmission into the network and which can also be connected to the network for information retrieval.

All of these technical developments in the data processing area will combine to achieve the overall projected effective throughput for the networks of the mid-1980's.

2) Communications Technology and Economics

Since communications technology incorporates all of the latest developments in computer technology and adds advances in transmission media, it is even more exciting than developments in computer equipment. Unfortunately, the economics of technical advances and their timing is much more difficult to predict because of the unclear competitive and regulatory situation. For that reason the projections of network performance did not contain undue reliance upon improved economics in communications rates. However, there must be some reduction.

Our projected network performance improvement was that what cost $100 with current technology would cost between $10-$15 by the mid-1980's. With the case study network, we determined that communications costs represented approximately 30% of network costs (Exhibit III-5). If we assume our computer technological improvements will cut costs to 12% of the $70 allocated to network hardware, the result would be $8.40. In addition, our assumption that 40% of Level I processing would be distributed would automatically reduce the $30 communication cost by 40% to $18.00. This figure must be reduced to $6.60 in order to hit the high side figure of $15.00. This would represent a 73% reduction in data communications costs over the next 10 years. Such a reduction seems reasonable in view of the following:

a) Use of satellites for intercity communications. Such service has recently reduced communications service costs between the east and west coasts by over 50%.[4]

b) Availability of cheap earth stations which would permit satellite communications to be directed to Level I and Level II nodes regardless of geographic location.

c) Probable availability of cheap packet switching services between all major cities, as value-added carriers make use of advances in communications technology.

d) Use of coaxial cable for communications on an intracity basis. The use of existing cable systems is currently being considered for data transmission at extremely low rates because cable operators would be selling excess capacity. Even if such carriers came under regulation for data transmission the rates should still be significantly lower than are presently available.

Of course, everything in the communications area is somewhat speculative because of Federal and local regulation of communications carriers. Encouragement of intelligent regulations will permit orderly and significant lowering of communications costs which will give impetus to the design of computer/communiations networks which should benefit the total economy. The technology to implement such network[5] does not appear to be a problem. Establishment of the proper competitive environment may be.

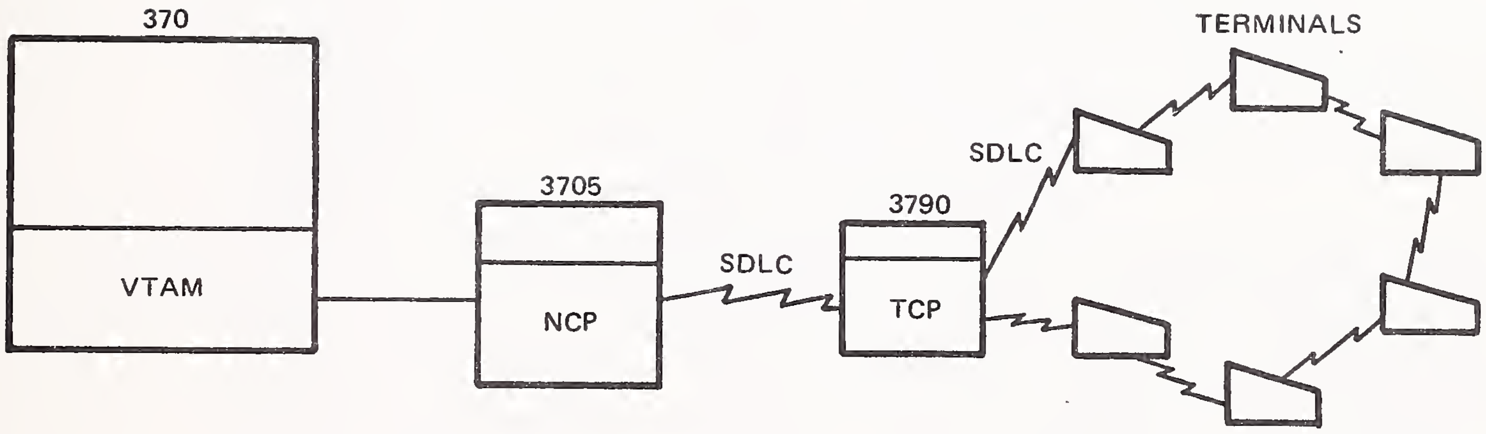
3) Network Architecture and Software Support

At the beginning of this section, we touched briefly on the current status of software development. Exhibit V-5 shows a rough schematic of IBM's System Network Architecture (SNA). It is based on the VS operating system, both the Network Control Program (NCP) and the Terminal Control Program (TCP) are in software, and the communications protocol is Synchronous Data Link Control (SDLC).

