digital SEP 27 1976 INTEROFFICE MEMORANDUM

TO: Operations Committee

DATE: September 22, 1976
FROM: Peter Christy
DEPT: Software Development
EXT: 6110
LOC/MAIL STOP: ML12/A62

SUBJ: DECsystem-10 Competitive Analysis

Attached please find a set of notes resulting from my competitive study. These include some qualitative comparisons that were presented to Andy's study committee but not at your meeting. Obviously these represent my value judgements to some degree, although I have attempted to be quite fair.

attachment

COMPANY CONFIDENTIAL

DECSYSTEM-10 Competitive Analysis

The IBM 360

In April of 1964, IBM announced a revolutionary approach to computing, the System/360. This was a uniform family of computer featuring upward compatibility and a single massive all-purpose software system. The success of the/360 approach is self-evident from the success of IBM in the last decade. Nevertheless, the initial design of System/360 and OS/360 left a substantial technical hole into which the PDP-6, PDP-10 and DECsystem-10 fit nicely. This hole was due to the batch orientation of the System/360 which was characterized by a very cumbersome interrupt and I/O structure, non-relocatable memory and a batch software design. OS/360 software represented a tremendous amount of development and suffered from its immaturity. On balance System/360 provided only mediocre real-time and interactive performance. These weaknesses were the strengths of PDP-6, PDP-10 and DECsystem-10.

IBM Development Highlights

Since 1964 IBM has invested a large amount of money in continuing hardware system and software development. Some of the key aspects of these developments vis-a-vis the DECsystem-10 and -20 are noted below.

In April of 1965 IBM announced the System/360 model 67 and the time-sharing software system that went with it, TSS/67. These developments were apparently motivated by competitive pressure from the Multics System developed by MIT, Bell Laboratories and G.E. The model 67 was a poor "Chinese copy" of the Multics System, with several key technical features poorly implemented, resulting in inadequate system performance. The product never was a commercial success. Nevertheless, one can assume that IBM has learned from this experience, which is now almost a decade old. 1965 also saw the introduction of the System/360

IBM DEVELOPMENT HIGHLIGHTS

Era	Date		Product	Impact
batch	1965	April	360/67 TSS/67	Experience
			360/44	
	1968		IMS	Functionality
	1969		CICS	Functionality
			TSO	Functionality
interactive				
	1970		System/370	
		Sept	370/145 Semi. Mem RCS	Technology, Effectiveness
	1972	March	3705	Function., Effectiveness
		August	370VS /158 /168 VOS'	Functionality
	1973	Feb	/158 /168MP MPOS	Functionality
		March	3340 (Winchester)	Technology
		July	370/115 (ICA)	Effectiveness
		Dec	3790 Terminal Processor	Effectiveness
			3330 II	Technology
----------			370 Installed-base Exceeds 360	----------
	1974	Sept	3767 Matrix Printer	Effectiveness
			3770 Remote Batch Terminal	Function.
	1975	July	3350 Fixed-media Disk	Technology
	1976	Jan	VS/PC (Personal Computing)	Effective, Functionality
			3790+ (more term, RJE, local TP)	" , "
interconnected				
		Sept	Ink-jet Printing	Technology

- DISTRIBUTED INTELLIGENCE ARCHITECTURE
- VIRTUAL MEMORY
- INVESTMENT IN INTERACTIVE FUNCTIONALITY
- FUNDAMENTAL TECHNOLOGY

model 44, which was a lean, cost effective implementation of the System/360 for computational purposes. This machine was also not a competitive success, but presumably a rich learning experience in terms of cost effective implementation of the /360 architecture.

In 1968 IBM first released the IMS data base software system. Since that time IMS and the CICS transaction processing system, first released the next year, have been two of the most richly developed application software systems in IBM's portfolio. Data base management and transaction processing are key to interactive distributed processing. In IMS and CICS, IBM has two mature systems with extensive development, investment and implementation experience.

In 1969 IBM released the TSO time sharing option to OS/360. Initially both the performance and functionality of TSO were mediocre, but in its seven year life time, it has been enhanced and improved tremendously. The massive price reductions on central memory represented by the /138 and/148 announcement make time sharing on a System/370 much more attractive (see below).

