Future Product Committee Meeting Firenze, 1980

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SDC´S VIEWS ON COMPUTER TECHNOLOGY AND ITS IMPACT ON FUTURE BRANCH OFFICE SYSTEMS.

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Contents:

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Introduction
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This paper has been prepared for the Future Product Committee Meeting in Firenze, 1980. Intended to serve as a base for future discussions in the product committee, it covers some important issues in the design and evaluation of future banking systems. The basic objective of the paper is to introduce the general overview of technology impact at the management level, without being too technical. The views expressed in this paper are those of my own, and not necessary those of SDC although the content has been discussed and ac~~cepted in SDC.~~

The paper is confined to cover the branch office systems in the savings banks, partly because this is the basic area of interest for the product committee and partly because this is the area where the technological evolution mostly will affect both users and costumers in the Danish savings banks.

SDC has for many years been trying to obtain leading-edge know-how within the fields of banking systems. This know-how has primary been concentrated on central applications development and ergonomic properties of end-user systems. The general awareness of the technology impact on systems has always been maintained, but never studied in details. We feel, however, that the today´s technology is beginning to perform an increasing impact, which cannot be neglected, especially in the area of microelectronics.

In the recent years, the use of microelectronics have been expanding rapidly. The main reason is the advent of **LSI (Large Scale Integration)** and **VLSI (Very Large Scale Integration)** technology. This technology makes it possible to integrate a large number of electronic circuits onto a single, small piece of silicon, called a **"chip"**. VLSI in particular offers the potential of integrating hundreds of thousands of electronic components (e.g. transistors) onto the single chip of silicon, measuring a few or even less than a square centimeter. The basic properties of LSI and VLSI is very advanced and complex circuits, which are cheap due to the large production volume. Modern computer technology relies heavily on the use of LSI-circuits and many of todays electronic circuits have passed the border between LSI and VLSI, e.g. the new 16-bit microprocessors and the 64 Kbit RAM.

VLSI impact on data processing building blocks.
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More and more computer systems are built around standard electronic building blocks. These building blocks get steadily more advanced in their performance and internal structure, but yet still more simple to employ in actual implementations.

Microprocessors, the product of the seventies which suddently caused a break-through in computer designers' view on how to architecturally implement systems, have in the last few years gained a very high level of sophistication due to LSI technology. ~~The first 4-bit microprocessors were primarily used for controllers and were virtually useless in any real data processing applications~~. The migration to 8-bit microprocessors like the 8080 and Z80 indicated a trend towards actual data processing capabilities within the chip. The 8-bit microprocessors were and are to some extend inhibited by their more or less ad hoc defined instruction sets, taken over from the 4-bit world, and their limited addressing capability of 64 Kbytes of memory.

The **new generation of 16-bit microprocessors** has taken a significant approach towards providing sufficient computer capabilities on a single chip. Microprocessors like the Z8000 and MC68000 now offer features hitherto only found on mainframes and large minicomputers. They provide a large addressing space, typically more than 16 Mbytes together with advanced memory management capability for dynamic relocation and virtual memory. They differ between execution of systems and user programs, with priviliged operations and are designed for multiprocessor applications. In spite of this, the price is low: typically around 100 dollars for a chip outperforming even the high end of the minicomputer market today.

Memories show the same trend of more circuits on a chip simultaneously with lowering prices. Semiconductor memories replaced the costly ferrite core memories in the seventies, and today you will find megabyte sized memories even on some hobby computers. Memory technology proceeds in different directions, providing high density read-only chips (ROMs), random access memories (RAM) and secondary storage media like the magnetic bubble memories (MBMs).

Also, VLSI technology is affecting different other blocks needed for systems design. The new generation of microprocessors are functionally expandable by the use of

co-processors: specialized processing modules capable of performing e.g. floating point aritmetic operations, Input/Output handling, database management, screen processing etc. Thus a microprocessor can be enhanced to perform e.g. floating operations in hardware just by plug-in modules.

Maybe one of the most important areas of impact will be on **communications facilities.** LSI-circuits are readily available today, which support different kinds of communications protocols on the same chip, thus transferring the hitherto very complex systems software needed for advanced communication into hardware. Chips have been announced, which implements e.g. the entire support of the X.25 interface, including sequencing and automatic retransmission. More important is, that communications devices based on VLSI technology will be cheap due to the high production volume, and they will support the accepted standards within the communication world. This implies that users have to follow standards in data communications if they should ever be able to take benefit of the new technology.

Data security is becoming a major issue in many computer systems. Many users refrain from using cryptography due to the very complex implementation of effective crypto-algorithms. Data encryption and decryption algorithms are now being implemented as single chip hardware devices, making the application of cryptography extremely easy in future systems.

Reliability is quite another aspect of VLSI technology. The reliability of integrated circuits has been dramatically improved as the manufacturers have learned to master the technology of production. But, due to the very complex structure of todays circuits embodying tens of thousands of electronic gates, the testing problems have accelerated. As a consequence chips are now being provided with internal self-test capabilities, enabling the user to externally determine whether the chip is performing correctly or not. These on-chip capabilities of self-diagnostics will in the future be enchanced to included e.g. redundant elements on the chip, which makes it possible for the chip to circumvent an internal failure, thus effectively providing a chip with some limited self-repair feature. The presence of internal self-diagnostics will also facilitate the more wide-spread use of total system self-diagnostic utilities.

VLSI impact on systems architecture
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Some have said (ref. 1) that **"if Large Scale Integration had always existed then centralized data processing would never had been invented".**

> "As an analogy, let us apply our imagination to that commonplace device in every office, the typewriter, and pretend that its inner technology had been a little different: that in order to function, it would have needed to connect (for some reason) to a large box costing $600.000 .
>
> The consequence of this are quite predictable. All corporate typing would have been concentrated in a huge typing pool in Corporate Headquarters, so as to use the same box. Amongst the several hundred typists there would have been a major career infrastructure. The head of Typing would be a very highly paid and important chap.
>
> We would see the evolution of remote terminals, for urgent remote typing jobs, connected to the large box via telephone lines. Enterprising organizations would buy large boxes of their own and would become typing bureaux.
>
> We can also see the negative effects. Remote offices just would not use typing except for crucial documents: they would use handwriting.
>
> Then let us suppose that some clever person comes along and invents a stand-alone typewriter. The outcry can probably be imagined and would almost certainly embrace visions of uncontrolled spending, the demise of typing standards, the appearance of diverse forms of stationery, and the absurdity of every Manager having to recruit his own typist"

Although the analogy is uncomfortably close, the role of centralized computing should not be diminished. True distribution of computing facilities holds the danger of lack of homogenity, lack of standards, lack of interface methods, lack of common business procedures and lack of control. As centralized computing diverts into decentralization, the migration path is governed by some set of standards. Most large organizations do have a need for standardization, and this has in many cases been accomplished by centralized control. It is true, however, that less use is made of computing than could be because of the unresponsiveness of a centralized service. Anyway, the concept of centralized computing will retain its role for many years in large scale systems, but the local nodes in such systems will be affected by a quite different approach: the concept of **distributive allocation of computing power.**

The cheapness and versatility of the microprocessor made it possible to place the computing power, where it is needed. Still, this possibility has not been fully utilized nor accepted by traditional data processing manufacturers. Systems designers are still being deceived by the traditional approach which defines a local data processing system to be centered around a "host" or central controller. More and more "smart" or "intelligent" terminals are being offered as a direct consequence of the new technology, but the actual data processing is confined to be handled by the host. This implies that the local host has to be configurated according to the load of terminals and not to the amount of applications. At some point, e.g. 20 to 40 terminal connections, the local host is saturated and expansion becomes inadequate or even impossible. As the local host has to be shared between the many users, the net effect is that the amount of processing power available in such a system to a single user is less that the processing power of the microprocessor in the user's terminal!

There exists today a strong demand from advanced users for systems which are really distributed, i.e. where the actual data processing is done at the point of use, the end-user's terminal. Terminals are being designed, incorporating microprocessors like the Z8000, giving the terminal the processing power of a large PDP-11/45 mini or a small IBM mainframe. This leaves no arguments left against the allocation of applications as near as possible to the user.

But. ~~sheer~~ computing power is ~~not enough. People have~~ to communicate, ~~and so do computers,~~ especially the distributed ones. Standards have been made concerning the communication between distributed systems through public data networks. But communications have to been maintained within the distributed system itself. Local networking is the main solution for this problem, and **the architecture of local network systems may well be the greatest challenge for the computer industry in the eighties.**

Local networks are generally confined to connect processing elements in a restricted area, e.g. a room, a building or a campus. The length of the network ranges from around 100 meters to some kilometers. Different architectures of local networks have been proposed, but there seems to be evolving a general trend towards single shared bus networks employing full distributed control, i.e. no master controller nor host. The requirements for local networks are quite different from those found in nation-wide networks. First of all, the data transfer rate is fast. Whereas public data networks are used for communication speeds up to some thousand of bits per second, local networks should be designed for speeds exceeding one million bit per second. Secondly, network routing problems are normalled excluded from local networks. The error detection and correction problem is quite different as local networks exhibit a very low error rate due to their physical implementations. The flow control, which is the most important aspect in communications protocol design, is also quite different.

A major feature of local networks is (or should be indeed) the **expandability.** The network should offer full distributed control, thus requirering no default master. Stations should be connected or removed from the network without hardware or software changes, as the network should be able to reconfigure itself, even during operation. Several kinds of stations should be able to connect to the network, e.g. word processors, local printers, terminals, disk systems, photocopiers etc. The number of attachable stations should be high, exceeding several hundreds. The network should be reliable and recoverable, thus allowing local failures in stations including the on-line removal or addition of stations.

Current implementations of local networks seem to be concentrated around the use of readily available, cheap standard CATV coaxial cables, although the future implementations will utilize the advancing fiber optic cable technologies.

VLSI impact on software.
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Hardware costs are declining. We can buy computer systems for nothing. But software will be our sword of Damocles.

Several semiconductor manufacturers are expecting a software crisis in the eighties. So much computing power is being produced in the form of microcomputers that there simply won´t be enough programmers to program them. Some of the means to circumvent this are:

> The use of high level languages (like PLZ, PL/1 and Pascal) will gain more acceptance. The use of Very High Level Languages (like Modula and ADA) will emerge, as

these will provide the basic tools for structured and modular software design and testing. The demands for software reliablity will be heavily stressed in the coming years, and these demands will only be met satisfactorily by Very High Level Languages. Software savings will directly be related to modularity and distributiveness.

A considerable reduction in costs will be provided through the effective replacement of software by hardware in data processing systems, as more and more dedicated functions will be transferred into VLSI devices. This includes encryption/decryption devices, communication controllers, screen processors, intelligent disk controllers etc. This impacts the way software should be designed. Everyone agrees that software should be modular, but practice is different. How much communications software today can take advantage of the new LSI communications controller? Is it possible to remove one of the bottom layers of software as this layer eventually becomes implemented in hardware?

Commonly used software will be put onto silicon. This includes operating systems, compilers and eventually general applications software like database management systems. In stead of buying a magnetic tape or disk with new software, one buys a new plug-in module or even a new processor, as some of the kernel software actually will become resident within the processor chip itself. Savings will be accomlished through modularity in design and increased willingness to replace components piecemeal. New components will carry the software changes on chips that can be thoroughly tested with automatic means before installation. Then they are simply plugged in throughout the system.

Sheer assembler programming languages will disappear. High Level Assemblers offering structured and modular development for those small tasks, which have to be programmed in assembler will be commonplace. Microprocessors have already been anounced, which are programmable only in a Very High Level Language, a superset of ADA.

The modular design of systems, that integrate hardware and software, increases the reliability of performance of such systems. The design process will greatly reduce the likelihood of error in the initial product. The hierarchical and modular structure used in future systems facilitates reliability (preventive maintenance) and use of backup facilities at the microstructure. A spare stock of modules can be maintained and modules can be replaced in the event of equipment failures (ref. 11). Software reliability is also increased through the use of techniques for proof of program correctness, and through use of good programming techniques to ensure the robustness of the software, i.e. the ability of the software to tolerate errors. Research into such techniques will continue to progress due to the urgency of the need for such methodologies. By 1985, new techniques to improve program reliability will be sufficiently advanced to be very useful to the software design teams and be expected to be a part of any distributed computer design.

As a paradox, microprocessors were used in the beginning of their life cycle as a mean of replacing previous hardware systems with software controlled systems. VLSI technology now features the transformation of software functions into hardware modules. Programmers must be able to cope with this new trend. They must be able to apply a mix of tools and resources to the design of systems, and be comfortable about crossing over the old boundaries between software and hardware. The persons involved in the design of systems should be able to effectively assign to hardware and software what is best done by each. This integration of hardware and software will result in systems with different architectures than today, but the systems will be simpler, less costly to design, and easier to maintain. The software design teams of the future will probably be composed of at least four types of individuals, all trained to interact effectively, combining their skills to to design the target applications. The four experts will include the hardware designer, the software designer, the person knowledgeable about the specific applications and procedures to be serviced, and the designer working on the problems of human factors and methods of more reliable and easier communication with the end users.

VLSI impact on suppliers.
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Several semiconductor manufacturers have entered the systems business, producing computer systems utilizing their own chips. The dedicated VSLI manufactures cannot produce and sell microprocessor chips without a substantial software support.

Likewise, many systems manufacturers are entering the semiconductor field, producing their own chips in order to support their specific system requirements, to obtain a secure supply of components and in order to impact other component suppliers.

