Of all the winning attributes of the OpenVMS operating system, perhaps its key success factor is its evolutionary spirit. Some would say OpenVMS was revolutionary. But I would prefer to call it evolutionary because its transition has been peaceful and constructive.

Over a 20-year period, OpenVMS has experienced evolution in five arenas. First, it evolved from a system running on some 20 printed circuit boards to a single chip. Second, it evolved from being proprietary to open. Third, it evolved from running on CISC-based VAX to RISC-based Alpha systems. Fourth, VMS evolved from being primarily a technical operating system, to a commercial operating system, to a high availability mission-critical commercial operating system. And fifth, VMS evolved from time-sharing to a workstation environment, to a client/server computing style environment.

The hardware has experienced a similar evolution. Just as the 16-bit PDP systems laid the groundwork for the VAX platform, VAX laid the groundwork for Alpha—the industry's leading 64-bit systems. While the platforms have grown and changed, the success continues.
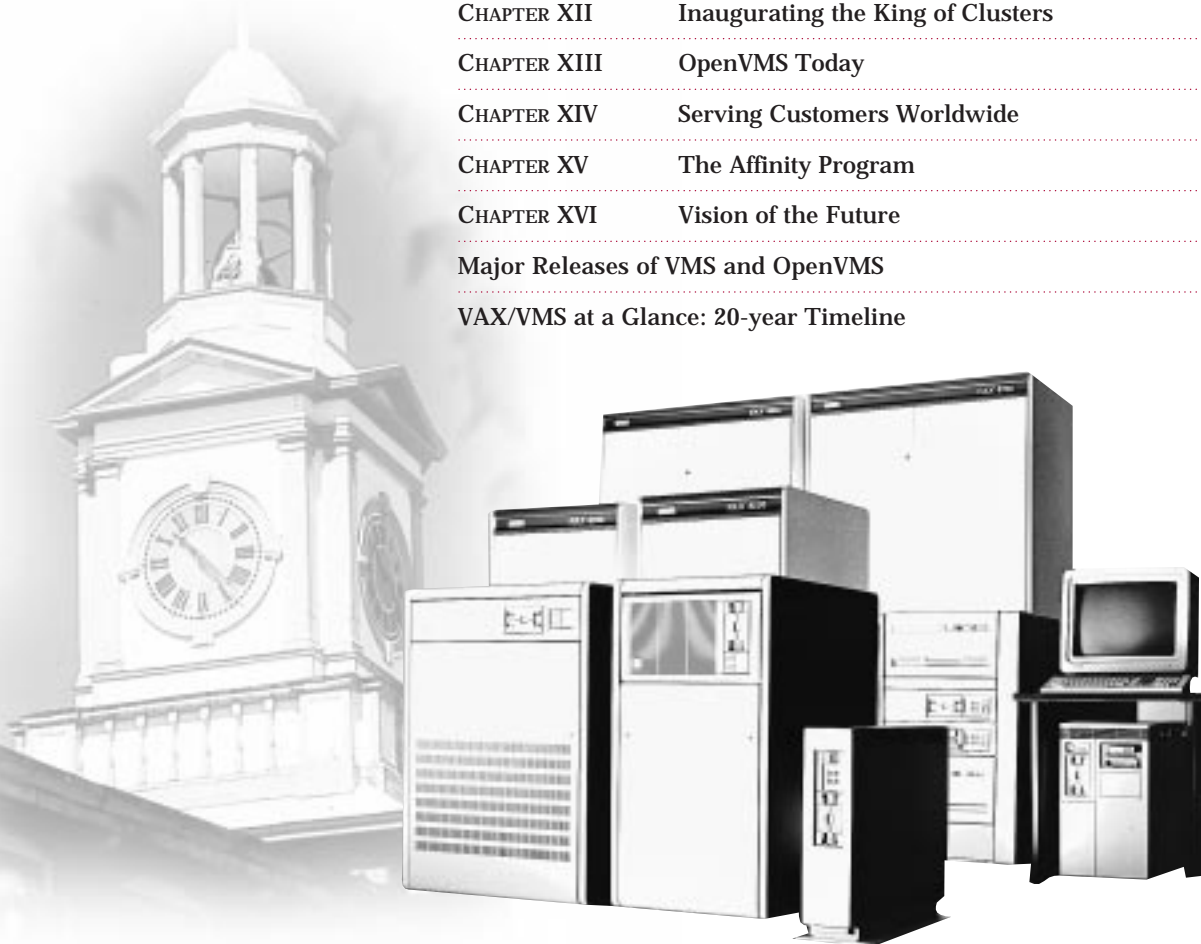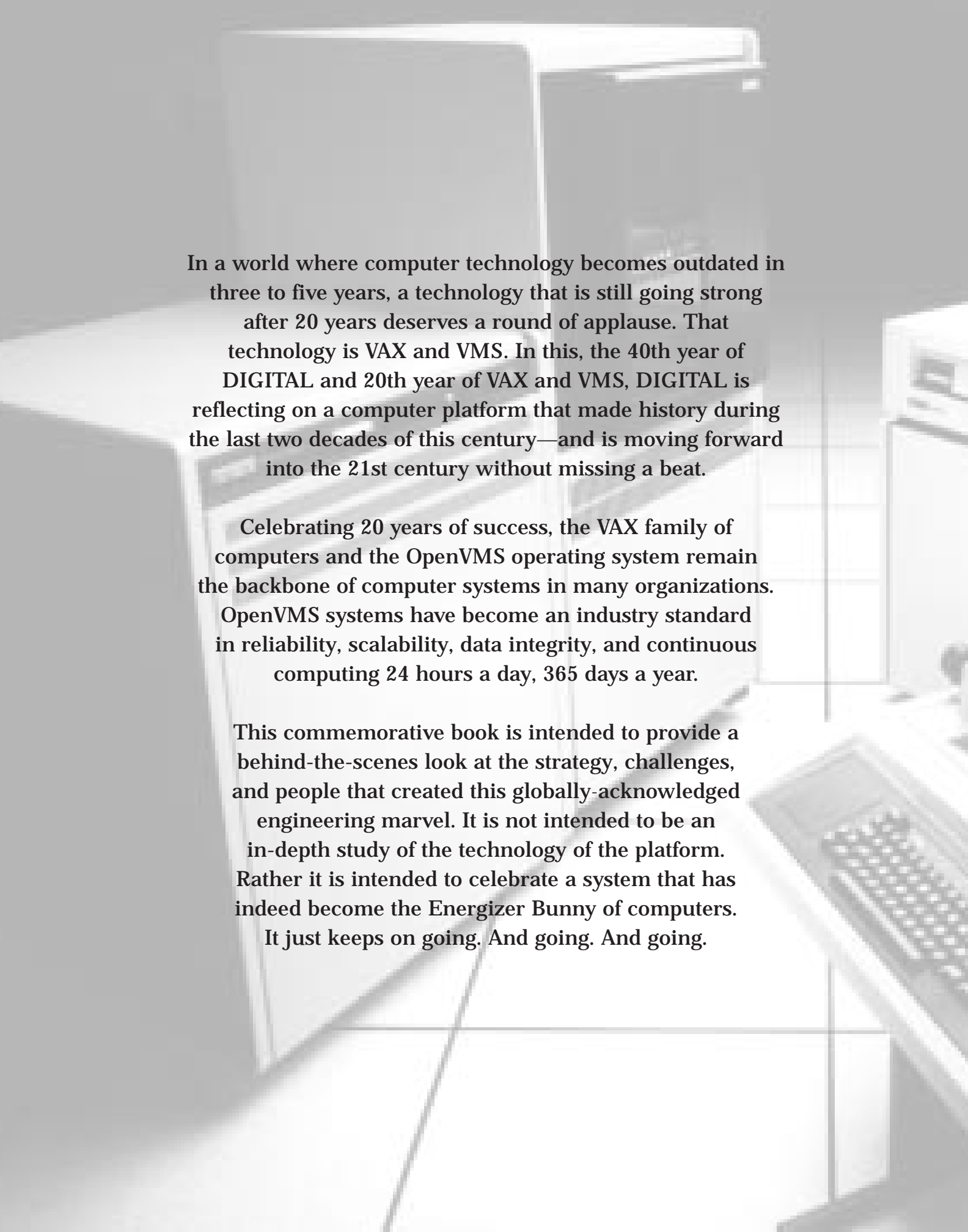
Today, OpenVMS is the most flexible and adaptable operating system on the planet. What started out as the concept of 'Starlet' in 1975 is moving into 'Galaxy' for the 21st century. And like the universe, there is no end in sight.