In June of 1970 IBM announced the System/370, which at that time represented only a modest improvement over comparable System/360 processors. In September of that year the /370 announcement was expanded somewhat by the introduction of the /370 model 145, which featured semi-conductor memory and reloadable control store (RCS). The introduction of semi-conductor memory at that time was an indication of the fundamental technology leadership of IBM. We should note that the PDP-11/04, announced last year, was the first Digital processor to feature semi-conductor memory. Reloadable control store represents a significant architectural evolution toward system oriented products. The only Digital processor with a reloadable control store is the KL-10. (The STAR processor will also feature a reloadable section of the control store.)

In March 1972 IBM announced the 3705 communication processor, which represented a tremendous evolution from the 27xx series of the System/360. The 3705 is a fully programmable communication processor providing rich front end functionality and a substantial off-loading of the central processor for interactive or distributed applications. The first Digital product to fully compare to the 3705 in terms of programmability will be a DCOPS front end, which is still some time to come.

In August of 1972, IBM revealed the full power in the System/370 announcement by describing the virtual memory capabilities of the system for the first time, by announcing two new processors featuring virtual memory, the /158 and /168, and by announcing virtual memory operating systems, including DOS/VS, OS/VS1, OS/VS2 and VM/370. The significance of virtual memory in the System/360 and System/370 product line is that this technical enhancement eliminates one of the most glaring architectural faults in the original /360 vis-a-vis interactive and distributed processing: the absence of relocatable memory. Having virtual memory permits the physical memory to be allocated only to those computational activities instantaneously requiring it, which in turn permits a smaller amount of real memory for a given application.

Virtual memory is available on the DECsystem-10 in TOPS-10 Version 6.02 and is a fundamental part of the TOPS-20 design. Virtual memory is also fundamental to the VAX machine design and is well-supported in the STARLET system.

VM/370 goes beyond virtual memory and provides a complete virtual machine operating system, the functionality of which is not available in any Digital product currently implemented or planned. VM/370 serves as a basic operating system which provides virtual machine facilities to a number of secondary operating system, such as DOS or OS/VS1. VM/370, in conjunction with the Cambridge Monitor System (CMS) developed at the IBM Cambridge Research Center, provides a rich time sharing environment quite comparable to what we offer in TOPS-10 and TOPS-20.

In 1973, IBM announced multiprocessor versions of the /158 and /168 and the second release of OS/VS2 which supported the multiprocessing configurations. It should be noted that this is richer multiprocessing support than we offer in the TOPS-10 operating system and that neither the PDP-11 nor the DECsystem-20 offer any substantial multiprocessing facilities at this time. Multiprocessing is an important part of distributed processing applications which require high system availability.

In March of 1973, IBM announced the 3340 disk unit featuring "Winchester" technology. This product announcement is indicative of the fundamental leadership which IBM holds in the disk area. The first Digital-supplied disk (which will be purchased from an OEM disk manufacturer) which features the Winchester technology will be the RP07. This product is not due for several years.

In July 1973, IBM announced the 370/115. This announcement is of significance because the processor features multiple microprogrammed support processors including an integrated communications adapter (ICA) which provides line support for up to 8 on-line terminals. The announcement of the /115 is indicative of IBM's evolution toward smarter architectures which offload basic overheads (such as line management) from the central processing unit.

In December 1973, IBM announced the 3790 remote, shared-processor, data-entry system. This represents a further evolution in intelligent terminal distributed processing system design. The first set of Digital products which will provide a reasonable alternative to 3790 functionality, will be the combination of ATAM, DECNET, the VT62, DCOPS software, and a front-end or remote concentrator processor.

In December IBM also announced the 3330 model II disk which is the technology available in the Digital supplied RP06.

The final item of significance in 1973 was the growth of the System/370 installed based to a point where the total value of installed 370 equipment was greater than the total value of the

installed System/360 equipment. This is indicative of the use of the much more powerful systems. In September of 1974 IBM announced the 3767 family of serial matrix terminals. This represented a substantial increase in capability over the Selectric-based 2741 terminal. IBM also announced the 3770 remote batch terminal.

In July 1975 IBM announced the 3350 disk unit, which was a fixed storage unit based on Winchester technology and represented a new level of mass storage efficiency measured in the cost of a megabyte of storage.

In 1976 IBM announced VS/PC which was built as a person-computing, time-sharing option to OS/VS. The significant features of this announcement were a computer system with a simplified, human-engineered interface comparable to what we tout in RSTS, and a notable software evolution in shared code processors for FORTRAN and BASIC, and the first IBM implementation of a shared APL processor. The value of shared processors in interactive applications is the substantial decrease in the amount of real memory required to support the application.