We will thus see an enhanced trend towards the merging of semiconductor manufacturers and system houses in the future.

The suppliers will also have to concentrate on the accelerating problems of service and maintenance. Despite their excellent reliability, VLSI devices are becoming increasingly more complex to test. Built-in diagnostic capabilities within the chip will help to overcome some of these problems. But as the chips grow more complex, so do the systems they are used in. There will be a great demand for highly qualified service and maintenance personnel, due to the increased complexity of systems and to the fact that complex systems are becoming more and more physically distributed. A large computing center can afford to have on-site service personnel during operation hours, but what do you do when each branch office has the computing power equal to or greater that that in the center ?

Future systems must be designed to incorporate a substantial self-test capability. They should be provided with facilities for remote diagnostics, e.g. by communication to a remote service center, where a specialized service processor can extend the diagnostic process. The problem is further compounded, as many errors cannot be directly related to either hardware or software. Thus, the service engineer must be an expert in both hardware and software technology in order to be able to diagnose a problem in due time. This can be accomplished by a remote service center, facilitating a competent staff of qualified people. They will be able to diagnose the problem, without having to travel long distance to the actual installation. In the case of software errors, new software releases can then be patched into the system through the line to the remote diagnostic processor. In the case of hardware failures, the problem is quite different. Luckily enough, most hardware failures can be isolated to a single circuit board or a functional module. As well as anyone can change a blown fuse, a burned-out light bulb or wheels on a car, there is no reason why the user shouldn't be able to exchange a defective module himself. This implies that the user keeps an inventory of spare parts, which is feasible if the user is large enough, or he should be able to get a spare module by mail.

Self-test, remote diagnostics and self-repair will become the keywords of computer systems maintenance in the eighties, whether the suppliers want it or not. Thus future systems must be designed with this in mind, and they should specificially be designed to be operational in a degraded mode during the wait for spare parts and during repair.

VLSI impact on SDC.

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Traditionally, computer users paid no special attention to the underlying technology of their computer systems, at most a curious interest.

I feel however, that the time has come when large scale users like SDC actively must follow up on the technological process, not just by theoretical reading but by achieving practical know-how within the field. SDC will need a substantial amount of know-how on computer technology in the eighties, in order to still be able to design, evaluate and implement state-of-the-art information processing systems for our costumers, the savings banks.

The pacing progress of advanced microelectronics will dramatically affect several areas concerning SDC and the savings banks:

> We must prepare to leave our traditional views on how computer resources should be located. We must prepare to realize, that computing power is cheap in the form of hardware, thus functionally assigning tasks to individual processors instead of requirering sharing of a single processor. We must realize the difference between public data networking and local networking.
>
> Software development will be the permanent headache of SDC. Software development costs are rizing exponentially. This rise can somehow be avoided by the move to modern high level languages. The selection of PLZ was a good step in that direction. But: due to the

selection of a modern high level language offering structured and modular software development, SDC's software costs will rise even more rapidly in the next few years to come. This is because only a very few of the programming staff in SDC actually have experience to utilize the new programming tools. The programming in SDC has for the last ten years been concentrated on applications development on our mainframes. These applications have mainly been the fetch of a transaction from the communications line, a disk access, the formatting of an answer and the return of the answer to the line. All the hard work has been done by the operating system and the TP-monitor, and is hidden for the average programmer in macro calls. Only a very few people have been involved in real systems software development and none have been designing systems software for minicomputers.

We now expect our programming staff to be capable of writing applications software for mini/micro-systems. But no one has ever tried to program an interactive program using the facilities of a video display terminal. They do not know the principles of screen formatting, screen editing and how optimal man/machine communication takes place.

We will experience a greater interaction between hardware and software. We must be prepared to exchange software with hardware if the technology facilitates it. The software must be modular, being so that each software module eventually can be replaced by a hardware module. This is especially true for systems software. The software must be reusable, meaning that even if it is originally designed for a centralized archictecture of the branch office system, it must be able to serve a distributed architecture. In order to follow this trend, we must eventually rethink on how to develop software. The sharp distinction between software and hardware development must be removed, and applications development will be the job of teams able to treat both software, hardware and human interfacing with the same degree of competence.

SDC must have a closer feeling with systems programming. We must be able to design e.g. operating systems for the new generation of computer system without being blinded by the way such systems were implemented years ago. Operating systems for distributed applications are quite different from those used on a host-based system, and if the applications software is affected by the way a specific operating system is designed, the transferrability and life-cycle of the applications software may be damaged. We must regard operating systems and systems software in general as being implementable in both soft- and hardware, and the only way SDC can be sure of getting systems software in accordance with our requirements is to be able to design such software ourselves. The actual implementation of system software should still be performed by our suppliers, but SDC must be able to devise the supplier on how specific details should be implemented. The traditional view, that operating systems are very complex programs only programmable in assembler, does not hold any more.

VLSI impact on banking applications.
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The new technology makes the implementation of distributed systems possible, which places the computing task at the user´s desk. The local network constitutes the connection between the various processing nodes. The actual architecture of the branch office system will be affected by the following issues:

A **standard interface** must be established to the local network. Any station connected to the network is capable of control as control is distributed. Any station can communicate with any other station in the network. The local network is **adaptable,** so the user himself can attach new stations to it without the need for a technician. When a station is connected to the network or it is powered on, it makes itself known to all other stations on the network. The flow control protocol ensures that the network is **reconfigurated** in case of a station failure.

Any station can be attached anywhere on the network. This means, that the pyschical installation of the network will remain unchanged as each room in the branch office building will be equipped with connectors to the network, just like power outlets and telephone sockets today are distributed throughout a building.

A station can be a teller system, a printer system, a back office system or a word processing system. Stations can contain their own file systems, enabling them to run in a stand-alone mode, or they can contain a file or data base system accessible from any other stations in the network.

Communication to public data networks are not done by the individual computers attached to the system, but by one or more shared communication stations. As the interface to the network is standarized, the same transaction can be directed to either the public data network, telex systems or any other communications facility.

The network will allow for **supplier independence.** The user can attach teller systems from one supplier, printer systems from a second supplier and word processing system from a third.

Local networks will eventually provide for voice communications as well as any other form of digitized data.

The **shared file systems** will be general, allowing integrated information processing systems. The data base containing costumer information, account information will be accessible from both teller terminals and management informations systems, which then can prepare data directly usable for word processing. The shared file system will also provide for the storage of digitized voice, so electronic mail can be a mix of voice, facilimile, data and programs.

The use of **manager terminals** will become a part of future branch office systems. The manager can invoke MIS utilities for status preparation, budgetting and forecasts. He can use the terminal as a word processor to acknowledge and correct documents, to submit documents for electronic mail or printing.

SDC will allow users to delevop their own applications. This will be due to the huge turn-around time for individual programming requests in SDC and the scarce resources of qualified programmers. It will also be neccessary in order to avoid the use of non-integrated stand-alone computers in the branch offices, as personal computers at their low price will be attractive for many users if the service on the SDC systems is inadequate. The trend towards end-user programming will be enhanced by easy-to-apply management information systems and non-procedural languages.

Small branch offices will facilitate from the availability of a system which is expandable and upgradable. The branch office can start off with one or two teller systems and a communications system without the need for an expensive local host controller. As time goes on, word processing systems, data base systems etc. can be attached immediately as the need arises without having to reconfigure a controlling host.

The **man-machine communication** will undergo a dramatic change, as graphic terminals and colour display terminals become commonplace. SDC and the end-users must cooperate to learn how to display information graphically rather than by figures in order to grasp the increasing amount of information needed for banking management.

What then ?
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Will we be the masters or slaves of technology? SDC believes, that a substantial amount of know-how on technology and its impact on data processing is needed in order to provide the best service for our costumers in the future.

We feel, that the only way the user can impact the process of technology is to obtain a competent level of know-how and skills in all the fields of data processing. We must be prepared to make practical experiments with the technology, as we cannot design useful systems by theory. We also feel, that in order to get know-how, we must share our experiences with other competent companies, being prepared to go into joint ventures with advanced suppliers. SDC cannot require optimal banking systems, if we are not aware of the actual problems of design and manufacturing at the supplier, and our supplier cannot produce the systems we want if they do not know our intended migration path and the viewpoints of the end-user.

Joint-venturing between users and suppliers will eventually become the basic means to implement the future information processing systems based on advanced technology which can be a help and not a hinderance in the ever more demanding world of banking applications.

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Special Commemorative Issue

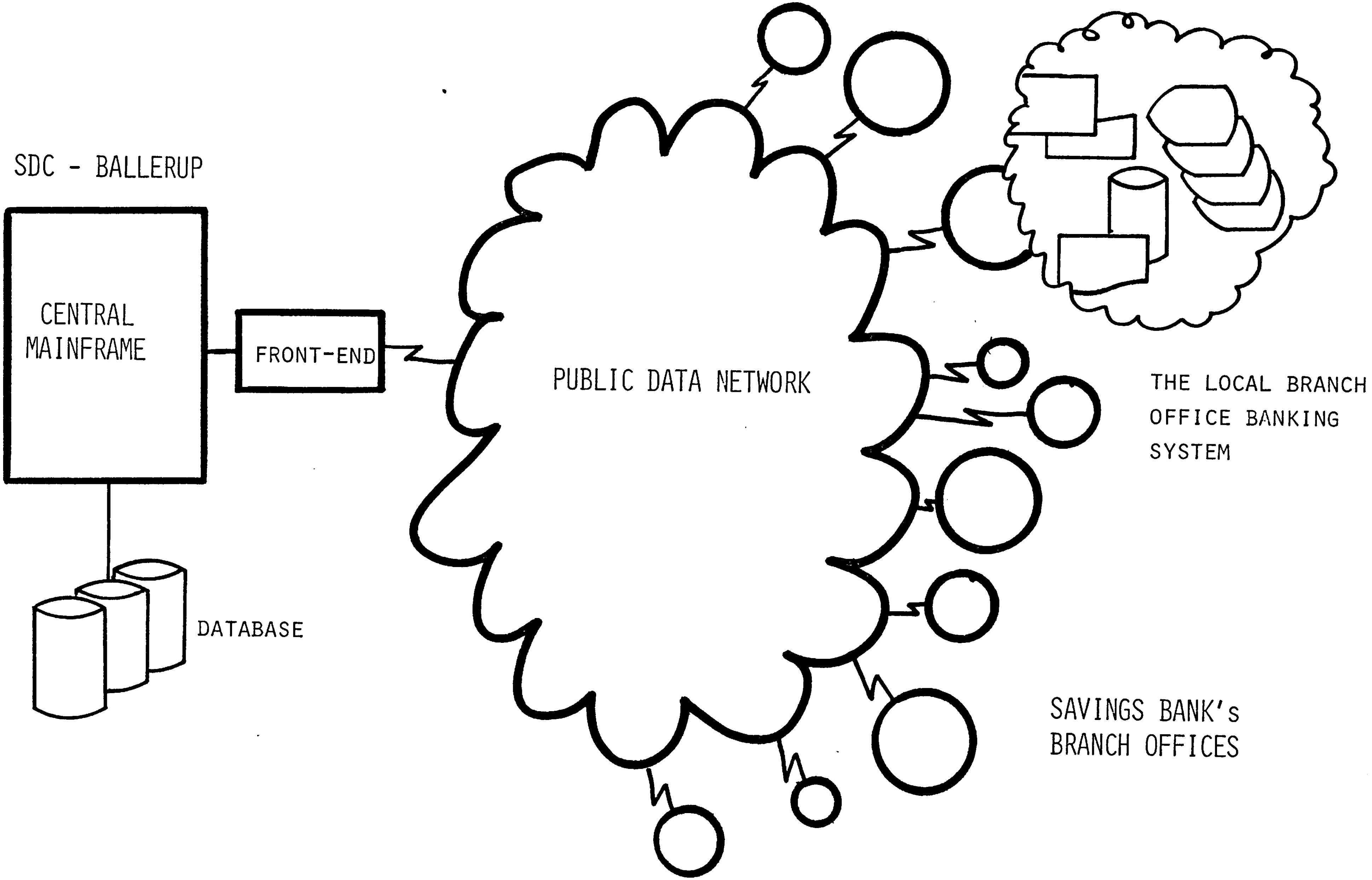
SDC's VIEWS ON THE TECHNOLOGICAL EVOLUTION