—Jesse Lipcon
Vice President of UNIX and
OpenVMS Systems Business Unit

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In a world where computer technology becomes outdated in three to five years, a technology that is still going strong after 20 years deserves a round of applause. That technology is VAX and VMS. In this, the 40th year of DIGITAL and 20th year of VAX and VMS, DIGITAL is reflecting on a computer platform that made history during the last two decades of this century—and is moving forward into the 21st century without missing a beat.

Celebrating 20 years of success, the VAX family of computers and the OpenVMS operating system remain the backbone of computer systems in many organizations. OpenVMS systems have become an industry standard in reliability, scalability, data integrity, and continuous computing 24 hours a day, 365 days a year.

This commemorative book is intended to provide a behind-the-scenes look at the strategy, challenges, and people that created this globally-acknowledged engineering marvel. It is not intended to be an in-depth study of the technology of the platform. Rather it is intended to celebrate a system that has indeed become the Energizer Bunny of computers. It just keeps on going. And going. And going.

ACKNOWLEDGEMENTS

Changing the Face of Computing

After more than 300 man-years of intensive development, DIGITAL announced its first 32-bit computer system—the VAX-11/780 and its companion operating system, VMS—at the Annual Meeting of Shareholders on October 25, 1977. Because of its 32-bit technology, the VAX system represented a new milestone for DIGITAL and was heralded as a major breakthrough in the computer industry.

The VAX platform and VMS operating system were unveiled by the President and founder of DIGITAL, Ken Olsen. The new product was showcased with a clear plastic front so that the audience could see the CPU, cache, translation buffer, and other integral parts of the machine. The VAX system was demonstrated running a Scrabble program— astonishing spectators by winning the match against a human. The winning play was the word "sensibly," taking the 50-point, seven-letter bonus and scoring a total of 127 points.
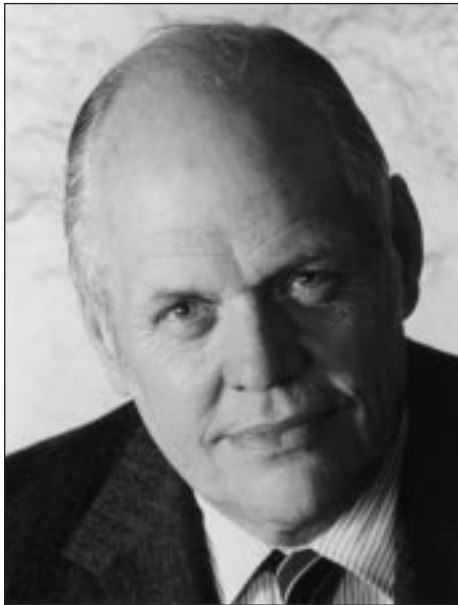
Over the next decade, VAX and VMS products were destined to change the way people used computers—and catapulted DIGITAL into a position as one of the world's top computer manufacturers.

Setting the sights high

The VAX system was designed to meet several key objectives. First, it was based on a revolutionary 32-bit architecture. Second, it solved many of the problems associated with earlier computer technologies. Third, it was designed to be useful to the largest possible number of users in diverse markets, and to offer DIGITAL customers a seamless transition from earlier product architectures. And finally—in direct opposition to the questionable strategy of planned obsolescence—the VAX system was designed to last between 15 and 20 years. An impressive list of requirements, to be sure. But VAX and VMS met them all.

"The best of what we've learned about interactive computers in our first 20 years has gone into this machine. We have spent more than 300 man-years of intensive engineering effort in its development, and during that time I have sensed more excitement and enthusiasm among the developers of VAX than I remember seeing at any other time in the short history of DIGITAL."

—Ken Olsen
Founder, Digital Equipment Corporation
October 25, 1977

"Jesse Lipcon continually reiterated, 'Our top three goals are time to market, time to market, time to market.' At one point I said, 'Wait a minute, Jesse, what about quality?' Without missing a beat, Jesse replied, 'Quality isn't a goal, it's a given.'"

—Jay Nichols
Computer Special Systems, Manager of Engineering

Moving from 16-bit to 32-bit computing.

A total systems focus

From its inception, the VAX development program had a total system focus, encompassing groups from hardware and software engineering, support, product management, documentation, and manufacturing. More than 1,000 people in the corporation worked on the first VAX and VMS system, in some capacity, on an extremely aggressive schedule. Without question, the work produced within the limited time frame exceeded all expectations.

Hardware meets software at the drawing table

VAX and VMS made engineering history by being the first interactive computer architecture in which the hardware system and software system were designed together from the ground up. This was a novel approach to designing a computer architecture, where hardware and software teams worked jointly and altered their designs in consideration of each other's requirements. The result of this united engineering effort was a tightly integrated system that provided unprecedented reliability, flexibility, scalability, and data integrity. In short, bullet-proof computing.

The first VAX system demonstrated a major industry breakthrough by providing the functionality, capacity, and performance of a mainframe—coupled with the interactive capabilities, flexibility, and price/performance of a minicomputer.