Also in 1976, IBM announced substantial enhancements to the 3790 data entry subsystem, including a substantial increase in the number of terminals supported, RJE capabilities and local transaction processing capabilities.

In summary we see this decade of IBM developments as making substantial inroads into the technical weaknesses which the PDP-6 and PDP-10 exploited. These weaknesses included a cumbersome machine architecture for interrupt handling and I/O. Although the central processor design has not been redone, the CPU is now augmented by a number of intelligent support processors for functions like communications which eliminate the vulnerability of the cumbersome CPU design. Virtual memory has been added, which makes the system 370 processor much more useful for providing realtime and interactive functions. There has been a tremendous investment in interactive functionality, particularly in the IMS and CICS software systems. Finally, over this decase IBM has evolved as a clear leader in data processing technology, particularly semiconductor central memory and disk storage units. IBM has a substantial cost advantage in these technologies which comprise the majority of the cost of a computer system, giving IBM tremendous pricing leverage competitively.

The 370/138 and 370/148

In June of this year IBM shocked the data processing industry with the introduction of the 370 models 138 and 148. These products represented meaningful conservative advances in technology but a dramatic deviation from the traditional IBM pricing algorithm. The /138 and /148 are slightly higher in performance than their predecessors, the /135 and /145, due to the use of a faster 2K MOS memory chip and the expansion of the reloadable control store by a factor of 4 or 5 to a total capacity of 128K bytes. What is much more dramatic however, is the pricing of these products. Traditionally IBM would announce a new product with approximately twice the performance of a predecessor at a price increment of approximately 40%. The /138 and /148 represent perhaps a 40% performance improvement, but a price reduction of almost 50%, dominated by dramatic reductions in the cost of central memory. The attached pricing chart indicates the size of the price reductions. Whereas a 1/2 megabyte /135 processor had a purchase price of $659,000. The corresponding /138 processor, with improved performance, has a selling price of $350,000. A 1 megabyte /145 processor sold for $1,250,000, whereas the corresponding /148 processor with improved performance had a purchase price of $689,000. Similarly, a 2 megabyte /145 processor sold for $1,840,000, whereas the corresponding /148 model sells for $859,000. These prices are seen as all the more remarkable in comparison to the /158-3 prices of $2,020,000 for a 1 megabyte processor, and $2,280,000 for a 2 megabyte processor.

Viewing the pricing of incremental memory (memory in addition to the basic memory of the processor) also shows dramatic reduction. The price of incremental memory for a /135 processor was $500/KB; the incremental price for memory on the /138 processor was $162/KB. The incremental price for the /145 processor was $548, where it had been slashed to $166/KB for the /148 processor. 11/70 memory is priced incrementally at $110/KB (11/70 memory is one of the nighest marked-up Digital options). By comparison, incremental DECsystem-10 memory is currently priced at approximately $180/KB.

JUNE 1976 370/138 370/148

- CONSERVATIVE TECHNOLOGY

  2K MOS MEMORY CHIPS

  EXPANDED RCS

- DRAMATIC REPRICING

CPU AND MEMORY

	MB	/135	/138	/145	/148	/158-3	BURROUGHS
(K$)	1/2	659	350				495 (3830) 311 (6807)
	1		435	1,250	689	2,020	912 (4840) 648 (6811)
	2			1,840	859	2,280	

INCREMENTAL MEMORY

$/KB	500	162	548	166		462 (3830) 582 (4840)

11/70 is $110, DEC-10 $180

- KEY MARKETING ACTION

  DB/DC ENTRY MOVED DOWN,
  FULL VS2, CICS, IMS, SNA/SDLC
  PRICE/PERFORMANCE ATTACK
  BACKUP FOR BIG MACHINE
  REASONABLE T/S ADD-ON
  GREATER INTEGRATION OF PERIPHERALS, CPU, SOFTWARE