AND ITS IMPACT ON NEW BANKING APPLICATIONS

PRODUCT COMMITTEE MEETING

FIRENZE, 1980

BASIC AREA OF INTEREST FOR THIS PRESENTATION



TOTAL SYSTEM COSTS ARE AFFECTED BY

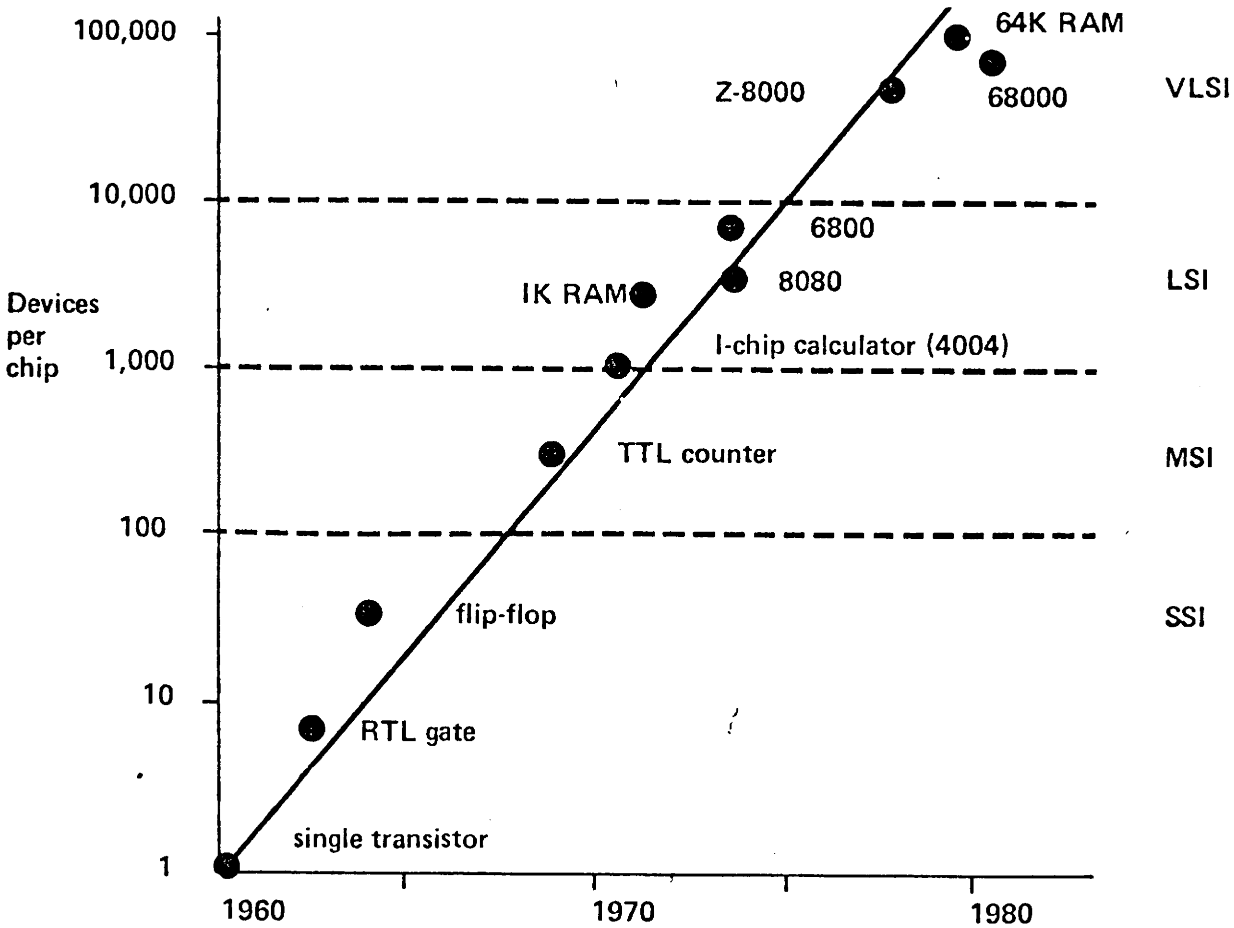
HARDWARE COSTS

SERVICE AND MAINTENANCE COSTS

SOFTWARE DEVELOPMENT AND MAINTENANCE COSTS

SYSTEM EXPANSION AND RECONFIGURATION COSTS

LIFE CYCLE

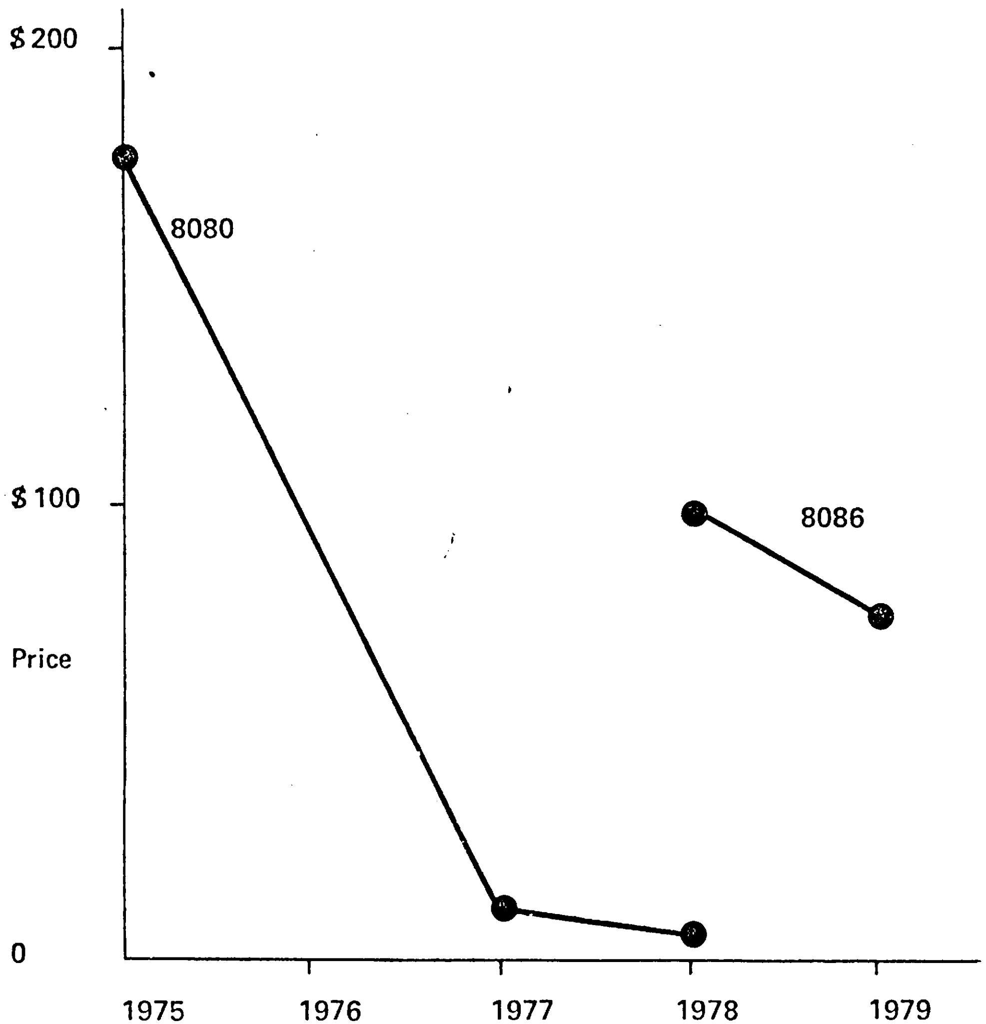


The continuing increase in number of devices per chip

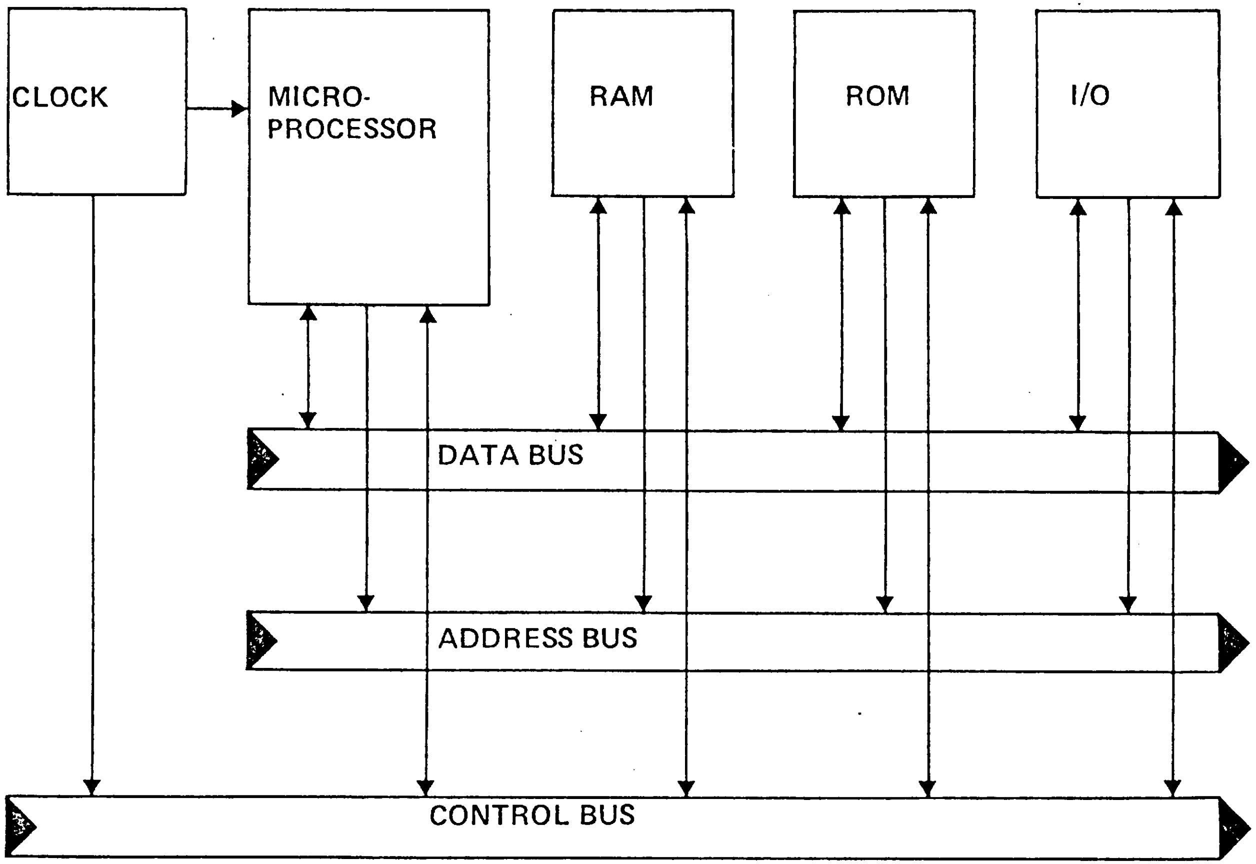
TECHNOLOGY CHANGE AND COMPLEXITY AVALANCE
MAKE IT NECESSARY FOR SDC TO FOLLOW-UP AND GAIN KNOW-HOW
ON THE IMPACT OF MICROELECTRONICS ON FUTURE BANKING SYSTEMS

LSI (LARGE SCALE INTEGRATION) AND
VLSI (VERY LARGE SCALE INTEGRATION) TECHNOLOGY
HAVE DRAMATICCALLY AFFECTED THE DESIGN OF COMPUTER SYSTEMS
AND WILL IMPACT THE COMPUTER INDUSTRY EXTENSIVELY IN THE YEARS TO COME.

THE MOST WELL-KNOWN PRODUCT BASED ON LSI AND VLSI TECHNOLOGY IS THE
MICROPROCESSOR



Microprocessor prices in the US



Bus structure

* 1975: EARLY MICROCOMPUTER APPLICATIONS
  WERE BASICALLY FOR LOGIC REPLACEMENT

* CRT TERMINALS
* CASH REGISTERS
* SCALES
* TOYS
* ELECTRONIC INSTRUMENTS

THE SYSTEM REQUIREMENTS WERE MODEST

* CPU
* TTL LOGIC
* MEMORY CHIPS
* ASSEMBLER LANGUAGE

* 1980: TODAY'S APPLICATIONS OF MICROPROCESSORS UTILIZE HARDWARE AND SOFTWARE IN MORE COMPLEX CONFIGURATIONS

* WORD PROCESSORS
* BANKING TERMINALS
* TELEPHONE SWITCHING SYSTEMS
* PROCESS CONTROL
* COMMUNICATIONS PROCESSORS

THE SYSTEM REQUIREMENTS ARE BECOMING EXTENSIVE

* MULTIPLE PROGRAMS/MULTIPLE USERS/MULTIPLE PROCESSORS
* NETWORK COMMUNICATIONS
* HIGH LEVEL LANGUAGES
* OPERATING SYSTEM SOFTWARE
* PERIPHERAL CONTROLLERS
* HIGH SYSTEM PERFORMANCE
* SEVERAL TYPES OF MEMORY

THE NEW GENERATION OF MICROPROCESSORS OFFER FEATURES HITHERTO FOUND ONLY ON MINICOMPUTERS AND MAINFRAMES.