"In our spare time, Stan Rabinowitz and I wrote a Scrabble program for the PDP-11. As soon as the VAX was available, we ported it over to the VAX. Ken insisted that we demonstrate the Scrabble program at the announcement. I ran the Scrabble program—pitting it against a human being—and the VAX demolished him. Then Ken stood up and said, 'It's time for the big league games. This isn't Tic Tac Toe, this is Scrabble!'"

—Richie Lary
Corporate Engineering Consultant

Setting the Stage

The pre-VAX years

The first VAX computer was introduced as DIGITAL celebrated its 20th anniversary. The company—founded by Ken Olsen, Harlan Anderson, and Stan Olsen in 1957 with an initial capital investment of $70,000—began as a small module manufacturer in a corner of a sprawling mill complex in Maynard, Massachusetts, a small town 30 miles west of Boston.

Moving from printed circuit modules to computers

While DIGITAL initially produced printed circuit logic modules, the company's real mission was to bring computing to the people. In its second year, DIGITAL made the transition to computers and in 1959 introduced its first computer—the PDP-1. During the 1960s, the company rolled out a family of PDP computers, each more powerful than its predecessor. Early on, innovation and engineering excellence were hallmarks that have characterized DIGITAL products throughout its entire history.

Peer-to-peer networking—the birth of distributed computing

The company's first computers were stand-alone systems. But in the early 1970s, DIGITAL pioneered peer-to-peer computer networking with the introduction of its first successful networking software product, DECnet. Networking allowed customers to connect many minicomputers and share a common database of information. This approach to computing launched the concept of distributed computing. It was a novel approach because at the time mainframes and stand-alone minicomputers were the only computing game in town.

Front cover of Fortune *magazine, October 1986. Features story on Ken Olsen and Digital Equipment Corporation.*

Up to that point, computers did not talk to each other. Moving information from system to system involved using slow magtape and sneaker net. Distributed computing offered the advantage of flexibility and connectivity. Now information could be moved across computer rooms and later across the country almost instantly—making the DIGITAL goal of bringing computing power to the people who needed the information a reality. Technical customers embraced the interactive, accessible nature of these new minicomputers, and DIGITAL began to flourish with PDP systems selling in the tens of thousands.

"Gordon Bell's vision was the primary driver behind the entire VAX family. And I think its success was due to his vision."

—Bill Demmer
Former VP, Computer Systems Group

Digital Equipment Corporation headquarters in Maynard, Massachusetts, with the famous clocktower.

The beloved Mill

The physical environment in which VAX and VMS was created was very much in keeping with its New England heritage. "The Mill"—a set of brick buildings in the center of Maynard, Massachusetts—exemplifies two old New England traditions. One is the classic mill town pattern with the development of an industry and the growth of a community around it. The other is the thrifty Yankee "make do" principle—it's better to "make do" with what you have if it's still useful, rather than abandon it and buy something new and expensive.

The original mill site on the Assabet River was once part of the town of Sudbury; the opposite bank belonged to the town of Stow. The present town, incorporated in 1871, was named for the man most responsible for its development, Amory Maynard. At the age of 16, Maynard ran his own sawmill business and later went into partnership with a carpet manufacturer. They dammed the river to form a millpond to provide power for a new mill, which opened in 1847.

The clock tower

After Amory Maynard died in 1890, his son Lorenzo built the Mill's famous clock tower in memory of his father. The clock's four faces, each nine feet in diameter, are mechanically controlled by a small timer inside the tower. DIGITAL never electrified the timer nor the bell mechanism. To this day, someone has to climb the 120 steps once a week to wind the clock: 90 turns for the timer and 330 turns for the striker.

In 1899, the American Woolen Company, an industrial giant, bought the Assabet Mills and added most of the existing structures. The biggest section was Building 5, which was 610 feet long and contained more looms than any other woolen mill in the world.

Over the next 50 years, the Assabet Mills survived two world wars and the Depression. But when peace returned, the Assabet Mills were shut down entirely in 1950. Like many New England mills, it succumbed to a combination of Southern and foreign competition and the growing use of synthetic fibers.

From textiles to computers

In 1953, ten businessmen from nearby Worcester bought the mill and leased space to tenants. One of the companies attracted by the affordable space was Digital Equipment Corporation, which started operations in 8,680 square feet in the mill in 1957.

DIGITAL grew so fast that within 17 years, it bought and expanded into the whole mill complex. Inside, old paint was removed from the walls, exposing large areas of the original brickwork. Pipes were painted in bright colors, in contrast to the massive beams and columns. The large interior once used for textile machinery became filled with modular office cubicles—offering flexibility to meet the company's changing requirements. DIGITAL left the exterior of the buildings largely unaltered, but cleaned up the Assabet River, which once was colored with the residue from the mill's dyeing plant.

When the employees first moved in, the floors were wavy and soaked with lanolin from the wool processing days—which would eat right through crepe-soled shoes.

While the engineers started designing the VAX and VMS architecture, the floors were being refinished, so they had to live with the ambient music of hammering on the floors above. Then the floors were sanded and polyurethaned. During the sanding, the engineers were given plastic sheets to cover their desks and equipment each night. Before the roof was replaced, rivers of water flowed through parts of the mill when it rained.

Industry trends of the time

During the mid 1970s, industry trends included interactive computing and networking. Corporations were discovering that distributed computing was a viable alternative to the mainframe batch environment. Distributed computing allowed a company to decentralize information and put it in the hands of decision makers—an idea which dovetailed perfectly with Ken Olsen's original goal of giving computer power to the people.

PDP-11/70–moving from 16-bit to 32-bit computing.

Due to industry-wide technological advances, more computing power could be packaged in every square centimeter of space for less money. As a result, computer systems could be made smaller and more affordable, and provide functionality previously found only in large mainframes.

DIGITAL drove the industry trend of building increasingly more powerful—but less expensive and physically smaller—computer systems.

DIGITAL had developed tools to meet the opportunities created by these industry trends: the interactive minicomputer, DECnet, more powerful and easier-to-use software, a volume manufacturing capability, and financial applications. However, corporations were being constrained by the limitation in the addressing range of 16-bit computer architectures— a bottleneck the industry needed to address.

Outgrowing 16-bits

As early as 1974, DIGITAL recognized the limitations of its 16-bit PDP architecture—especially for such tasks as writing large programs and manipulating large amounts of data often needed in scientific, engineering, and business data processing applications. The company realized there was a need for a new architecture that would be compatible with PDP systems, but would have larger addressing capabilities and enough power to meet the computing needs of the future.

"I would say probably the most significant thing that DIGITAL has done is make computing available to the masses. Instead of the high priests in the white robes behind the glass walls, DIGITAL brought computing out of the glass house and made it affordable and acceptable to the mainstream."