One can assume that this dramatic IBM price reduction which substantially impacts IBM's near-term profitability, as well as the profitability of competitors, has very sound reasoning behind it. One can see these system offerings, along with the enhancements of the full virtual memory operating system family to run on these processors, as IBM's aggressive lowering of the entry price for full data base, data communications systems. Previously, the 370/158 was the practical low-end processor for full systems support. The repricing is a direct price/performance attack on the mainframe competitors in this price range, and an indirect threat to many competitors. For example, it is now attractive to purchase a /138 or /148 as a backup machine for a large System/370. A customer with a new interactive or distributed application, may choose to purchase a /138 or /148 rather than purchasing a competitive product which would be of no backup use. Similarly, the reduction in the cost of central memory makes the addition of time-sharing to System/370 (adding the TSO option) much more attractive than it was previously. With the cost of incremental central memory for a System/370 now more in line with DECsystem-10 prices, it becomes attractive to consider the purchase of a larger central memory to support time-sharing as well as batch processing. Previously the exorbitant cost of IBM central memory made the purchase of a specialized time-sharing machine, such as a DECsystem-10, very attractive. Finally, these machines represent a continuing integration of peripherals, CPU and software. This represents both a threat to the IBM add-on vendors, and to other mainframe vendors since the cost efficacy of the product has gone up substantially. In the System/370 /138 and /148 the expanded reloadable control store is used to store microcode implementation of commonly used operating system facilities. This permits an improvement in performance above and beyond that which machine level recoding of functions can achieve, in particular the overhead of supporting the virtual machine operating system, BM/370, is said to have gone down by over 50%. The overhead of the more conventional operating systems, OS/VS1 and OS/VS2, have been improved by 10 - 20%.

Basic Performance Factors

Computer system architectures have evolved to a point where there is no longer a dramatic difference in the intrinsic performance between one modern architecture and another. For example, a recent Army/Navy study showed the intrinsic power in the PDP-11 and 360 architectures to be comparable, which might be surprising to one who thinks of the PDP-11 as a "minicomputer". Although the 360, PDP-11 and HP-3000 architectures all have substantial defects (paged memory management support in the hardware), the evolved systems, the 370 and VAX architectures, can be considered to have no intrinsic defects. What differs among the products is seen in other factors, including the implementation of the architecture, the software design, the software maturity, the system maturity, the basic technology.

The implementation of the architecture can be seen as a measure of how well the different parts of the computer system play together. The 360 with its relatively cumbersome processors and controllers represented a relatively inefficient implementation (by measure of cost/performance) of the architecture. In contrast, the 370 represents a mature and effective evolution of the comcepts of the architecture. The PDP-11 started as a relatively elegant but limited in performance implementation of the architecture, especially in the limited power of the device controllers and the limited thruput of the Unibus, but in the initial VAX implementation (STAR), most of the known problems have been overcome. The DECsystem-20 represents an elegant and powerful architecture with the most substantive implementation limitations lying in the relatively small engineering investment thus far. The HP-3000 also suffers from a relatively modest investment and a somewhat archiac fundamental architecture.

BASIC PERFORMANCE FACTORS

	1360	/370	PDP-11	VAX	-20	HP-3000
ARCHITECTURE	= -	=	= -	= +	= +	= -
IMPLEMENTATION	-	++	=	+	=	= -
SOFTWARE DESIGN	-	+	+	++	++	+
SOFTWARE MATURITY	N/A	++	+	- -	-	+
SYSTEM MATURITY	N/A	++	=	+	=	=
BASIC TECHNOLOGY	N/A	++	+	+	=	= +

The original System/360 software could be considered cumbersome at best; it suffered from tremendous size and performance problems. However, the 12 years since the introduction of the product line have seen enormous investments in software and system performance which result in the OS/370 software being generally as good or better than any in the industry. The PDP-11 software in general has been well-designed and well-implemented, but represents only a very small fraction of the total 370 software base. The VAX software represents perhaps the most powerful design with the most maturity in the design, but represents an immature and unfinished product which must be considered a substantial initial liability. The DECsystem-20 software is an elegant design for limited purposes and has seen only relatively modest investment. The HP-3000 software is relatively mature and represents an apparent effort on the part of HP to improve the performance.

System maturity is a measure of now much real experience with the system product has been factored into its redesign and evolution. The System/370 is the clear leader in this area. VAX is a very mature design, but its initial implementation problems have yet to be discovered. The DECsystem-20 is hindered by a relatively modest engineering investment and the HP-3000 by an inauspicious beginning.

The final factor in basic performance is the technology used. The 370 is the clear leader in fundamental technology and manufacturing ability, although the full power of IBM has never been applied to an ultimately cost-reduced product. Both the PDP-11 and VAX will benefit by the relatively high volumes. The DECsystem-20 is at a relative disadvantage due to its lower engineering expenses and relatively modest product volumes. The HP-3000 lies somewhere in between the PDP-11 and the DECsystem-20 in terms of volume.