Standardization on a communications protocol is highly desirable and we feel this will be done (actually there are some who feel microprocessor technology makes standardization unnecessary). Whether it is SDLC, HDLC or BDLC should not make any difference as long as some standard is established and reasonably well adhered to.

EXHIBIT V-5

SYSTEMS NETWORK ARCHITECTURE



Without a detailed critical analysis of SNA, we would like to make the following observations:

a) VS was not designed in anticipation of distributed processing and distributed data base. This is not to say such a network cannot be implemented under VS, but it contributes very little to such implementation.

b) An adequate NCP cannot be implemented on the 3705. There is every indication that IBM recognizes this and will eventually correct it.

c) However there is little indication that IBM either understands or has any intention of implementing networks incorporating multifunctional Level II's as described in Exhibit III-1.

d) The various nodes in the network are heavily software dependent - this could make life difficult for the manufacturers of competitive minicomputers and terminals as SNA evolves. In a network environment various manufacturers' hardware should be accommodated. However, playing follow-the-leader on software could be not only expensive but impossible.

e) There is a fundamental conceptual problem between today's data base - data communications systems and either hierarchical or distributed networks. Such systems were designed to accommodate large centralized data bases. Large centralized data bases are neither required nor desirable for most data processing problems in a network environment; and even when they are, subsets and/or supersets (in terms of local data elements) will be required. Anyone who establishes a centralized data base using today's software systems has a substantial exposure to conversion problems as SNA and other network architectures develop.

Even prior to the availability of today's computer technology, there was a serious question whether so much reliance should have been placed on programming. Today such dependencies are inexcusable and cannot long survive. The reason we still have the problem and the reason it developed in the first place is two fold:

a) Computer architects and engineers have little idea of how general purpose computers will be used - especially in the commercial market.

b) Computer architects and engineers are under substantial pressure to keep costs down and are measured on their ability to do so.

Therefore, many functions which could be done more economically in hardware have been left to software - at tremendous cost to both the manufacturers and to the user community. Unfortunately, the manufacturer only pays once-during the development of the software; the user continues to pay over the life of the system. Consequently, the manufacturer does not feel compelled to solve the problem.

This fundamental problem should be solved by the mid-1980's and many operating system functions, language processors, network control programs, terminal control programs, and common applications will be included in hardware. The technology and knowledge to accomplish this exist today and the first steps in this direction are already being taken - this trend will accelerate.

This will result in a lowering of programming costs to the user because both systems and applications programming functions will tend to be minimized at that level. The "programming" in a network environment will be done by the end user and specialized languages will appear to assist accountants, statisticians, doctors, chemists, students in various disciplines, secretaries, and eventually the general population.

While all of this sounds very attractive, there is a great deal of work which must be done in two areas - network directories and data dictionaries. The designers of any internal network must give special attention to the ability to address any: computer, terminal, individual, organizational entity, or geographic location serviced by the network and appropriate directories must be established. In addition, the data resident within the network must be defined and described in a concise and meaningful manner. Much of this is tedious and unattractive work which does not appeal to systems analysts and programmers. However, it is of extreme importance and must receive their attention.

Another consideration in network design must be the interfacing and possible absorption of internal networks by those of broader scale. Thus industry-wide and perhaps nation-wide directories must be contemplated. This will require national direction from some source and should be

encouraged as a major standards effort. Standardization on data dictionaries is also essential in major systems areas such as medical, education, banking, retailing and various governmental functions. Interested users should participate actively in encouraging and directing such efforts.