* REGULAR ARCHITECTURES
* LARGE ADDRESSING SPACES, TYPICALLY MORE THAN 16 MEGABYTES
* MEMORY MANAGEMENT AND VIRTUAL STORAGE CAPABILITY
* PRIVILIGED OPERATIONS AND PROTECTION FACILITIES
* RESOURCE-SHARING CAPABILITIES FOR MULTIPROCESSING SYSTEMS
* 32-BIT OPERATIONS
* PERFORMANCE COMPETING WITH HIGH END OF MINICOMPUTER MARKET
* FUNCTIONAL EXPANDABILITY BY CO-PROCESSING MODULES

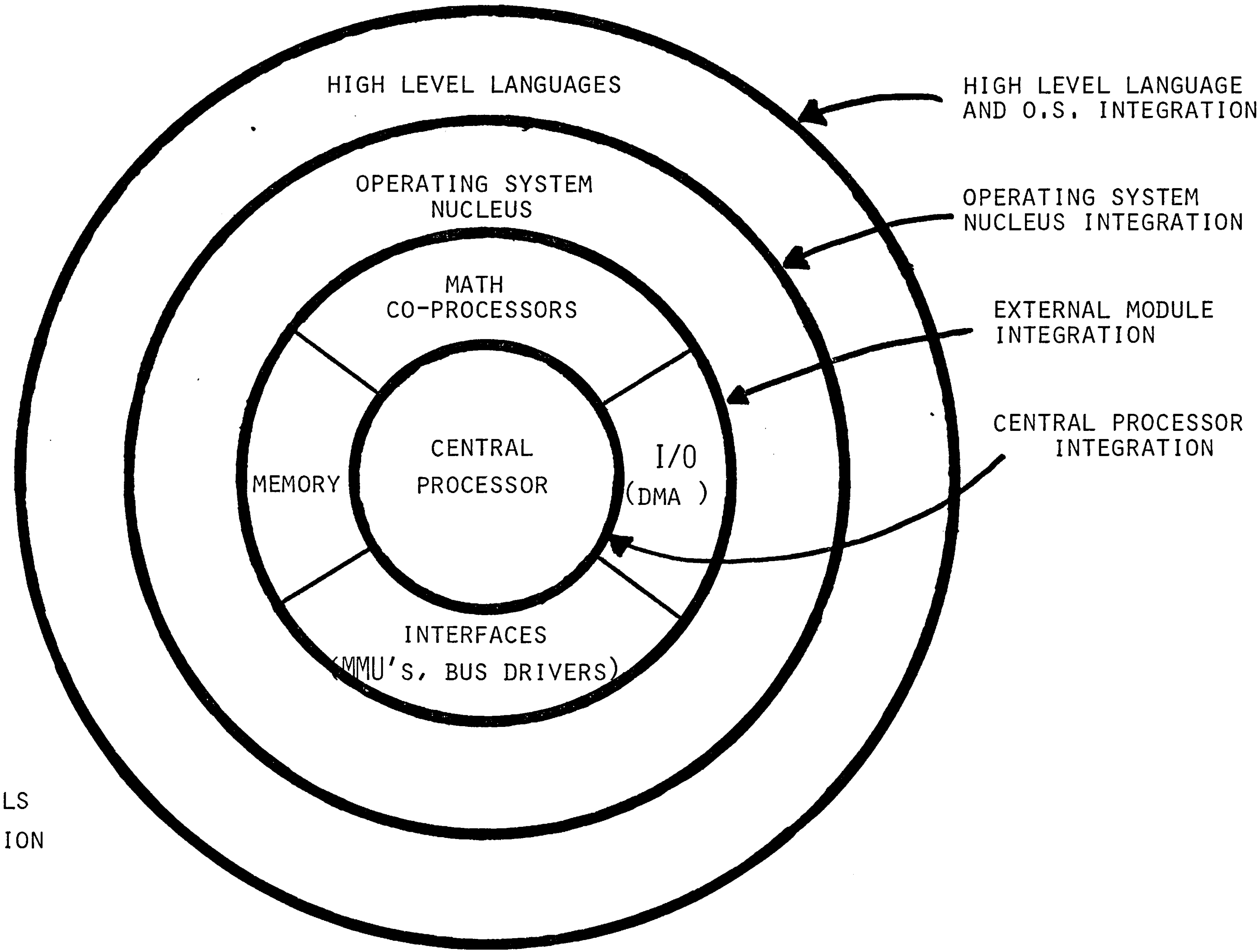
\+ * LOW COST DUE TO THE HIGH PRODUCTION VOLUME

THE NEXT GENERATION OF MICROPROCESSORS WILL OFFER

- MAINFRAME FUNCTIONALITY AND PERFORMANCE AT THE CHIP LEVEL
- DIRECT INSTRUCTION SET SUPPORT FOR OPERATING SYSTEMS AND HIGH LEVEL LANGUAGES
- PROTECTION FACILITIES
- GIGABYTES OF ADDRESSABLE MEMORY
- PROCESS SYNCHRONIZATION AND CONCURRENCY PROVIDED NATURALLY IN HARDWARE
- HARDWARE-IMPLEMENTED PROCESS SCHEDULING AND INTERPROCESS COMMUNICATION FOR MULTIPROCESSOR APPLICATIONS
- OBJECT AND MESSAGE-DRIVEN DATA PROCESSING

Comparison of mainframe and minicomputer with a microprocessor

	IBM 370/168	DEC PDP 11/45	ZILOG Z-8000
Cost	$4.5 million	$50,000	$100 +
Word Length (bits)	32	16	16
Memory capacity (megabytes)	8	0.256	48
Add time (μs)	0.13	0.9	2.5 1.0
Data Rate (megabytes/sec)	16	4	0.89
Number of general registers	64	16	26



VLSI OFFERS
HIGHER LEVELS
OF INTEGRATION

* 1985: TOMORROW'S APPLICATIONS WILL REACH A CRISIS LEVEL IN SYSTEM COMPLEXITY

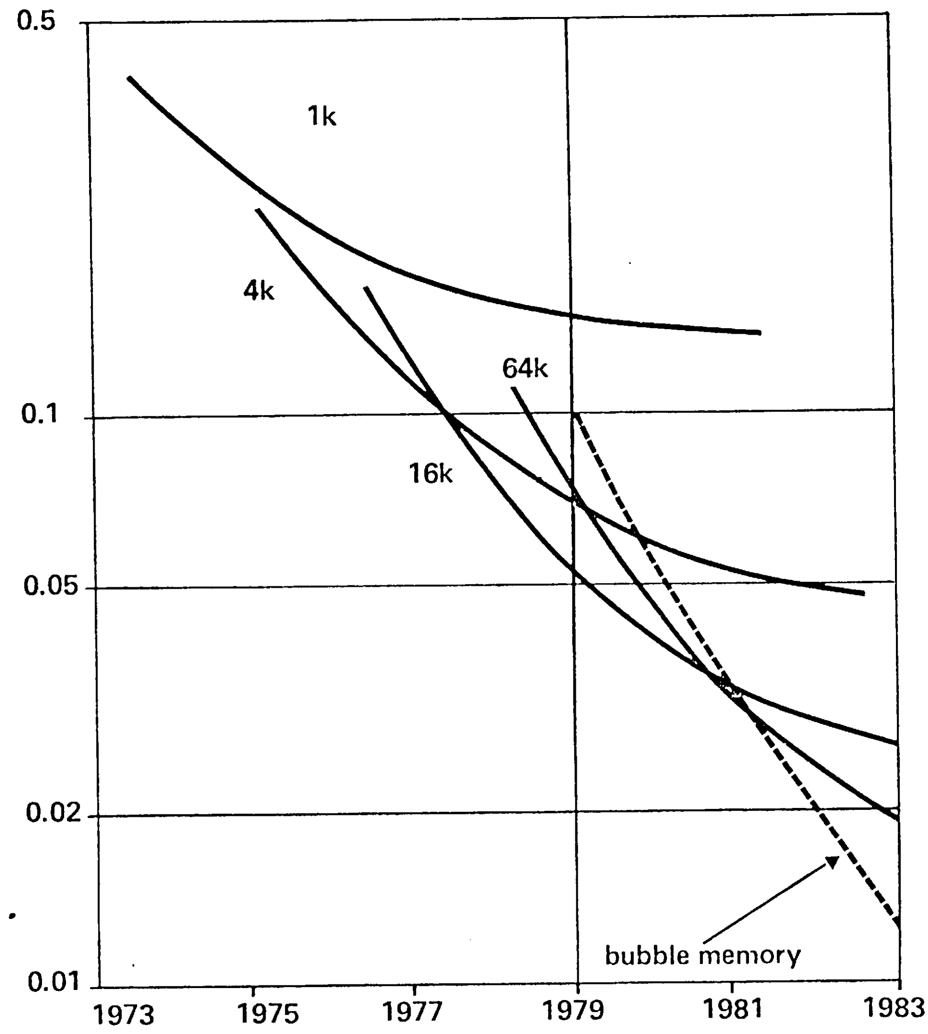
* ALL ELECTRONIC OFFICE
* COMBINED COMPUTER AND COMMUNICATION
* NATIONWIDE DISTRIBUTED SYSTEMS
* 10 PROCESSORS/EMPLOYEE ON THE FACTORY FLOOR
* HIGH SPEED CONTENTION LOCAL NETWORKS

THE SYSTEM REQUIREMENTS ARE BEYOND THOSE OF MINICOMPUTERS, OR EVEN MAINFRAME COMPUTERS TODAY

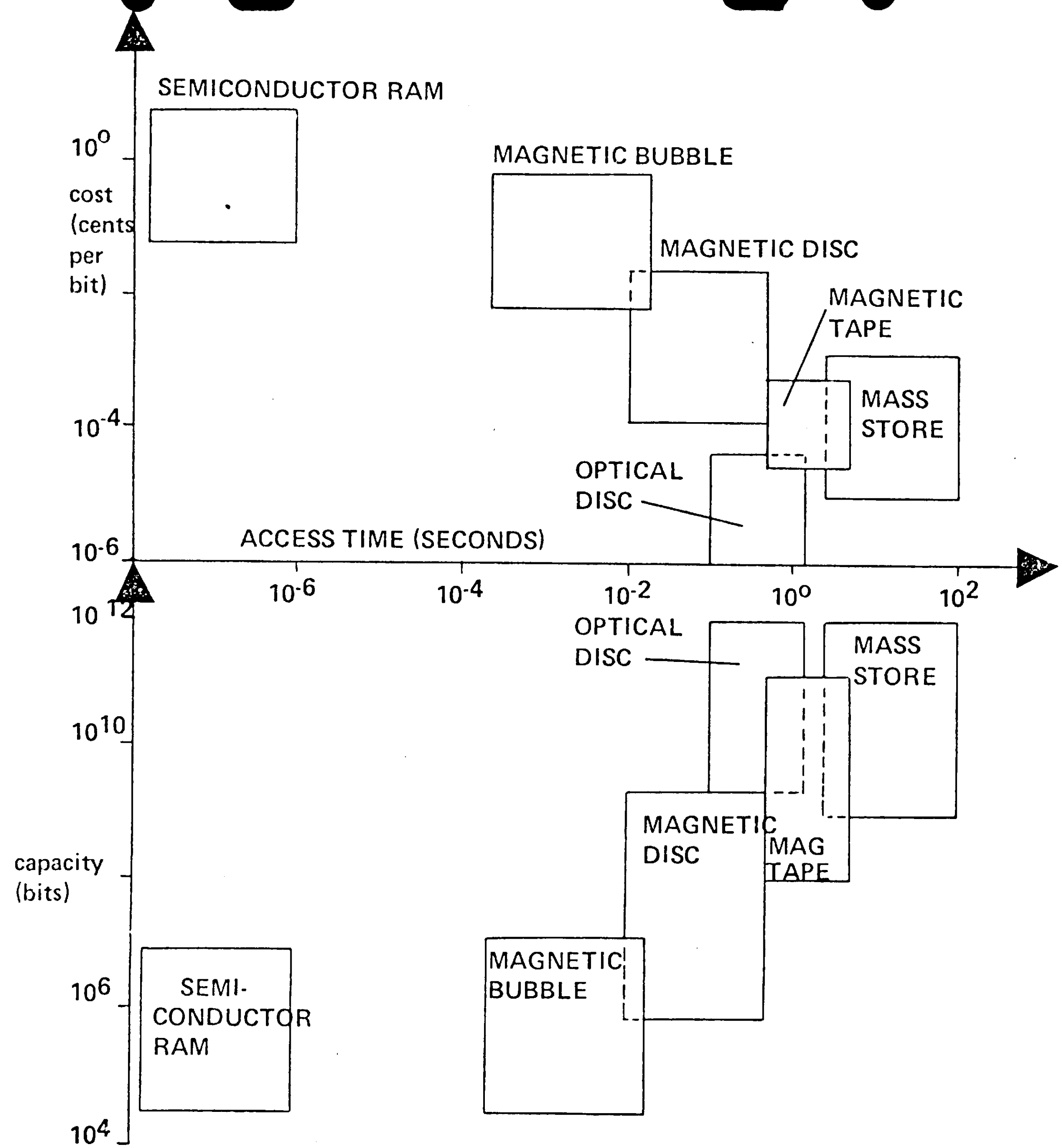
* FAULT TOLERANT COMPUTING
* TRANSPARENT MULTIPROCESSING
* DISTRIBUTED OPERATING SYSTEMS
* NETWORK SYSTEM ARCHITECTURES
* FAMILIES OF HIGH LEVEL PROGRAMMING LANGUAGES

BESIDES MICROPROCESSORS, VLSI TECHNOLOGY IS SUPPORTING OTHER BUILDING BLOCKS:

* HIGH DENSITY MEMORIES
* MAGNETIC BUBBLE MEMORIES
* CO-PROCESSORS
    - FLOATING POINT MATH OPERATIONS
    - INPUT/OUTPUT PROCESSING
    - MEMORY MANAGEMENT HANDLING
    - DATABASE PRIMITIVES
    - OPERATING SYSTEM PRIMITIVES
* SCREEN CONTROLLERS
* DISK CONTROLLERS
* DATA SECURITY ENCRYPTION AND DECRYPTION DEVICES
* COMMUNICATIONS CONTROLLERS