Virtual Memory Performance

Virtual memory designs can be best viewed as an engineering exercise, the purpose of which is to keep an adequate stream of instructions and data available at the central processor for a minimized cost in the memory system. Memory hierarchies are comprised of a number of different memory technologies each of which has a distinct performance level and cost. If the cost per byte for all technologies were equal, all systems would be designed with a single level of memory consisting only of the fastest technology. Instead, however, we see a memory hierarchy consisting of the central processor registers with the fastest performance and highest intrinsic cost, a cache memory of lesser performance and lower cost, a large (currently semi-conductor) central memory, possibly a fixed head disk, and finally a moving head disk storage system. The performance design of the 370 family can be seen by the presence of all members in this memory hierarchy. Of particular note, IBM has developed a fixed-head option to their moving head disk products, permitting an installation with multiple on-line spindles to use part of those spindles as a swapping storage for virtual memory without an incremental investment in mechanical parts or electronics. The 2040, due to the absence of an economical fixed head disk and the removal of the cache for cost purposes, has only the CPU, central memory and moving head components of the memory hierarchy. The 11/70 has a cache but is usually sold without fixed-head disk. The STAR system currently is conceived without a fixed-head disk, although CCD and bubble alternatives have been explored to some degree. The HP-3000 is without both a cache and a particularly cost attractive fixed head disk, but there have been industry rumors that HP is strongly examining the use of bubble technology.

Both the PDP-11/70 and HP-3000 have relatively weak architectures for virtual memory support, lacking paging. The end effect in any weakness in a virtual memory design is relative cost-ineffectiveness. For example, the absence of a cache in the 2040 processor limits the effective thruput of the CPU and the absence of the cost-effective fixed-head disk option requires the use of more core memory than would be needed with a fixed-head disk.

SUMMARY

In summary, we can see the following attractions and limitations to each of the compared system products.

The PDP-11 - The value in the PDP-11 products centers around the relative maturity and high volume. The maturity of the product means that every major feature has gone thru at least one reimplementation and is relatively well understood. The volume of the product leads to good manufacturing volumes and basic cost attractiveness of volume parts. The volume of sales has also supported a large software investment, both within Digital and from our customers. This investment leads to a relatively large and well-evolved set of software systems for the PDP-11.

The negative aspects of the PDP-11 include the minicomputer history (which causes many people to conceive of its uses from a historical background and neglect the true power of a modern "minicomputer"), the address space limitations, and some aspects of the architecture, including the Unibus design (which limits the upward levels of performance available on a Unibus-based PDP-11 system).

The PDP-11/VAX - Being the most recent of any of the architectures compared, it is expectable that the PDP-11/VAX will have the most mature architecture representing the greatest amount of combined understanding in computer system design. This mature architecture will represent a fundamental attraction of the product. Because the VAX architecture is aimed for the PDP-11 marketplace, we can assume that the VAX machine will benefit from PDP-11 product volumes and achieve good basic cost efficiency of the manufactured parts. Finally the system design currently anticipated for VAX products represents a relatively mature view and should achieve a good balanced implementation based on experience. The liabilities of the VAX set of products include the fundamental immaturity of the product and the low software investment.

The DECsystem-20 - The attraction of the DECsystem-20 include the fundamental elegance of the design and the base of established PDP-10 software, which is available at an application and utility level. The disadvantages of the DECsystem-20 include the relatively low volume of the product, which limit the manufacturing efficiencies available, the relatively low volume in DECsystem-20-specific software (a problem which is exacerbated by the incompatibility between TOPS-20 and TOPS-10) and the relatively small number of DECsystem-20 peripherals that are currently available due to the low overall volume in the DECsystem-10 and -20 product lines.

System/370 - Attractions of the 370 include the maturity in the system design, the completeness of the software and system products available, the volume of the product, and the basic technology leadership which IBM has. The disadvantages of the System/370 derive primarily from its history, in particular the fact that the original System/360 operating system was relatively poorly designed and implemented.

HP-3000 Series II - The attraction to HP-3000 Series II compared to the VAX machine and DECsystem-20 machines, is the relative maturity of the product and the software system. Compared to the DECsystem-20 the HP-3000 probably has a small volume advantage. The disadvantages of the HP-3000 include the basic architecture, which represents detrimental compromise between a machine of tremendous generality and power and a minicomputer, relative lack of peripherals that are available for the HP-3000, the relatively primitive software technology which does not include a powerful paging mechanism, and the relatively small software investment that has been made in the product to date.