—Terry Shannon
Publisher, Shannon Knows DEC

32-bit computing: the next logical step

Some users were also beginning to feel hampered by the limitations of 16-bit computing. They were becoming frustrated that large programs had to be broken up into smaller pieces in order to run on their computers. The 16-bit addressing was hindering progress, and finding a solution became eminent. Extending the addressing architecture to 32 bits could supply the power needed to solve this problem. Other computer companies also recognized the shortcomings of 16-bit addressing and had begun working on 32-bit systems, which seemed to be the next logical step in computer development.

Considering the alternatives

DIGITAL was intent on maintaining its lead in the minicomputer industry and knew that extending the addressing architecture was critical. The company considered many approaches to extending the addressing that built on its current line of products, the PDP family and the DECsystem-10. The company also knew that customers not only required more system power and memory, but wanted more economical systems that would be compatible with their PDP-11 family of processors, peripherals, and software.

In late 1973, DIGITAL began development of the PDP-11/70—an extension of the basic architecture of the PDP-11 family—in an attempt to solve the memory-addressing problem. The PDP-11/70 had a larger memory capacity (up to 4MB), but using it with the 16-bit PDP-11 software architecture was cumbersome. The development team had the choice of finding a way to continue to "brute force extend" the PDP-11 family architecture, or to create something new.

VAX-11/750

VAX Hardware Development

Creating a whole new architecture

In March of 1975, a small aggressive development task force was formed to propose a 32-bit PDP-11 architecture. The team included representation from marketing, systems architecture, software, and hardware.

The project included three phases. During Phase I, the team produced a document that encompassed a business plan, system structure, build plan, project evaluation criteria, the relation to longer term product development, software, and the alternatives considered. In Phase II, they produced the project schedule. Phase III was the implementation of the program.

The planned ship date for the new hardware system was for 18 to 20 months from the start date. The overriding concern was getting to market quickly with a 32-bit system to satisfy customers' need for more computing power.

Setting celestial sights

Initially, the VAX and VMS development team used the code name "Star" for the hardware and "Starlet" for the operating system. Thus began the celestial code naming of hardware and software. Plans for a new family of 32-bit systems had already been drawn. Over time, about 40 engineers worked on the hardware development team. Everyone involved expected this new class of computers to propel DIGITAL to the forefront of technology—and the air was charged with excitement and enthusiasm.

Planning the project

Gordon Bell, VP of Engineering, was the primary driver behind the new direction for DIGITAL. Bell drew up plans for a new system that would extend the addressing scheme used on the PDP-11.

While the initial code name for the new system was Star, it soon became known internally as VAX, an acronym for Virtual Address eXtension. When the product was announced, the company added the number 11 to the name VAX to show customers that the new system was compatible with the PDP-11.

"It's the addressing capability that has probably been, over history, the major driving force behind new computer architectures. It's what initially brought about the whole notion of the VAX computer."

—Bill Demmer

Former VP, Computer Systems Group

Above, VAX-11/780 Announcement, from left to right: Gordon Bell, Richie Lary, Steve Rothman, Bill Strecker, Dave Rogers, Dave Cutler, and Bill Demmer.

ANNOUNCING NEW VAX SOFTWARE
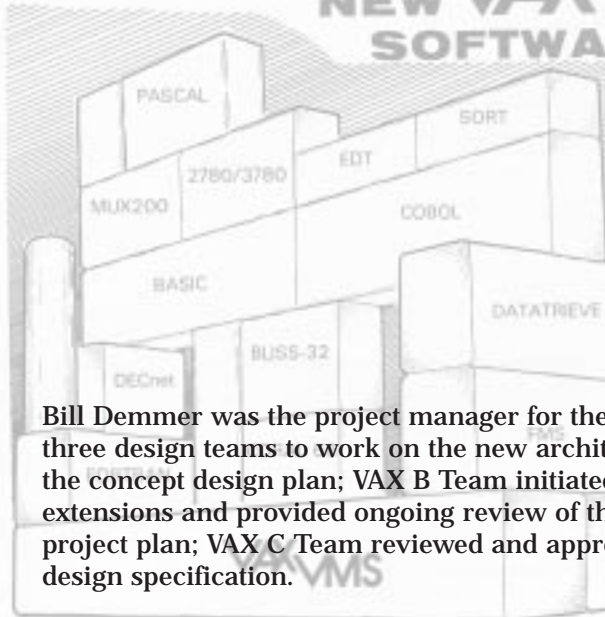
Ken Olsen powers up first VAX. The first time the original VAX breadboard (prototype) was powered up, Ken Olsen almost burned his hand on the power supply.

Bill Demmer was the project manager for the VAX project and assembled three design teams to work on the new architecture. VAX A Team developed the concept design plan; VAX B Team initiated some of the architectural extensions and provided ongoing review of the design specification and project plan; VAX C Team reviewed and approved the final project plan and design specification.

Working the plan

The VAX and VMS kick-off meeting took place in April 1975. The task force—addressing such items as instruction set extensions, multiprocessing, and process structures—closeted themselves away to discuss their options. Their goal was to make the least possible changes in the PDP-11, and still extend it to have a larger virtual address base.

The fundamental questions were, "Can the PDP-11 architecture have its addressing structure expanded to achieve the goals of transparency to the user? Can this expanded architecture provide a long-term competitive cost/performance implementation similar in style and structure to the base architecture?" It was not long before the team realized that both these goals could not be met completely, and so they made the decision to develop a completely new architecture.

All team members agreed that the new system would have to be culturally compatible with the PDP-11 and it would have to maintain the same look and feel as its successful predecessor.

An architecture evolved that cleanly solved the fundamental limitations of the PDP-11. The team developed an implementation plan to overlay both the extended architecture and the basic PDP-11 architecture, thus permitting the new system to appear to be an extended model of the PDP-11 family. This would help to achieve one of the major goals—allowing customers to capitalize on their investment in PDP-11 and grow their systems.