Thus, while projections of overall network technology appear attractive from an economic point, careful planning is required for the development of both private and service networks. Otherwise severe problems of interconnection will develop at some future point.

VI. GENERAL ENVIRONMENTAL FACTORS

By definition, computer/communications networks imply the tying together and merging of not only separate technologies, but various disparate interests. Other sections of this report have alluded to some of the problems which must be anticipated and addressed. The economics of network technology will dictate their development - how they develop is a matter of some concern.

If we aggregate computer manufacturers, communications carriers, computer service organizations, and the U.S. Postal Service we have gross revenues well in excess of 50 billion dollars per year. Depending upon how networks <u>are permitted</u> to develop, serious problems could arise for any of them:

1) Communications services in a network environment can be substituted for a substantial portion of computer hardware. While terminal equipment is projected to be a fast growing area, is it a data processing or a communication's product? This question has already been raised and it is significant since regulation may be implied if it is considered a communications product.

2) If computer manufacturers are permitted to sell unregulated terminal equipment the impact on communications companies is apparent. If computer manufacturers are permitted to become allied with specialized communications carriers the common carriers will lose much of their future growth potential and even current services could be impacted.

3) As computer service companies expand their networks, significant communications traffic will be diverted from the common carriers. Is this subject to regulation?

4) If computer manufacturers or common carriers become involved in providing full network services, computer service organizations will have severe competition.

5) No matter what happens, the U.S. Postal Service faces a significant threat to first-class mail service unless it provides network communications and/or processing services.

Thus, all four interest groups must vie for the attractive network services market since data processing and communications services will interact so closely in the new environment. Each must aggressively pursue the new technology if they are to maintain their present position, much less participate in the enormous growth potential. This competition will have a pronounced effect upon the way business is conducted in the United States and its economic impact will be felt directly by every private citizen. It would appear that it is in the best interests of the nation and the competing forces if all survive and prosper since their resources are required in order to implement this drastic change. However, this is by no means assured since no effective policy has been established to guide, govern and control the development of this new technology. This is understandable since there is no established organizational entity within the Federal government which is either charged with the responsibility or is technically qualified to provide the leadership which is required.

Competition

At the present time, it is apparent that both IBM and the Bell System understand clearly the stakes involved and have enough chips to play the game. They will obviously be there at the end.

IBM has the world's best marketing and systems support organization and an installed base of still loyal customers. It also reaches into even the smallest business enterprises with its office and general systems products - the typewriters of today are the Level III and IV's of tomorrow. IBM understands this and is organized to take advantage of the opportunity. It has not demonstrated superior capability in communications based systems.

AT&T has an installed network which reaches into every home and business in the country. It has technical resources in all aspects of computer/communications networks which are unsurpassed in the world. It has service facilities which are unparalleled in terms of coverage and excellent in terms of quality. It has not demonstrated systems marketing capability, but recognizes this deficiency and is attempting to correct it.

Both IBM and AT&T will remain under close scrutiny from the Federal government and their smaller competitors as they move into closer competition. Viewed in abstract, it is an extremely interesting situation. Unfortunately, every user of computer and communications services has a vital interest in what happens and these interests may not be served.

Some of the specialized and value added carriers also understand the competitive situation (perhaps even better than the main participants) and with luck and help, they will survive--perhaps to be absorbed. AT&T makes point that one system is theoretically "best".

The other computer equipment manufacturers have an excellent possibility for expansion of their present markets as the ratio of investment in a network environment shifts from mainframes to Levels II through V. IBM has not been dominant in these markets. With an understanding of the network architecture significant opportunities exist for established companies with only modest new investment. The investment would be in software,

firmware, and hardware which would establish and maintain an interface to Level I IBM (or IBM compatible) systems. This implies the replacement of IBM's Network Control Program and Terminal Control Programs, and the ability to access IBM data bases. This would assure competition for hardware and applications systems at lower levels in the network and these represent the most promising new markets.