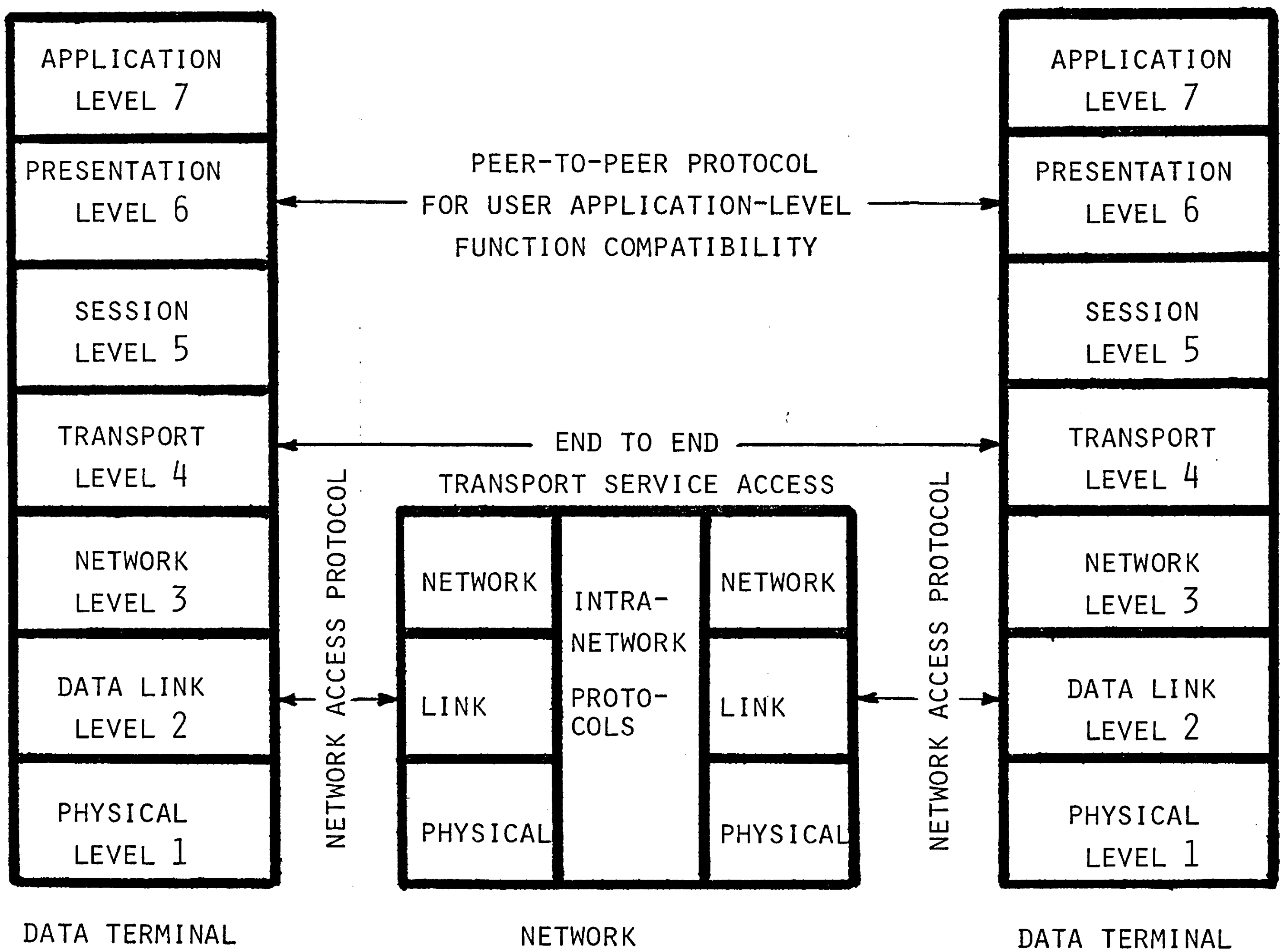


Cost per bit of computer memory has declined and will continue to decline as is shown here (Source: Scientific American/Intel/Bleasdale)



Costs, capacity and access time of the memory technologies

VLSI DEVICES ARE UTILISING AND IMPACTING EXISTING AND FUTURE STANDARDS OF DATA COMMUNICATION.



VLSI OFFERS HIGH RELIABILITY,
WHEN FUNCTIONAL CORRECTNESS HAS BEEN ASSURED.

BUT

VLSI DEVICES ARE EXTREMELY
DIFFICULT TO TEST AND VERIFY.

ALSO, SYSTEMS EMPLOYING VLSI DEVICES
ARE BECOMING VERY COMPLEX AND SOPHISTICATED,
AND BECAUSE OF THEIR RELATIVELY LOW PRICE
THEY ARE BECOMING MORE AND MORE DISTRIBUTED THROUGHOUT THE COUNTRY.

THIS

ACCELLERATES THE PROBLEMS OF SERVICE AND MAINTENANCE.

VLSI IMPACT ON SYSTEM RELIABILITY

AT THE CHIP LEVEL, VLSI DEVICES WILL BE EQUIPPED WITH INTERNAL SELF-TEST CAPABILITIES

- ACCESSIBLE FOR CHIP TESTNING BY MANUFACTURER
- ACCESSIBLE FOR QUALITY ASSURANCE FUNCTION IN INCOMING INSPECTION AT COMPUTER MANUCATURER
- ACCESSIBLE FOR DIAGNOSTIC DURING SYSTEM OPERATION

ERROR-CORRECTION CAPABILITIES AND REDUNDANT CIRCUITS ON THE CHIP WILL BECOME A BASIC PART OF FUTURE VLSI CIRCUITS

- TO INCREASE THE PRODUCTION YIELD OF CHIP MANUFACTURER
- TO ALLOW FOR TRANSIENT ERRORS (E.G. VOLTAGE SPIKES OR THE ALPHA PARTICLE EFFECT)
- TO ALLOW FOR REAL FUNCTIONAL REDUNDANCY AT THE CHIP LEVEL FOR GRACEFUL DEGRADATION OF OPERATION

VLSI IMPACT ON SYSTEM RELIABILITY

AT SYSTEM LEVEL, DESIGNERS WILL USE THE ON-CHIP CAPABILITIES TO

- IMPLEMENT SYSTEM SELF-DIAGNOSTIC CAPABILITY
- ALLOW FOR DEGRADED MODES OF OPERATION

THE IMMENSE VLSI SUPPORT OF COMMUNICATIONS CIRCUITS WILL FACILITATE THE ADVANCE OF REMOTE DIAGNOSTIC CENTERS

- RAPID DIAGNOSTIC CAPABILITY IN THE CASE OF COMPLEX ERRORS
- NO UNNECESSARY TRAVEL OF SERVICE ENGINEERS
- MORE COMPETENT SERVICE ORGANISATION INSTANTANEOUSLY AVAIABLE TO ALL COSTUMERS
- ONLY REALISTIC SUPPORT OF REMOTE, DIFFICULT ACCESSIBLE INSTALLATIONS
- REDUCTION IN SERVICE COSTS FOR THE COSTUMER

VLSI IMPACT ON RELIABILITY

VLSI TECHNOLOGY OFFERS AN EASIER IMPLEMENTATION OF DIFFERENT DIAGNOSTIC FUNCTIONS IN ORDER TO SHORTEN THE TIME NEEDED TO LOCALISE A FAILURE.

IT ALSO PROVIDES THE MEANS FOR IMPLEMENTING SYSTEMS WHICH CAN OPERATE SATISFACTORALY IN A DEGRADED MODE OF OPERATION.

THE HIGH RELIABILITY OF VLSI SYSTEMS IMPROVES THE MEAN TIME BETWEEN FAILURE, AND THE POTENTIAL OF INCLUDING SELF-TEST AND REDUNDANCY IMPROVES MEAN TIME TO DIAGNOSE.

MEAN TIME TO REPAIR, HOWEVER, IS NOT AFFECTED THE SAME WAY BY THE TECHNOLOGY. MTTR IS AFFECTED BY THE SERVICE POLICY OF THE MANUFACTURER. THE VLSI POTENTIAL OF SELF-DIAGNOSTICS IS HOWEVER APPLIABLE BY THE USERS THEMSELVES, AND SYSTEMS SHOULD BE DESIGNED TO HELP THE USER PERFORMING THE DIAGNOSTIC PROCESS AND ENABLING THE USER TO CHANGE FUNCTIONAL MODULES, E.G. CIRCUIT BOARDS, BY HIMSELF. THIS METHOD OF SELF-REPAIR CAN ALSO BE DIRECTED BY THE REMOTE SERVICE CENTER.

SELF-REPAIR

SELF-REPAIR IS THE FUTURE WAY TO OBTAIN VERY SHORT TIME DELAYS CAUSED BY SYSTEM FAILURE, ESPECIALLY AT REMOTE LOCATIONS.

IT DOES HOWEVER IMPLY, THAT AN INVENTORY OF CRITICAL SPARE PARTS MUST BE MAINTAINED ON LOCATION OR AT LEAST NEARBY.

COMBINED WITH THE ABILITY OF THE SYSTEM TO OPERATE IN DEGRADED MODES, SELF-REPAIR WILL BE A GOOD APPROACH TO MOST SYSTEM FAILURES, AS NEW CIRCUIT MODULES CAN BE MAILED TO THE COSTUMER.

MECHANICAL DEVICES, HOWEVER, ARE STILL THE HEADACHE OF SERVICE ORGANISATION, AS THEIR RELIABILITY ARE INHERENTLY LOWER THAN FOR ELECTRONIC DEVICES.

SERVICE COSTS ARE REDUCED BY:

* LEVELS OF DIAGNOSTIC CAPABILITY:

  VLSI BUILT-IN TEST

  SYSTEM SELF-DIAGNOSTICS

  REMOTE DIAGNOSTICS

* LEVELS OF REPAIRABILITY:

  REDUNDANT AND ERROR-CORRECTING VLSI

  GRACEFUL DEGRADATION CAPABILITY

  USER SELF-REPAIR

DEALING WITH HIGHER SOFTWARE COSTS IS THE MOST SIGNIFICANT PROBLEM FACING DESIGNERS TODAY

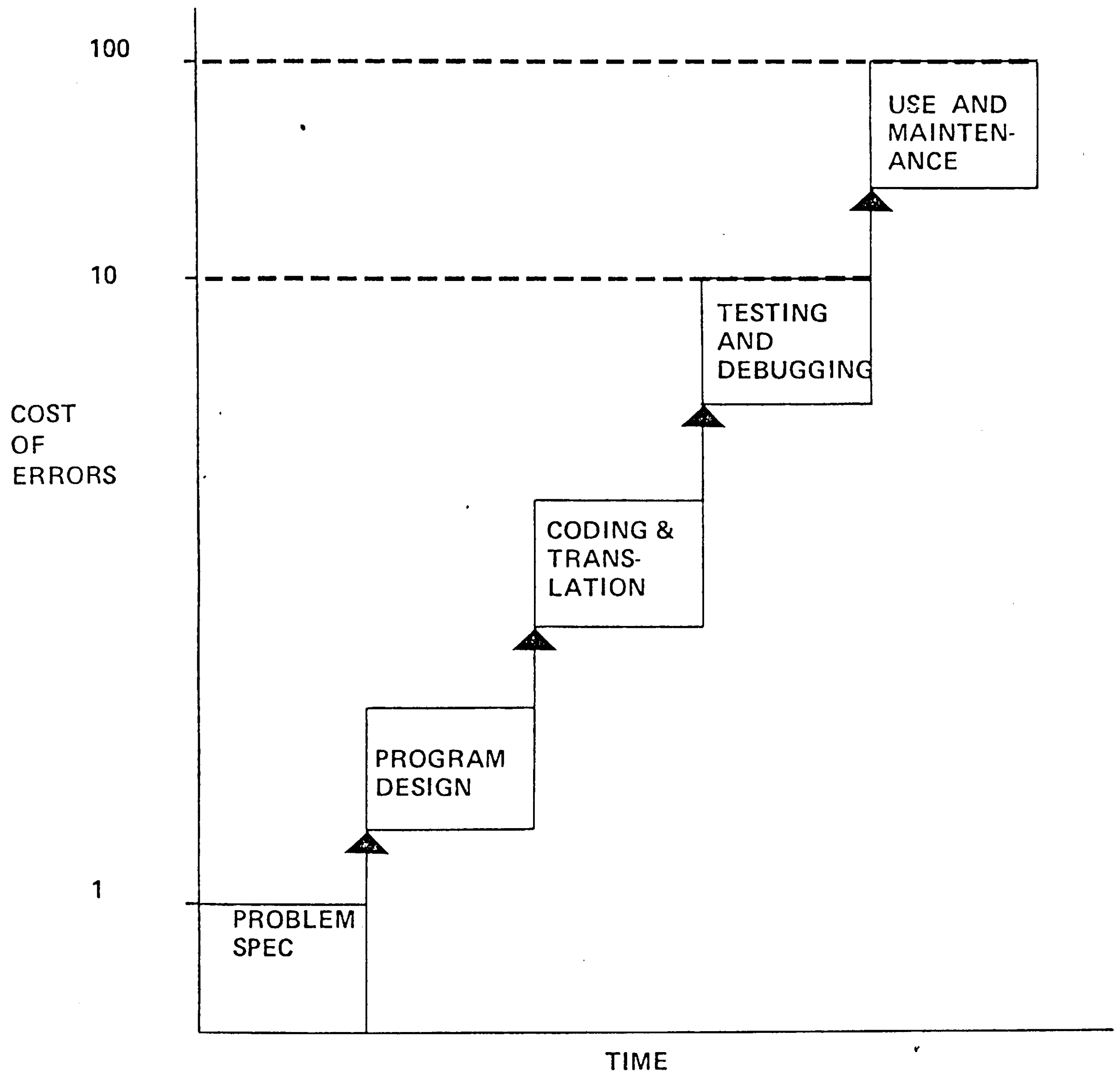
* VLSI IS PROVIDING HIGHER COMPLEXITY SYSTEM BUILDING BLOCKS AT VERY LOW COST

* AVERAGE PROGRAM SIZES HAVE DOUBLED IN FIVE YEARS, AND THIS INCREASE WILL BE EVEN GREATER FOR FUTURE BANKING APPLICATIONS.