In addition to expanding the address space and ensuring PDP-11 compatibility, another goal was to create an architecture that would support user requirements for 15 to 20 years.
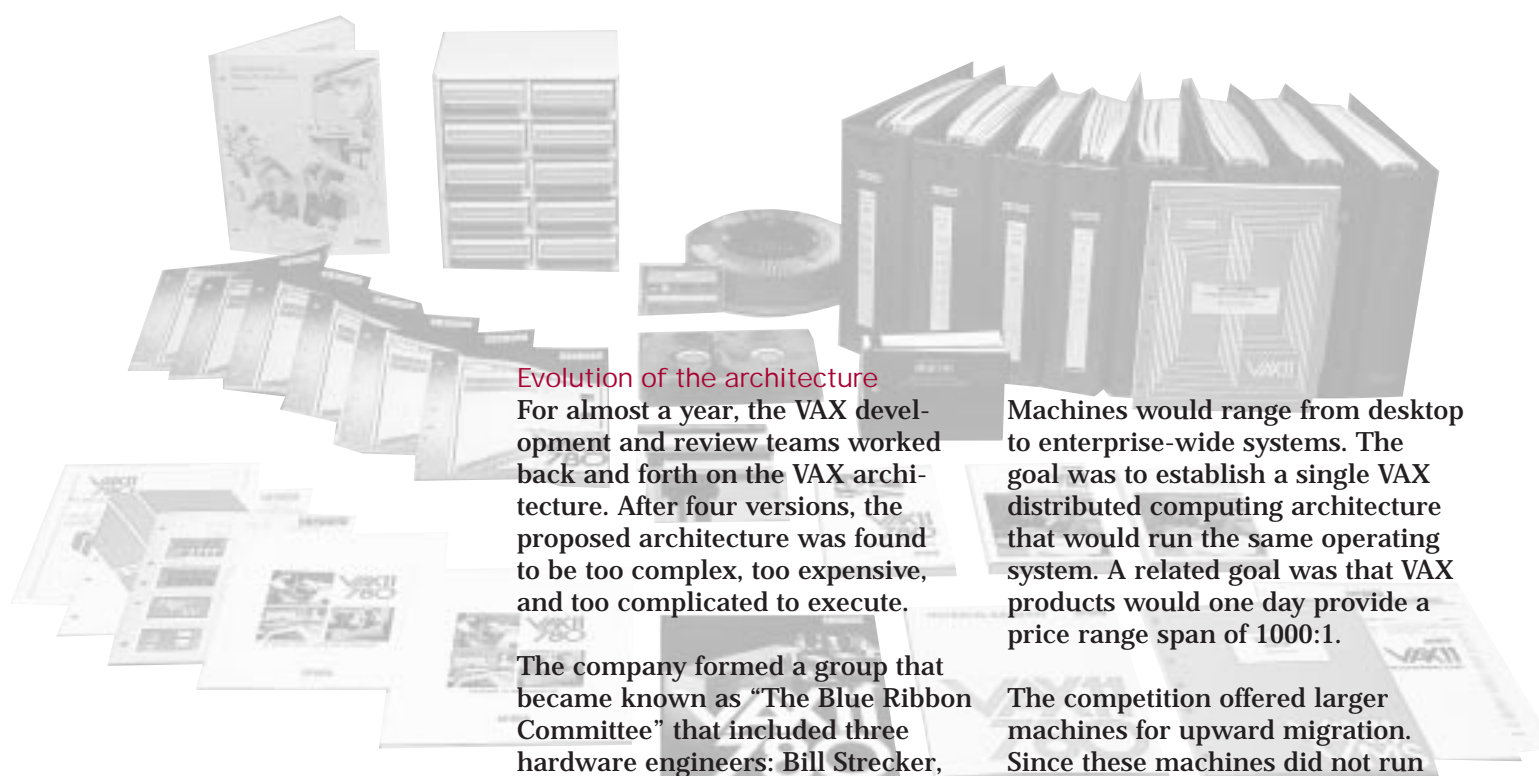
Evolution of the architecture

For almost a year, the VAX development and review teams worked back and forth on the VAX architecture. After four versions, the proposed architecture was found to be too complex, too expensive, and too complicated to execute.

The company formed a group that became known as "The Blue Ribbon Committee" that included three hardware engineers: Bill Strecker, Richie Lary, and Steve Rothman, and three software engineers: Dave Cutler, Dick Hustvedt, and Peter Lipman. They simplified the earlier design and created a plan that would be possible to execute. Key modifications included drastic simplifications to the highly complex memory management design and the process scheduling of the proposed system. The simplified architecture, the fifth design evolution of the VAX system, was perfected and accepted in April of 1976—exactly a year after the design work began.

The VAX strategy

Simplicity was the essence of the VAX strategy. The VAX strategy provided for a set of homogeneous, distributed computing system products that would allow users to interface, store information, and compute on any of the products—without having to reprogram their applications.

Machines would range from desktop to enterprise-wide systems. The goal was to establish a single VAX distributed computing architecture that would run the same operating system. A related goal was that VAX products would one day provide a price range span of 1000:1.

The competition offered larger machines for upward migration. Since these machines did not run the same code, the code had to be recompiled from the smaller machine in order to run. The DIGITAL single-architecture strategy equated to cost savings for customers and simplified their computing environments.

In addition, a single architecture enabled the building of network and distributed processing structures.

Implementing the VAX hardware

Once the plan was accepted, the VAX and VMS project entailed several months of laying out the basic design for the architecture, followed by nine months of filling it in. The plan was executed by two separate hardware engineering teams. One used existing technology to design what eventually became the VAX-11/780; the other team developed a new VAX chip technology through the DIGITAL fledgling semiconductor group

"VAX was the project name—Virtual Address eXtension—but it was never meant to be the product name. When it came time to choose a name, we thought PDP-what? Then some marketing specialist said there are two attributes that are really important in a name, if you want it to be memorable. One is that it be short and pronounceable and that it have an X in it, because Xs are rare letters, so they catch your eye. According to that theory, we had the best name sitting right in front of us: VAX."

—Peter Conklin,
VMS Engineering Manager

"I don't think many people ever get the kind of opportunity we did. We had good people, and we grew into a great team. We had lots of differences, but we sorted them out and built what was expected."

—Roger Gourd
Software Engineering Manager

which became the VAX-11/750.

Memory and CPU design

In planning the memory design, there was a question of what size memory and how many bits were needed. Trade-off decisions were made between achieving the best performance and optimizing the number of bits used from a cost perspective. The VAX-11/780 memory design was the first in which error-correction and detection code (ECC) was designed into the system. The semiconductor DRAM (Dynamic Random Access Memory) was susceptible to soft errors. In order to protect the system from memory loss or changing information, it was necessary to store the information in the memory using some code with additional bits of memory. In the unlikely event that one of the bits changed, the memory system could reconstruct the code, know which one changed, and correct the problem.
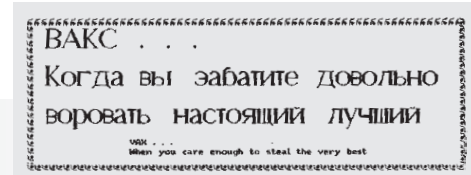
With virtual memory, memory space no longer had to be in the system's internal memory all at once. Instead, the whole program sat on a disk, while the operating system moved pieces in and out of internal memory as needed. Because the first VAX systems had very little internal memory, this was important. Relative to internal memory, disk memory was economical. Virtual memory also allowed programs that were too large to fit completely into memory to run parts at a time—which was not possible on systems that did not do virtual addressing.

VAX-11/780 – moving from 16-bit to 32-bit computing.

Actual Russian words translated: VAX... when you care enough to steal the very best.