The computer services industry has developed under an umbrella of high prices and in marginal market areas. However, it has one strength -- it got involved in networks early because of timesharing and it is just beginning to understand and exploit the remote batch market. For those companies in a position to exploit network technology the future can be extremely bright. For those who do not understand the technology or who do not have the resources (technical or financial) to take advantage of it, there cannot be much of a future. Only a limited number of computer users will have the internal resources to take advantage of network economics - those who do not are excellent prospects for service organizations. Under any circumstances, it would appear to be a time of consolidation in the computer services industry with smaller companies being absorbed by larger firms with more financial and technical resources.

The plight of the U.S. Postal Service should concern everyone since we all must use it. It's problems are very real and they can only become worse, unless services are expanded and improved rather than cut back. Some immediate imagination and creativity is required in order to take advantage of today's technology. How much would it be worth to the individual citizen to receive a consolidated statement for most of their bills and make electronic payments? Obviously, several dollars a month in postage and checks. Businesses currently mailing bills would also find such services attractive. Can mail drops become terminals? There are numerous possibilities and if the Postal Service does not supply such services others will, and this will directly impact revenue and ability to provide adequate traditional service. It is difficult to be optimistic about the prospects for the Postal Service under the present circumstances.

Regulation

In this environment, the Federal government must establish an overall policy to encourage and/or control the development of computer/communications networks in the best interests of the nation. This requires understanding and vision which does not appear to be readily available in either government or industry. It is essential to define clearly the products and types of service which are subject to regulation, and much of the competition will occur in the regulatory arena. Vendors are actively involved in putting forth their own particular points of view on this subject. It is our opinion that, for better or for worse, many network services will eventually be classified as communications and consequently subject to regulation. For most vendors, this is not necessarily bad since the Bell System has certainly been able to thrive in this environment. However, it will certainly change the way business is conducted. On the other hand, because of anti-trust, there is also a tendency and temptation to breakup the major vendors, and the economic impact of such 'forced competition' is not at all clear. Users of data processing and communications services are not adequately represented in many of the deliberations which go on and they should be. Filing before the FCC does not cost a great deal, and users have an obligation to become knowledgeable and express their opinions on these vital issues.

Privacy and Security

There is one major issue which may stand in the way of realizing the true benefits of the rapidly developing technology. This is the issue of privacy and security - which is really two interrelated issues we prefer to treat as one. There are very legitimate concerns in these areas. On the other hand, if some of the proposed solutions had been applied to the development of previous systems, we would not have a Bell System or Postal Service to worry about today. Indeed, no commercial or governmental structure could have developed. The mere fact we can consider such solutions today is a result of technology - the problems existed previously. The technology has brought focus and possible solutions to these problems.

Dr. Ruth M. Davis, Director of the NBS Institute of Computer Sciences and Technology has defined the problem:

> "The problem of 'Security in Automation' is multi-dimensional in scope. Its several components can be characterized along axes of:
>
> - Protection of the privacy of the individual: a responsibility of the judiciary and legislative branches.
> - Management of information in automated record-keeping systems: a responsibility of management and information management technologists.
> - Assessment and assignment of costs of Security in Automation: a responsibility of the services industries and government.
> - Establishment of procedures, guidelines and standards to assure information management is in compliance with legislative and judicial requirements for privacy: a responsibility of government, management, industry and the public.
> - Development and application of the needed automation and information management technologies and products: a responsibility of industry, information services and the government.

Resolution of the problem of Security in Automation will result from the derivation of solutions that will satisfy all the individual problem components. It is an empty exercise to pass legislation that is technologically impossible to implement. Similarly, it is just a tour-de-force to design equipment or procedures that are too costly to use.

Progress towards resolving the problems of Security in Automation is thus dependent upon coordinated, in-step efforts of the judiciary, congressional and state legislatures, Federal, state and local government, management information service industries and the automation and information technology industries."

The above definition of the problem and statement of responsibilities is helpful, but if we must depend upon the "coordinated, in-step efforts" of the entities listed in the last paragraph to "progress towards resolving the problems," it is difficult to be hopeful of meaningful resolution.