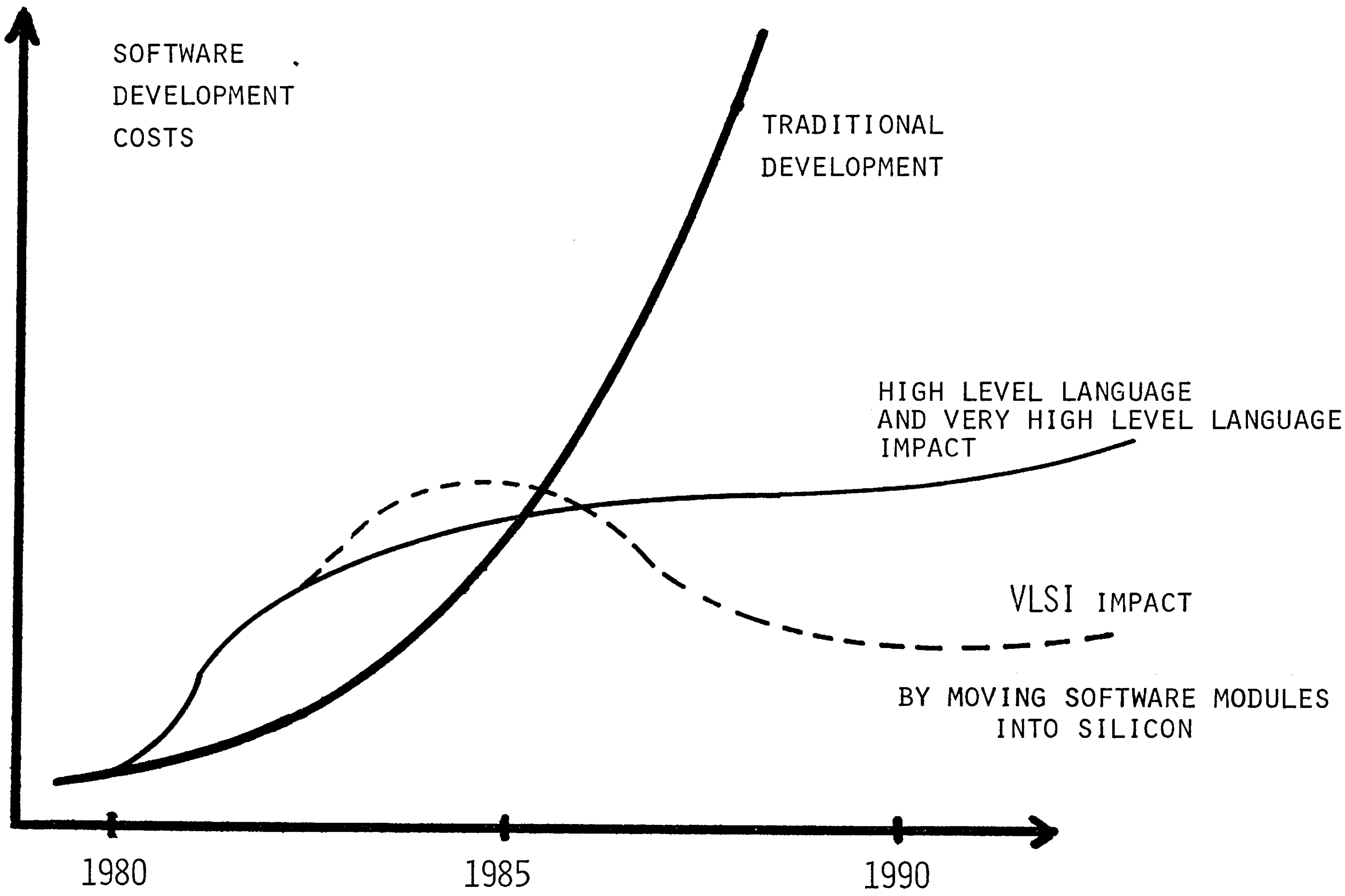
* SOFTWARE DEVELOPMENT COSTS ARE RISING $10 TO $20 PER WRITTEN LINE OF PROGRAM CODE

* SOFTWARE MAINTENANCE COSTS ARE SKYROCKETING

  - ONLY 30% OF SOFTWARE COSTS ARE NOW INCURRED IN DEVELOPMENT, 70% ARE INCURRED IN APPLICATION DEBUG AND MAINTENANCE



The cost of correcting an error increases as the project advances


SOFTWARE
DEVELOPMENT
COSTS
TRADITIONAL
DEVELOPMENT
HIGH LEVEL LANGUAGE
AND VERY HIGH LEVEL LANGUAGE
IMPACT
VLSI IMPACT
BY MOVING SOFTWARE MODULES
INTO SILICON
1980
1985
1990

SOFTWARE COSTS ARE REDUCED BY

REDUCING DEVELOPMENT COSTS

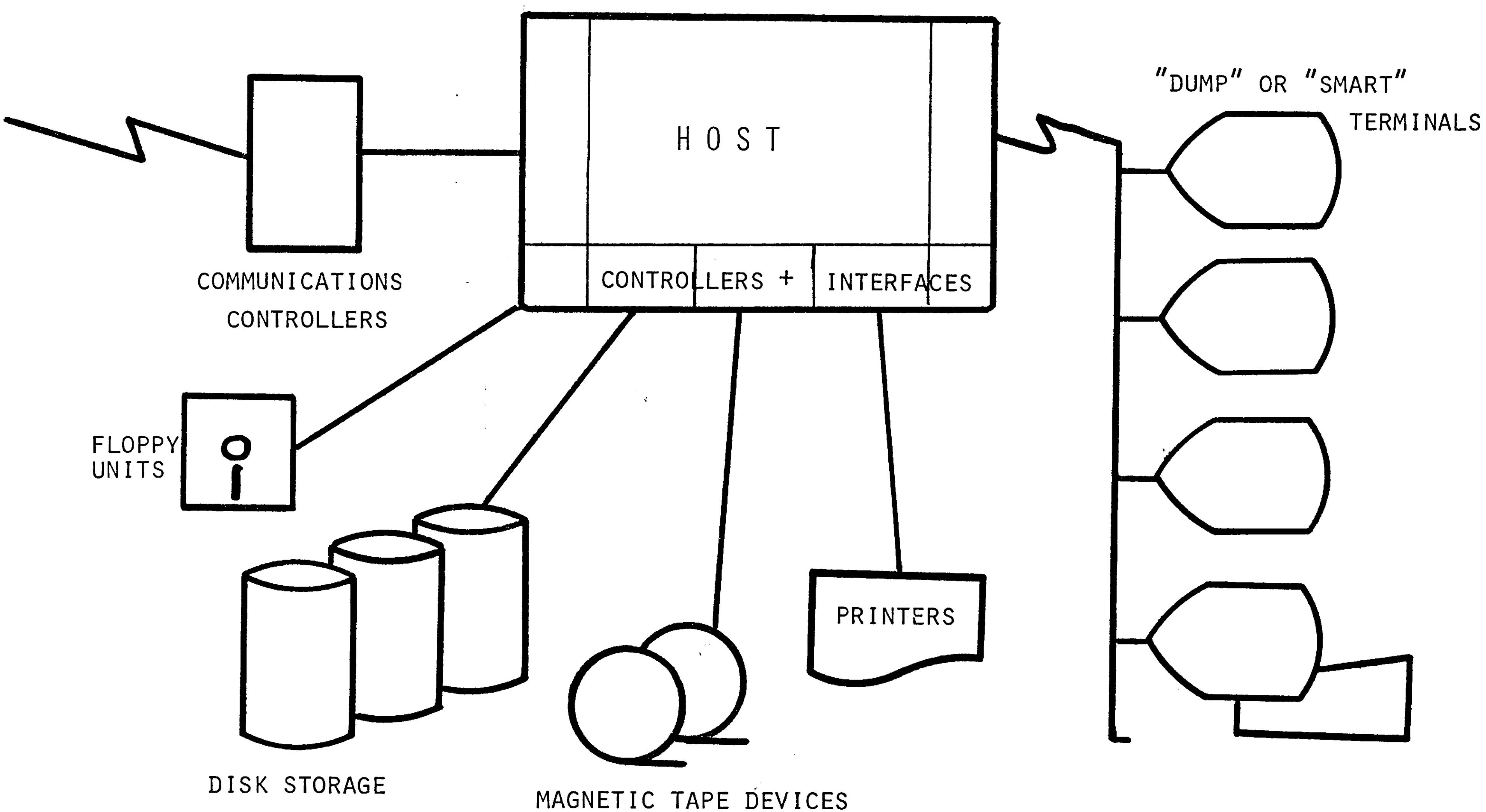
MINIMIZING MAINTENANCE COSTS

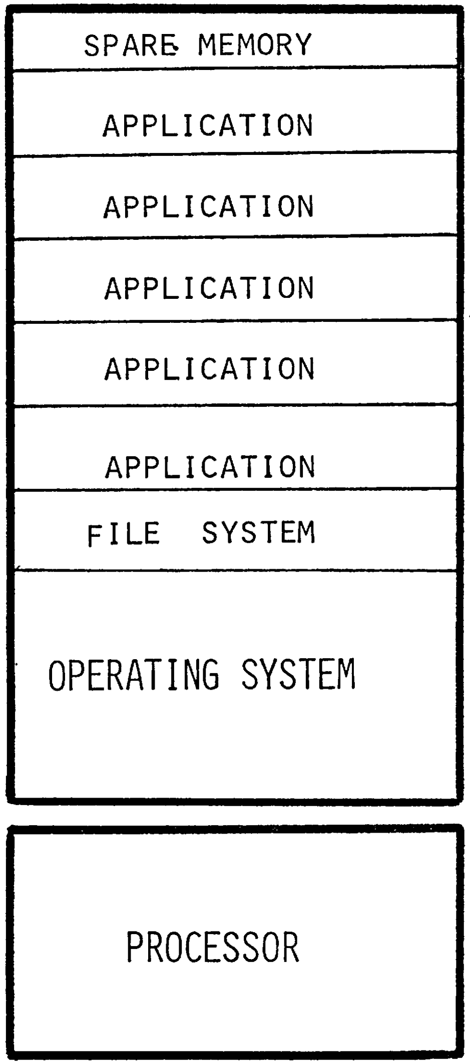
IMPROVING THE LIFE CYCLE

THE BASIC MEANS TO OBTAIN THIS CAN BE

- FAMILIES OF HIGH LEVEL LANGUAGES
- MODULAR SOFTWARE
- MOVING SOFTWARE MODULES INTO SILICON
- USING STANDARD SOFTWARE MODULES
- STRESSING THE IMPORTANCE OF SOFTWARE RELIABILITY
- ALLOW FOR END-USER PROGRAMMING IN NON-PROCEDURAL LANGUAGES

TRADITIONAL SYSTEMS ARE CENTERED AROUND A LOCAL HOST:



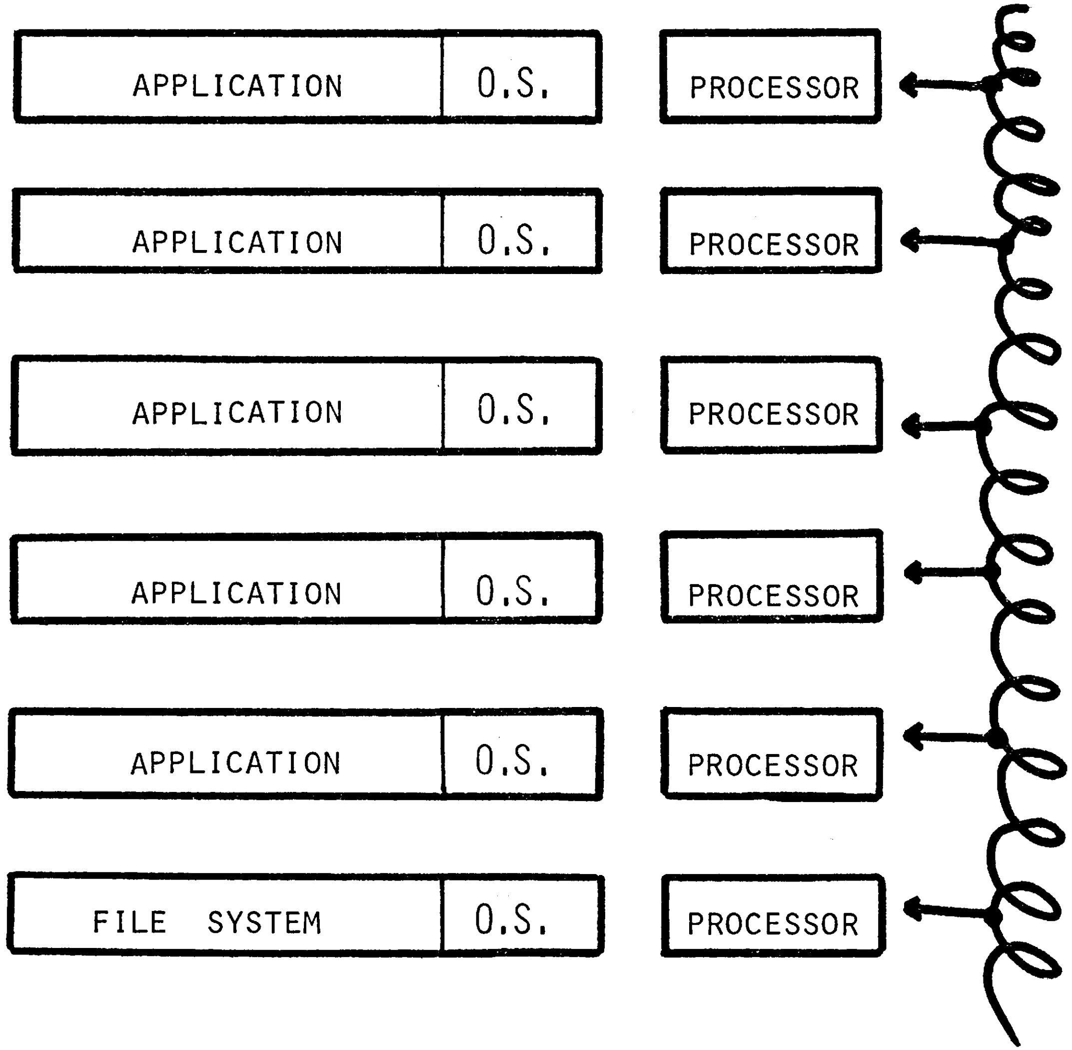


IN TRADITIONAL SYSTEMS FEATURING A LOCAL HOST, APPLICATIONS MUST SHARE THE MEMORY AND PROCESSING POWER OF THAT HOST.