VAX...when you care enough to steal the very best

During the cold war, VAX systems could not be sold behind the Iron Curtain. Recognizing superior technology, technical people cloned VAX systems in Russia, Hungary, and China. After learning that VAX systems were being cloned, DIGITAL had the following words etched on the CVAX chip, "VAX...when you care enough to steal the very best."

"In the early 1980s, we were designing computers so complex, our engineering processes couldn't keep up with them. We discovered we had to use the latest VAX to simulate the new one we were building. Building VAXes on VAXes–our first computers became tools for building the next generation of VAXes."

—Bill Strecker
Chief Technical Officer, VP, CST

CHAPTER IV VMS Software Development

With the VAX hardware development underway, the software development—code named Starlet—began a few months later in June of 1975. Roger Gourd led the project and software engineers Dave Cutler, Dick Hustvedt, and Peter Lipman were technical project leaders, each responsible for a different part of the operating system.

VMS project plan

The Starlet project plan was to create a totally new operating system for the Star family of processors. The plans called for a high-performance multiprocessing system that could be extended to support many different environments. Just as the hardware was designed to be culturally compatible with the PDP-11, Starlet was designed to augment the hardware compatibility by providing compatibility with the existing operating system, RSX-11M.

The short-term goal was to build an operating system nucleus for the first customer shipment of VAX systems. It would have sufficient functionality to be competitive, but would also provide a base that could be extended and subsetted over time for a variety of DIGITAL markets. Long-term goals for the project included quality, performance, reliability, availability, serviceability, reduced support costs, and lower development and maintenance costs. The main focus was to support high-performance applications, such as real-time and transaction processing.

VMS V1 software development team.

Putting it in writing

From the beginning, the software team considered documentation to be a significant part of the project. The first technical writer, Sue Gault, attended design meetings with the software development team and helped them write the Starlet Working Design Paper. This document contained an in-depth technical description of the operating system. Since this project was defined as building a system of hardware and software together, it was more complex in scope than any DIGITAL project to date.

Through the exercise of writing, the engineers received input from the documentation writers and were able to troubleshoot potential problems. Ideas had to be expressed clearly enough to be written in the specs. This method helped to resolve assumptions and potential differences of opinion. The design document also served to keep the rest of the company informed about the VMS project as it was made public—contributing to the overwhelming support and enthusiasm throughout the company for the new project.

Working in tandem

In order to ensure tight integration between the software and hardware, several software programmers attended the VAX design committee meetings and contributed to the hardware design from a software perspective.

Close cooperation between the hardware and software engineers also helped work out potential software problems, and ultimately created a hardware and software system that was tightly integrated. It meant the difference between being *designed-in* rather than *added-on* later. Many hardware factors changed as a result of the software development work.

The VAX and VMS development team recognized that an early hardware implementation was critical to developing the software concurrently with the real hardware.

Accordingly, a team of hardware engineers built a system called the "hardware simulator." Constructed of PDP-11/70 components, some custom logic boards, and a lot of firmware, it provided a quick first implementation for the VAX platform. The VMS team designed and tested all the operating system software on that simulator. It ran 10 to 20 times slower than the actual system was to run, but it enabled the development team to work and develop the software on the system as it was being designed.

Breadboard on wheels

The VAX-11/780 engineering team first built a machine called the breadboard and placed it on a large metal cart. All the circuit boards were created with wire wrap; while

Creativity with discipline

From its inception, DIGITAL realized the importance of creativity, and sought to create an environment in which individual creativity would thrive within a disciplined environment. The strategy was to hire talented people and empower them to develop plans, have those plans reviewed and approved, and to accept ownership of the project. The company believed that people would be most productive when they had to meet milestones and stay within a budget—this is where the discipline factor came in. Each product line group was responsible for meeting its plan within time and budget constraints.

"Software development is very creative, very individual. We want to give the engineers the freedom to work independently, to work together, and to do the things they want to do."

—Bill Heffner
VP of Software Engineering

the power supplies sat loose on the lower shelf of the cart. The software development team ran a time-shared VMS system on the breadboard for a short time, because it became available around the time VMS had evolved sufficiently to support multiple users. However, the breadboard was not entirely reliable because the operating speed was pushing the limits of what could be handled with wire-wrap construction.

The breadboard was replaced by the first VAX-11/780 etched prototype. The prototype was the first machine built with "real" parts—the real frame, power supplies, etch circuit boards, etc. The only thing lacking was the external cabinet. This prototype was not replaced with a production machine until well after VMS and the VAX-11/780 shipped. The prototype continued to be used for years for stand-alone testing. Systems developed after the VAX-11/780 never went through the breadboard stage, but rather went directly to real etched circuit boards, after extensive simulation.

The software developers used the prototype to do their work—which provided a closed loop of using what they were building. This strategy of using the software system to do the design work helped them to pinpoint potential problems as they progressed.

VMS engineers Dick Hustvedt and Ben Schreiber.

"One of the VMS group's philosophies was that we lived on the software that we were writing. Because if it wasn't good enough for us, then it wasn't good enough yet for our customers."

—Kathy Morse
VMS Engineer

Who's got the red flag?

The software build environment process, which is what transforms the software source code into a runnable system, allowed only one person at a time to do a build. If two people tried to do a build at the same time, they would overwrite each other and produce nothing useable. The engineers—who often worked in an intense, heads-down mode—had no way of knowing if another engineer was working on a build. It was inevitable that early on, two engineers in adjacent offices would try to do builds concurrently, thus destroying each other's work.

Being a creative team, they came up with a creative solution. As a mechanism for determining who was working on builds, a red flag with a magnetic holder was put up in the cubicle of the person using the simulator.

It was usually referred to as "the mutex," in reference to a commonly used software synchronization mechanism. If an engineer wanted to do a build, he or she found the flag and asked its current owner "Can I have the mutex?" and it would be theirs as long as the flag holder wasn't in the middle of a build.

Developing tools on the fly

Out of necessity, the team developed many of their own tools as the project progressed. For performance evaluation, the VMS engineers built the performance monitor tool and then used the tool to measure system performance. One part of the monitor was a separate computer system running on a PDP-11 that could act as a time-sharing workload. Using that, the engineers measured VMS on a number of different multi-user workloads to see how it performed for time-sharing.

Using what you're building

There was a lot of back and forth communication between the hardware and the software engineers. The writers were also using the software, which provided a good closed loop process. And that was the philosophy behind it—to use it and debug it as the project moved forward.

Ensuring compatibility

The development systems for VMS were housed in one large computer room; most of it was taken up by a huge dual-processor DECsystem-10 and a PDP-11/70 was shoehorned into one side of the room. Much of the first version of VMS was written in Macro and the rest in Bliss. Macro development was done strictly on the PDP-11, using a cross-assembler. The assembler object modules were then linked into executables on the PDP-11 and written to a disk which the VMS engineers would then carry over to the VAX system in the next room.

VMS documentation set.