Depending upon interpretation, existing and pending legislation could seriously inhibit the application of network technology to the detriment of government, business, and the population at large. Several observations are in order concerning the issue:

1) There is no documented evidence that computers have created any <u>new</u> problems concerning loss of privacy.
2) The number of documented security incidents related to computer based systems is extremely small considering the wide application of such systems.
3) The cost of "data confidentiality" to insure privacy, and data security to protect against fraud and intrusion can be substantial and afford little more protection than most systems already in existence. In some cases, the continuing cost could easily triple or quadruple; the processing expense and the one time costs could be astronomical as existing systems and data bases would have to be converted.

4) Equipment vendors have little incentive to oppose unreasonable legislation since additional sales will result.
5) It is important that users of data processing equipment be adequately represented before appropriate governmental bodies and organizations, and that they educate the general public concerning information systems technology.

At the present time, the following developments can be anticipated as a result of concerns about privacy and security:

1) There will be some form of national legislation in an attempt to insure the individuals right of privacy in terms of disclosure and control over information contained in commercial as well as government data bases. In addition, there will probably be substantial confusion as individual states also pass privacy legislation. Jurisdictional considerations will probably follow classic guidelines.
2) A substantial period of time will be required in order to implement systems which will insure compliance with such legislation, and the expense involved will probably dicatate significant changes in the specific requirements during the implementation period.
3) Standards will be established to insure compliance with privacy legislation and these will cover systems security. In all probability, the intial standards will have quite a bit of 'overkill' built-in since the primary models available are military systems. Once again, changes in standards will occur based on economics and user reaction.
4) Agencies established to insure compliance with privacy and security legislation and standards may raise serious questions concerning 'institutional privacy.' What rights do business enterprises and governmental organizations have to maintain records necessary to function successfully?
5) Current computer and communications technology (hardware & software) may require redesign in order to accomodate privacy and security requirements. This would be expensive (perhaps pro-

hibitively so).

6) Depending upon the individual organization's requirements, it will undoubtedly be more economical to contract for the processing of certain information through a 'certified public service.'

7) Current accounting systems and practices will not be adequate in the new environment.

Obviously, all of the above must influence any information systems plans and can impact the implementation of any system or network. Awareness is extremely important in this area, and participation in the technical and political processes which will establish the systems environment is essential.

Summary

Computer users and vendors confronted with the current economic and competitive environments which result from the development of computer/communications networks have some difficult decisions to make. However, reduced data processing costs and the availability of economic and reliable service (from either services or private networks) will permit users to address applications areas which have not been deemed feasible in the past. The data processing professional will be concerned with making network capabilities more readily available to end users and not with the installation and management of computer hardware. Management will find both the benefits and the costs of service to be much more understandable and controllable. The data processing industry will finally reach maturity and be put into proper prospective.

VII. GUIDELINES FOR DECISION MAKING

The complex economic, technical and environmental factors existing in the information processing and communications industries make it more important than ever to develop a meaningful information systems plan. The process of developing such a plan is extremely complicated, and there cannot be a simple "cookbook" solution to the problem. Each enterprise is different not only in its specific business requirements, but in its current application of technology.

The following guidelines are intended to provide a general framework within which a plan can be developed. The emphasis will be on the establishment of information requirements - the things which should be considered during the planning process as opposed to specific criteria. The guidelines will address only major technological and environmental considerations and not applications oriented questions.

The most fundamental step in developing a plan is to specify the planning period. In a stand-alone computer environment, a long range plan has traditionally covered approximately 5 years. This was dictated by the dynamics of the computer industry and the major vendors' product cycles. In a network environment, consideration should be given to extending the planning period. A ten year long range plan would seem more appropriate (even though it may be more difficult), and that will be used when referencing long range plans in the guidelines.

A short range plan will be understood to cover two-years, and a budget will cover one year. The guidelines are intended to assist decision making in the planning process (with emphasis on long range plans) and will not address budgetary considerations.