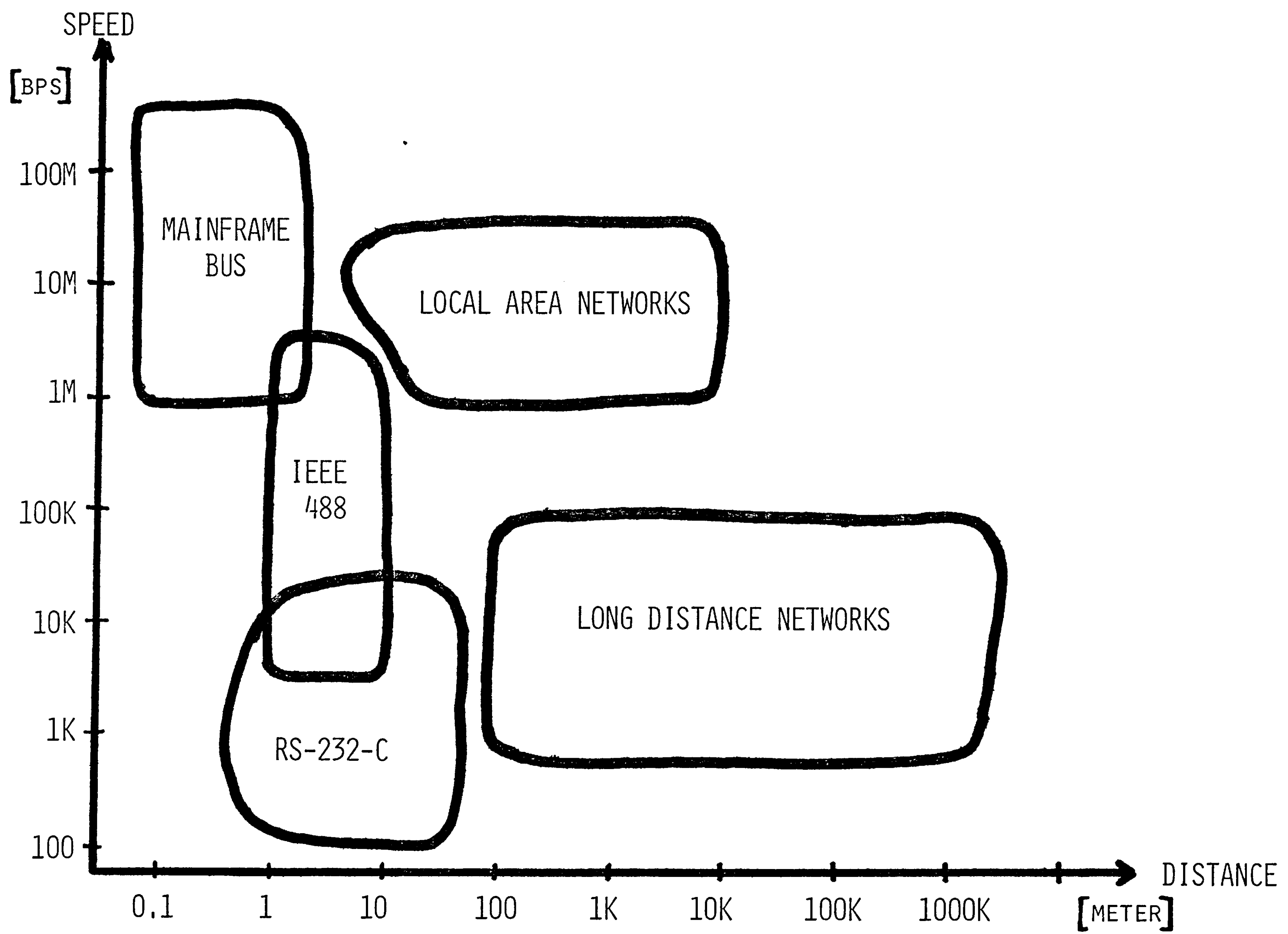
THIS RELATES BACK TO THE DAYS, WHERE THE CENTRAL PROCESSOR WAS THE MOST EXPENSIVE PART OF THE COMPUTER SYSTEM.

VLSI TECHNOLOGY IS NOW IMPACTING THE COST/BENEFIT OF SUCH SOLUTIONS.

VLSI TECHNOLOGY OFFERS THE ALLOCATION OF COMPUTING POWER WHERE IT IS NEEDED, BUT ....



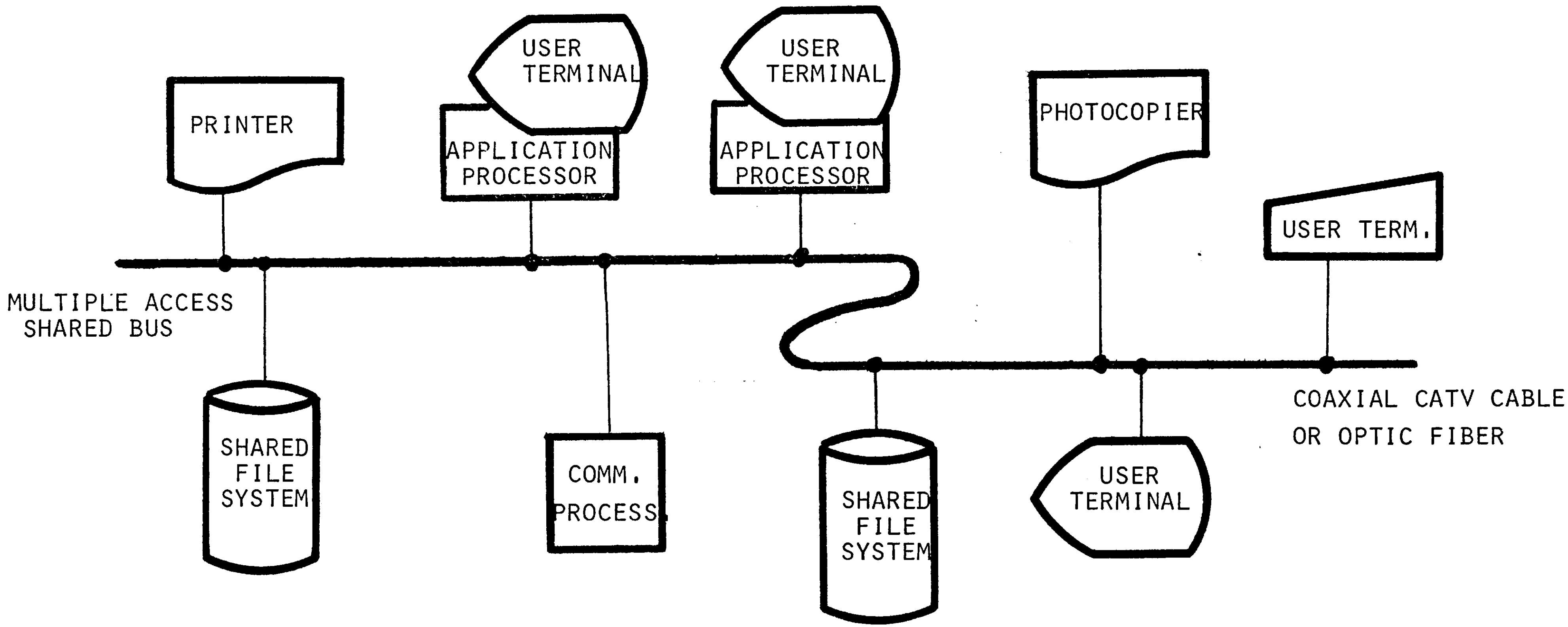
THIS IMPLIES THAT SOME KIND OF COMMUNICATION MUST BE ESTABLISHED BETWEEN THE DISTRIBUTED PROCESSING MODULES.


SPEED
[BPS]
100M
10M
1M
100K
10K
1K
100
MAINFRAME
BUS
LOCAL AREA NETWORKS
IEEE
488
RS-232-C
LONG DISTANCE NETWORKS
0.1
1
10
100
1K
10K
100K
1000K
DISTANCE
[METER]

LOCAL AREA NETWORKS MAY WELL BE THE GREATEST CHALLENGE FOR COMPUTER INDUSTRY
IN THE EIGHTIES

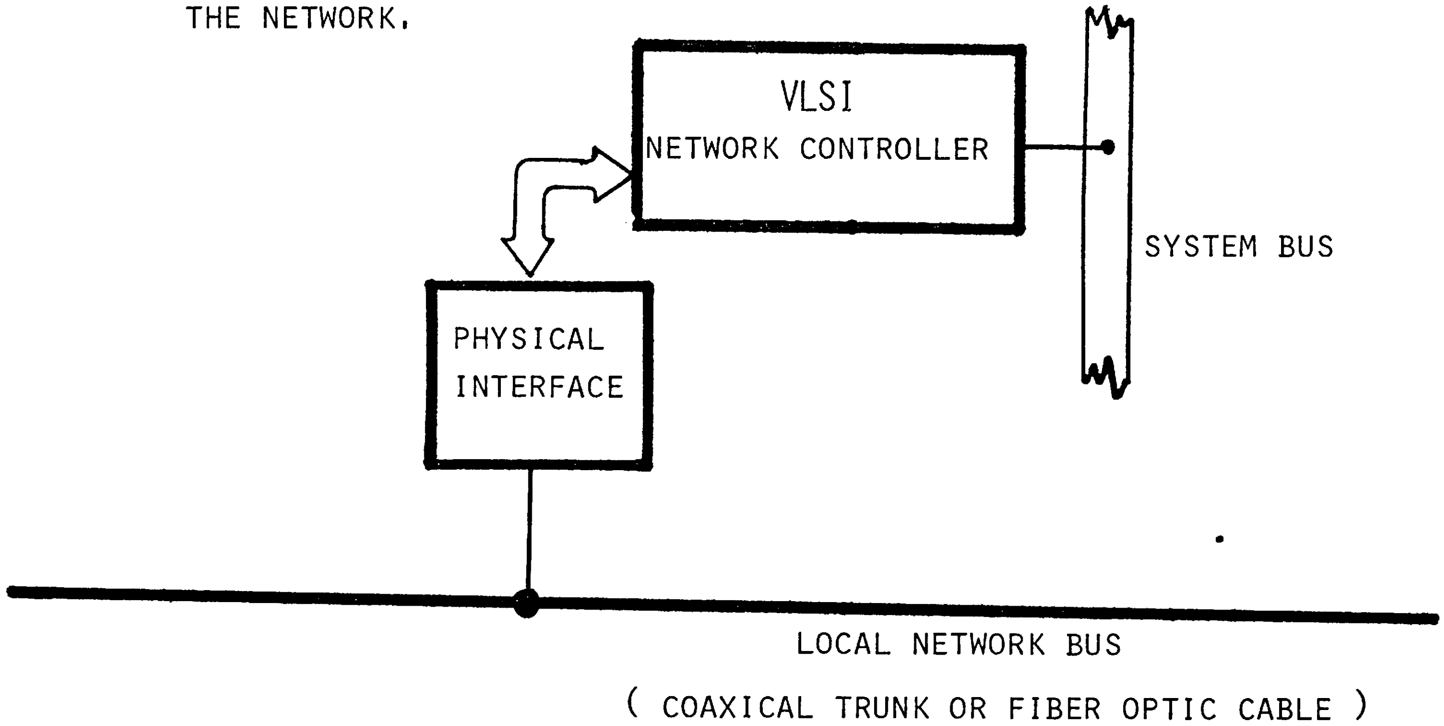
THEY FEAUTURE :