The DEC-10 was used to compile the VMS modules written in Bliss because at the time the Bliss compiler only ran on a DEC-10. The Bliss code had to be transported by tape to the PDP-11 to be linked.

This process of writing programs initially required a great deal of time and effort. However, the new virtual memory operating system was built in a relatively short time by any current standards.

The VMS system kernel and related critical function were written in "native mode" using the new VAX instruction set. However, many utility functions were simply ported from the RSX-11 operating system and so ran in "compatibility mode"—the PDP-11 emulation mode. Besides speeding up the implementation of these functions on VMS, this approach provided an effective live test of the VAX platform and VMS operating system compatibility features.

The virtual memory system software provided greater functionality than had ever been seen before in a minicomputer. VAX and VMS also supported networking capabilities as well as compatibility with PDP-11 thus enabling customers running PDP-11 programs to migrate their applications to the new VAX and VMS systems quickly and easily.

The VMS strategy

The VMS software strategy was based on developing a single VMS operating system that would span the product range from low-end to high-end. VMS would offer full mainframe capabilities allowing concurrent batch processing, transaction processing, time-sharing, and limited real-time processing.

This *single operating system* strategy behind VMS was a reaction to the multiple operating systems of the PDP-11:
• RT-11 for real-time and laboratory work
• RSTS-11 for educational and small commercial time-sharing
• RSX-11 for industrial and manufacturing control
• MUMPS-11 for the medical systems market
• DOS-11, the original PDP-11 operating system, largely superseded by the above.

VMS Version 3 release party on Cape Cod.

While each of the PDP-11 operating systems was targeted to a particular market segment, there were a lot of cross-over sales. At the same time, the multiple operating systems with incompatible interfaces diluted the system base for applications. Any application might have to be implemented in multiple versions to run on a large number of systems.

Therefore, the strategy with VMS was to have a single operating system that would be sufficiently flexible, powerful, and efficient to address most of the PDP-11 target markets.

Betting the business on VAX and VMS

Prior to developing the VAX system and VMS operating system, DIGITAL operated according to a multi-product line environment. However, in 1978, DIGITAL adopted a vision called The VAX Strategy which would guide the company through the next decade. Although DIGITAL would continue development on the PDP-11 and DECsystem-10, the company's main direction would be on VAX development.

The VAX and VMS strategy led to a consistent message from DIGITAL: "One platform, one operating system, one network." Simply put, DIGITAL decided to bet the business on VAX and VMS—and VAX and VMS business began to skyrocket.

"As the technical writer, my belief was that the technical writer is the advocate for the customer. So I always put myself in the shoes of someone who is trying to learn how to use the system, and wrote the documentation accordingly.

"The VMS Documentation Group grew from five people in 1977 to 45 in 1987, and the documentation set grew from 9,000 to 20,000 pages. It was a massive effort."

—Patti Anklam
Technical Documentation Writer

Debugging in the Blizzard of '78

On the first evening of the blizzard, Andy Goldstein was working late on the new VMS file structure. If he couldn't make it home, he wasn't worried. Hank Levy lived across the road from the Mill, so anybody from VMS who was really stuck would just pound on his door and sleep on his couch.

"I hit a bad directory error and said, Oh my God, I've got a bug in the file system. I was trying to collect data on this, but the snow was getting deeper and we lost power. The whole state was closed for the next week, but I drove to the Mill and talked my way inside.
I powered up the machine, got dumps of the failed directory, and took them home with me.

"I called Richie Lary—who lived across town from me—and said, 'Richie, I think there's a bug in the microcode.' And he said, 'Why don't you come over. I've got the microcode listings here.' I walked through the snow over to his house. Richie fished a six-inch binder out from under his bed and we went through it, and sure enough, we found the bug and fixed it."

—Andy Goldstein
VMS Engineer

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Market Acceptance—Beyond Expectations

Rolling out the first VAX and VMS systems

Roughly 18 months after the design team sat down to execute their plan for the new interactive architecture, the first machine rolled off the manufacturing floor and into a customer site.

The first VAX-11/780 was installed at Carnegie Mellon University and was released to more than 50 customers. In 1978, the VAX-11/780 became accepted internationally with installations at CERN in Switzerland and the Max Planck Institute in Germany.

A major industry contribution

In October of 1977, DIGITAL made a significant contribution to the industry by announcing both a new architecture hardware product and a new architecture-based operating system. One of the primary advances that the VAX architecture brought to computing was that it had a plan for the intercommunication of computers at the architectural level. DIGITAL had not only engineered the capability for computers to talk to computers with homogeneous existing architectures, but had planned for a complete range of computer systems—from the personal workstation level up to the high-performance systems—all having a homogeneous architecture.

President Ronald Reagan visits a DIGITAL VAX manufacturing facility with DIGITAL President/CEO, Ken Olsen.

Overcoming resistance to change

When VAX and VMS systems became available in 1978, customers were just beginning to understand the need for a 32-bit architecture. Analyst reports published after the introduction of VAX and VMS system discussed the significance of the 32-bit architecture.

While some forward-thinking customers embraced the advantages of the 32-bit architecture—especially in specialized scientific applications—many were still satisfied with their current 16-bit architectures and didn't think the larger addressing space was necessary. Resistance to change is always an obstacle in introducing new ideas, and the VAX platform certainly represented a change for customers.

Migrating from PDP to VAX

As customers saw how efficiently VAX and VMS worked in their environments, acceptance for the new system grew overwhelmingly positive. Organizations suddenly proclaimed, "We are a VAX and VMS company" and focused all their efforts in that direction.

The VAX system drew on years of DIGITAL engineering experience in developing the PDP family of computers. Wherever possible, the VAX architecture took advantage of existing PDP-11 technology such as the UNIBUS—thus allowing existing PDP-11 I/O technology and products to be used on the VAX systems.

Thus, the new VAX system appealed to the installed base of PDP customers because of the built-in *compatibility mode*—which provided an easy migration path for moving up to the new 32-bit architecture, while still protecting their existing PDP investment.

Woods meetings

In 1983, DIGITAL began to hold day-long, off-site meetings. Initially these meetings were held at Ken Olsen's cottage deep in the woods of Maine. Soon, these off-site strategy meetings became known throughout the company as woods meetings—regardless of where they were held.

Key success factors

32-bits at an affordable price

Although the VAX-11/780 was not the first 32-bit system on the market, it was the earliest computer that was capable of taking on large-scale problems at a reasonable price.

FORTRAN for the scientific world

The DIGITAL investment in VAX FORTRAN is credited with some of the VAX and VMS architecture's early success in the marketplace by gaining a leadership role in the world of scientific and technical computing.

Two aspects of VAX FORTRAN contributed to the early success of the VAX. First, the compiler produced excellent quality, fast performing code. Since it was a very complete implementation of FORTRAN, a FORTRAN program written for a competitor's machine could easily be brought over and run on a VAX system. Second, the interactive, source-level debugging allowed the programmer to interact with the program in FORTRAN, rather than machine language.