During the planning process serious consideration should be given to the following areas:

1) Centralization vs. Decentralization

The economics of hierarchical networks outlined in this report dictate that any organization with multiple stand-alone computer facilities should do a thorough economic analysis of centralilation vs. decentralization. While the economic benefits of centralization using today's technology are most pronounced for the large user who can take advantage of the superior price-performance of large scale systems, worthwhile cost savings can also accrue to users of medium scale equipment. Even when the initial economics seem marginal careful consideration should be given to the other advantages of centralization.

Centralization vs. decentralization is an issue for immediate decision making and short range planning (although actual implementation may extend beyond the two year period). It should not be necessary to conduct lengthly feasibility studies since the technology is currently available, and realistic cost comparisons should not be difficult to develop. The information developed in this analysis will also serve as useful input into the long range planning process, but an immédiate decision concerning centralization can be made before the long range plan is completed with reasonable confidence that centralization will not have an adverse impact on the long range plan.

2) In-House vs. Outside Service

Whether or not the economics and other considerations justify the establishment of a computer/communciations network the cost of establishing and operating such a network should be compared to the cost of purchasing comparable service through an outside vendor. An important consideration in addition to cost is the availability of the necessary technical talent to implement a private network. (This will discussed under personnel requirements).

Any users of stand-alone medium or small scale equipment should explore the possibility of acquiring better service at less cost through an outside vendor. Such standalone systems can seldom be justified if a truly accurate cost analysis is done.

Even if the economics and service levels of an outside vendor appear attractive, a company may opt for an internal system or network. However, accurate cost comparisons with outside service companies are a good measure of the performance of the internal operation. Since the economics will probably improve in favor of service organizations as public networks develop, such cost comparisons should be made on a continuing basis.

On the other hand, services purchased from an outside vendor must be evaluated against developing technology. For example, the primitive timesharing networks may no longer be competitive with comparable services available from a Level II minicomputer installed on a local basis (in either a public or private network).

While all of the above are short range considerations, there are also long range ramifications of "in-house vs. outside service" for anyone establishing a private network. The long range plan should include the possibility of joining or interconnecting with a broader network in any of the following ways:

a) merger with other private networks,
b) through purchase of specific services from another network,
c) through absorption into a public network.

3) Hardware Effective Life

The projected effective life of computer/communications networks hardware will be substantially greater than that of traditional computer equipment and substantially less than that of current communications networks. A level by level analysis should be made depending upon network usage since effective life will vary because of applications systems design. However, some rough long range planning guides are as follows:

a) networks should be designed with Level I and II computers having anticipated life of at least 10-15 years,
b) Level III intelligent terminals should have at least 10 years of effective life, and
c) Level IV terminals should have anticipated life of 5-10 years.

Under most circumstances it is obvious that long term lease or purchase of network hardware is indicated.

However, there are several areas which should receive special consideration during network planning and systems design:

a) Most card readers and high speed printers can be obsoleted early through good systems design.

b) Today's magnetic tape and disk storage systems may be obsoleted by accelerated development of low cost non-rotating memories.

c) General purpose Level III intelligent terminals will probably be obsoleted quite rapidly in terms of cost and function. Careful systems design is required to insure effective life of 10 years.

d) Level II minicomputers which are used exclusively for network control functions will probably be replaced by systems with capability to perform multi-functional services. (It is possible such systems can migrate to other functions in the network and maintain the targeted effective life, but this must be planned.)

e) Level V portable terminals are in such an early stage of development their life expectancy is unpredictable, but it will probably be short since their cost will drop substantially within five years.