* NO HOST
* DISTRIBUTED CONTROL
* ADAPTABILITY
* CONFIGURABILITY
* INDEPENDENT SUPPLIER ALLOWANCE

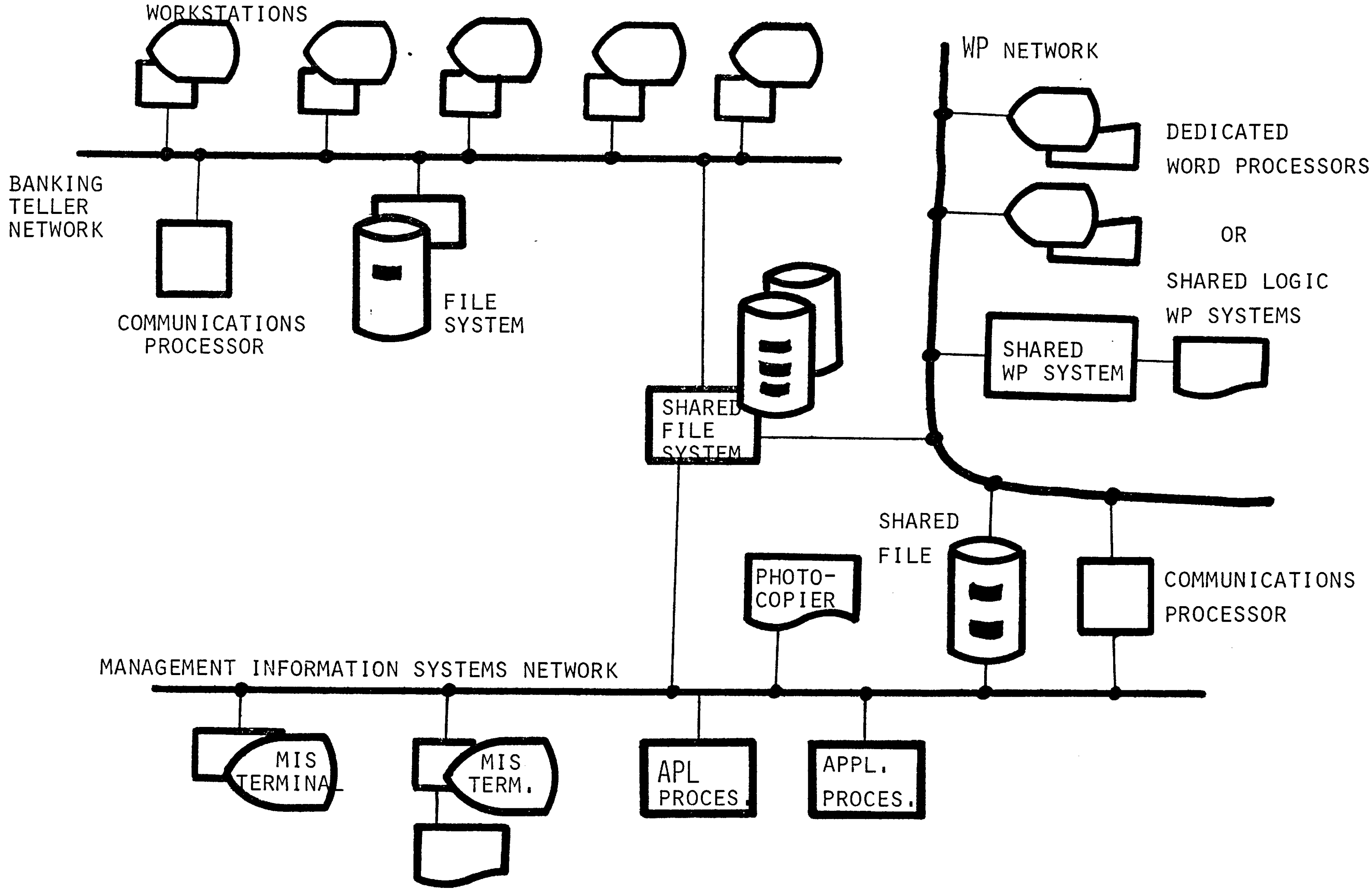


THE INTERFACE TO THE LOCAL AREA NETWORK WILL EVENTUALLY BE SUPPORTED BY SINGLE-CHIP, VLSI CONTROLLERS OR INTEGRATED AS A PART OF THE MICROPROCESSING UNIT ITSELF.

THIS ENFORCES THE USE OF A STANDARD INTERFACE ALLOWING SEVERAL SUPPLIERS TO CONNECT TO THE NETWORK.



LOCAL NETWORK ARCHITECTURES CAN BE ADAPTED TO SYSTEM REQUIREMENTS



TECHNOLOGY IMPACT ON SDC

SDC MUST LEARN TO UNDERSTAND AND USE THE NEW ARCHITECTURES BASED ON LOW-COST PROCESSING ELEMENTS

SDC MUST BE PREPARED FOR THE GREATER INTERACTION BETWEEN HARDWARE AND SOFTWARE, THE SHARP DISTINCTION BETWEEN SOFTWARE AND HARDWARE DEVELOPMENT MUST BE REMOVED, AND IN OUR APPLICATIONS DEVELOPMENT WE MUST BE ABLE TO TREAT BOTH SOFTWARE, HARDWARE AND HUMAN INTERFACING WITH THE SAME DEGREE OF COMPETENCE.

AS SOFTWARE AND HARDWARE ARE AFFECTING EACH OTHER IN VLSI-BASED SYSTEMS, SDC MUST ACQUIRE KNOW-HOW AND SKILLS IN SYSTEMS PROGRAMMING IN ORDER TO BE ABLE TO DEVISE OUR SUPPLIERS ON THE DESIGN OF SUCH SYSTEMS.

AS VLSI TECHNOLOGY PROVIDES LOW-COST PROCESSING POWER CLOSE TO THE END-USER WE MUST LEARN TO UTILISE THIS POWER IN ORDER TO OBTAIN AND DESIGN SYSTEMS WITH THE OPTIMUM HUMAN INTERFACE.

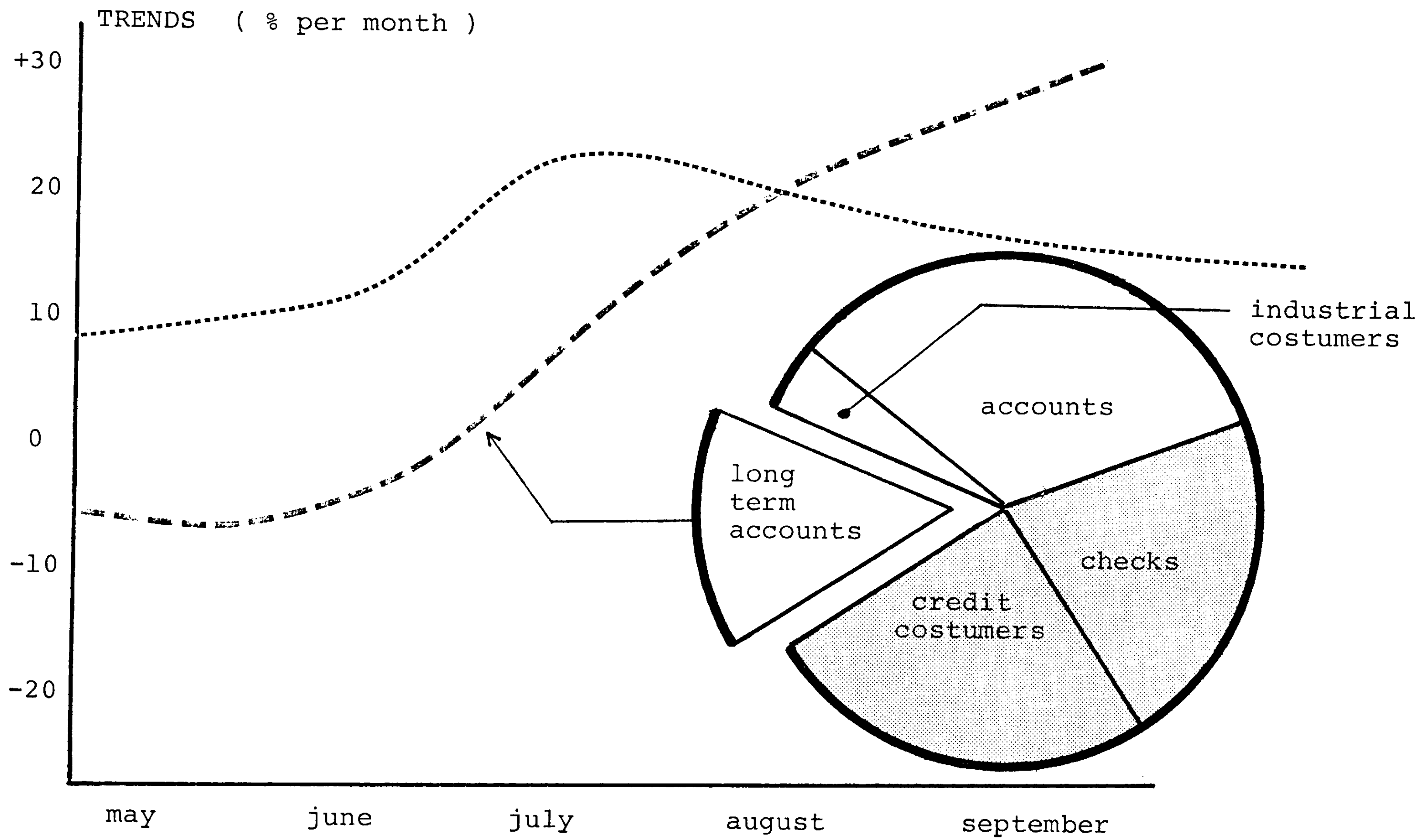
financial statements

july 1981

account number	num of trans per month	trend %	balance may	june	july	(next)
526-88-828827727	4	+7	1762	1872	2013	2233
526-89-612818817	37	+1	26627	25677	27888	28500
197-17-772661542	0	0	7888	7888	7888	7888
728-00-888256412	19	-8	10099	9100	8671	7552
452-00-777565321	3	0	2676	2767	2699	2700
113-47-672555141	176	+2	177262	180990	190776	195000
661-62-556765211	77	-10	73462	65838	58811	53911
708-65-718787999	25	+1	7161	7161	7265	7301
787-45-002891871	10	+1	67646	25771	68761	69871
852-78-004547177	0	0	87726	17	17	17
663-61-773662552	35	-19	7700	73	62	-67
663-61-344500012	0	+9	-567	8776	9103	10702
963-42-754569875	7	-9	1002	968	913	887
809-00-008715651	109	+4	30982	25891	26788	27004
total	487	+3	376155	358006	417726	467188

press N for next, Q for quit.

priority code : 9 num in data set : 8279
function selection: HPQZ com_id : A413



TRENDS (% per month)
+30
20
10
0
-10
-20
may
june
july
august
september
industrial
costumers
accounts
long
term
accounts
checks
credit
costumers

TECHNOLOGY IMPACT ON BANKING APPLICATIONS

THE BASIC IMPACT ARISES FROM THE PROVISION OF CHEAP PROCESSING POWER CLOSE TO THE END-USER

THIS WILL ALLOW FOR PROCESSING APPLICATIONS HITHERTO ONLY IMPLEMENTABLE ON THE CENTRAL MAINFRAME. MIS SYSTEMS AND ELECTRONIC OFFICE FUNCTIONS WILL BE FACILITATED BY THIS TREND. ALSO THE LOCAL SHARED FILE SYSTEMS WILL BE GENERAL, ALLOWING INTEGRATED OFFICE INFORMATION PROCESSING

THE CONCEPT OF LOCAL NETWORK ARCHITECTURES WILL ALLOW FOR EXPANDABLE BRANCH OFFICE SYSTEMS, AND THE NETWORKS WILL BE SUPPORTING EVEN THE SMALLEST BRANCH OFFICES, AS THE COST OF IMPLEMENTATION WILL BE DIRECTLY PROPORTIONAL TO THE NUMBER OF WORKSTATIONS, NOT BEING RELIANT ON THE EXISTENCE OF A LOCAL CENTRAL CONTROLLER OR HOST.

END-USERS WILL BE GIVEN MORE FREEDOM TO DEVELOP THEIR OWN DEDICATED APPLICATIONS PROGRAMS, AS THEY HAVE THE PROCESSING POWER AND DEVELOPMENT FACILITIES RIGHT AT HAND.

SUMMARY

VLSI TECHNOLOGY IS IMPACTING COMPUTER DESIGN BY

- PROVIDING COMPACT, CHEAP PROCESSING POWER
- ENFORCING THE USE OF DATA COMMUNICATIONS AT ALL LEVELS
- PREPARING THE MIGRATION PATH TO TRUE DISTRIBUTED SYSTEMS
- MOVING SOFTWARE INTO SILICON
- CHANGING THE METHODS OF SERVICE AND MAINTENANCE

USEFUL SYSTEMS CANNOT BE DESIGNED BY THEORY

USERS MUST UNDERSTAND THE TECHNOLOGY IN ORDER TO BE ABLE TO SPECIFY THE SYSTEMS THEY WANT, AND THEY MUST BE AWARE OF THE PROBLEMS OF APPLYING THE NEW TECHNOLOGY FROM THE MANUFACTURER'S POINT OF VIEW.

SUPPLIERS MUST KNOW THE MIGRATION PATHS OF THE USERS AND BE AWARE OF THE WAYS SYSTEMS WILL BE APPLIED IN THE USERS' ENVIRONMENT

THE WAY AHEAD MAY EVENTUALLY BE PREPARED BY JOINT-VENTURING

LEADING EDGE KNOW-HOW IN BANKING SYSTEMS

sparekassernes
datacenter

olivetti