4) <u>Systems Software Selection</u>

Everything else being equal, it is always desirable to keep reasonably well abreast of the latest operating systems developments. Unfortunately, things are never equal - there are good and even compelling reasons to use VS and there are good reasons to avoid it. Each case requires careful analysis but the following guidelines may help:

a) There is no reason a computer/communications network <u>must</u> be developed under VS regardless of vendor strategy.

b) VS will <u>not</u> be a logical bridge to the systems of the future.

c) Users should not let arguments concerning a and b above influence software decisions.

d) Be sure the true cost of using VS is understood in terms of systems overhead and additional hardware - this may be complicated but it is worth the effort. VS represents a continuing cost above and beyond OS.

e) Be sure the true cost of converting from OS to VS is understood, if it is required. 90% of the conversion might be done quite easily, but the final 10% may require considerable expenditure.

f) Support for new peripheral equipment is important, but if the device is attractive enough someone will support it or develop something comparable under OS.

g) Anticipate the possibility of significant performance improvement becoming available in OS. (Either through users or software houses.)

h) If systems security is <u>really</u> a requirement, VS may be necessary regardless of other considerations.

i) Be aware that adoption of the overall Systems Network Architecture and its supportive software may limit the choice of communications controllers, terminal controllers, minicomputer and terminal equipment.

j) There are occasions when delaying a decision to convert operating systems may be costly since it will be more expensive to convert later.

k) Once a distributed network is developed it will be extremely difficult to make a major operating system change.

l) Consider the fact it will probably be necessary to interface the network with others.

m) Support packages from independent software vendors should be considered.

n) Needs should be carefully analyzed before installing any data base management system, especially with generalized data base systems if there is the need for a really large data base. Some of these systems are extremely costly for the functions they perform and there can be many hidden personnel costs. The premature establishment of a large data base using a generalized system may present serious conversion problems in the future.

o) Determine whether "savings in programming costs" associated with generalized systems are real or are merely being hidden (and perhaps increased) by having operating personnel perform "data processing functions."

5) Personnel Planning

Before undertaking any complex system development it is necessary to determine the human resource required for implementation. Computer/communications networks are quite complex and there is a shortage of skilled personnel who understand both technologies. When undertaking the centralization of computer facilities and the establishment of a network, resources must be pooled. This implies viewing the network as a single entity from a personnel point of view. All personnel involved with implementation should report to common management at an operating level - this includes systems personnel and all communications personnel. Applications personnel can remain under the local management; this will be the trend in future.

Once resources have been pooled, it may be found that the necessary technical talent is not available - it is important to recognize this since a half completed network is extremely costly. If the talent is not available internally, users must either: a) recruit or b) obtain consulting service. It is not recommended that vendors be relied on for significant implementation assistance, because of the network biases which will result.

The shortage of technical computer/communications personnel may make the purchase of services from a network service not only more

desirable but necessary.

6) Privacy and Security

Every responsible manager in government and business, and every individual has a vital interest in the fundamental issues of individual privacy which are being raised. This is a real issue and what happens will have significant impact on individual freedom (in either direction), and will unquestionably be costly. It is necessary for management to have both a business and personal understanding of the issues and the proposed solutions.

The following guidelines address only technical questions which must be considered:

a) Plant and industrial security specialists are seldom knowledgable of the security requirements of complex computer systems and should not normally be relied upon for decisions in this area.

b) Many consulting organizations specializing in security also lack the technical knowledge required to evaluate network security. Those that do have technical knowledge frequently apply standards which were developed for national security and which may not be appropriate for a business enterprise.

c) Responsibility for data base management and network security should be centralized into a single organizational entity. This organization will require both applications knowledge and systems programming expertise. After all of the talk about data base administration, the function must now be established.

d) "On-line systems" will always be considered more vulnerable than other systems. Careful consideration must be given to on-line data requirements.

e) The cost of security must be analyzed in detail and fully understood before any new system (hardware or software) is designed and implemented. Such estimates should be required in any planning process.

f) Accounting and auditing personnel should be educated in the ramifications of computer/communications networks and their advice sought on matters of security and ability to comply with commonly accepted accounting procedures, which themselves will be changed.

In overall summary, computer/communication networks and emerging technologies offer great promise in terms of providing cost effective information services. Low cost service will permit the application of network technology to new application areas with potential benefit to business, government and individual citizens. However, the competitive and environmental structure in which networks will develop is not clear, which makes the preparation of meaningful information systems plans difficult. Careful technical planning is such a situation becomes more important than ever before.