VAX systems became the first workhorse for numerical and scientific computing, supporting such power-hungry applications as computer-aided design, flight, operator training for nuclear and conventional fuel power plants, power monitoring and control systems for electric utilities, and seismic data reduction.

Scalability

By design, the VAX architecture was scalable, meaning that code written on small machines would run unchanged on larger machines. This made software development affordable, because the concept could be tested on a small machine before making a major hardware investment. Applications were not limited to a particular machine. Once an application was written, it could run on any size VAX system without changes. Scalability allowed customers to grow their VAX systems as they needed—without worrying about their software investments. It also minimized maintenance and support costs for software.

Connectivity

Another significant success factor was the connectivity strategy—interconnecting computers via networks. DIGITAL had developed DECnet in 1973, and support for this networking software was an integral part of the VAX strategy. The ability to connect computers gave minicomputers the power of mainframes. Distributed computing was an emerging concept and DIGITAL was in the leadership position.

The VAX and VMS architecture allowed for networking that was more efficient than in other systems at the time. Networking allowed DIGITAL to expand the application base for VAX platform and broaden its market base beyond the scientific and into the commercial world.
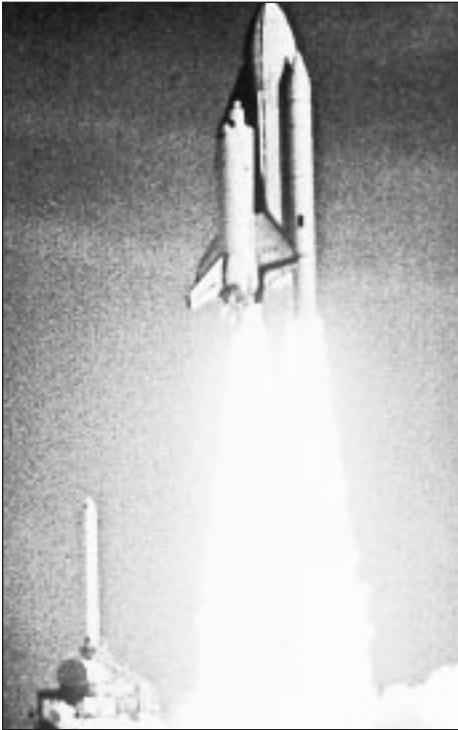
VAX and VMS play a part in the Space Shuttle development.

Software capabilities
With the increased breadth of software offerings of VMS V2.0, DIGITAL moved into the business marketplace.

These factors—along with the extensive software library and other interactive features of VMS—made it the best software development environment in the industry. In addition, the robustness and reliability of even the early VMS versions ensured that a customer's programming staff spent their time working on their programs rather than figuring out what had gone wrong with the operating system.

In short, the expanded address space, sophistication of the operating system, inherent networking capabilities, and affordable price were the integral factors in the success of this new technology.

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Moving into Commercial Markets

By 1979, the company's sales revenues topped the $2 billion mark for the first time. DIGITAL was a major player in the worldwide minicomputer market, and was marketing its systems, peripherals, and software in 35 countries around the world.

This success was attributed to Ken Olsen's original strategy of selling small, easy-to-use computers to a wide range of customers. Research scientists, accountants, banks, and manufacturers alike could use these systems.

By the 1980s, DIGITAL had established itself as the number-two computer company behind IBM. At this time, VMS Version 2.0 commercial software was introduced. This second generation of VMS provided to the commercial marketplace the same leadership that FORTRAN did for the scientific world. By the spring release in 1980, Version 2 had users at 1,400 sites.

DIGITAL President/CEO, Ken Olsen addresses customers to deliver new product announcement.

With this announcement, DIGITAL made a commitment to the commercial marketplace and positioned the VAX system as the flagship product for new commercial applications. The company also emphasized networking and distributed data processing concepts as ongoing efforts.

Expanding the family

The initial evolution of the VAX family was downwards in size and price. This was a very deliberate strategy that was established when the VAX architecture was first conceived; the slogan was "$250K and DOWN." Even though the DEC-10 and DEC-20 systems were still going strong , the intent was that the VAX system would provide a replacement for high-end PDP-11 systems—without encroaching on the DEC-10/20 business.

DIGITAL spreads the word on the ease of scalability with VAX and VAXcluster systems.

Thus the first two successors to the VAX-11/780 were smaller, less expensive machines. The first successor to the 780 was the VAX-11/750. The VAX-11/750 was built of semi-custom LSI logic known as gate arrays. Each gate array chip consisted of about 400 standard logic functions. By interconnecting the basic functions, each chip was specialized to provide the needed functions of the 750 CPU.

The VAX-11/730 was the third member of the VAX family, introduced in 1982. The VAX-11/730 was built from off-the-shelf bit slice microprocessor and programmed array technology.

More power, please!

Meanwhile, some customers were beginning to clamor for more powerful VAX systems. In an effort to meet this demand, DIGITAL produced the VAX-11/782. This system was built with two standard VAX-11/780 processors using a shared memory. By supporting the VAX-11/782, VMS took its first step into multiprocessing—foreshadowing the symmetric multiprocessing capabilities of the VAX 6000 series years later.

This system was followed by the VAX-11/785—a re-engineered VAX-11/780 that used the same design with upgraded components—which allowed the CPU to be run at a 50% faster clock rate. Both the VAX-11/782 and VAX-11/785 were designed to bridge the long gap between the 780 and the 8600.

These new members of the VAX family—combined with ever-improving networking capabilities—provided significant and varied configuration possibilities for DIGITAL customers.

Increased software capabilities
The backbone of the new VMS commercial software capabilities was represented by six new products:

- COBOL was the flagship product

- BASIC was interactive and fast

- Multikey ISAM provided effective data management and was usable from all languages

- Integrated DECnet enabled multi-system communication

- DATATRIEVE V2 provided online inquiry and retrieval

- Form Management System (FMS) allowed for data entry and trans-action-oriented applications.

This extended the range of capability and power—enabling commercial customers to distribute their data processing more easily and efficiently.

CHAPTER VII   Networking

DIGITAL recognized early on that its customers needed a means of connecting various systems and coordinating their capabilities. To address this need, the company began research in this area as early as 1972, when it developed a multiprocessor that would combine a number of minicomputers to obtain the power of a large mainframe. This was accomplished through networking.

By 1973, DIGITAL formed a group to direct the design and implementation of a networking project; its goal was to achieve absolute compatibility and interconnectivity across all computer families. The company's initial efforts resulted in the DIGITAL Network Architecture that implemented a layered protocol approach. This method of connecting systems was recognized as state-of-the-art technology and put DIGITAL in the leadership position in the industry.

DECnet

In 1974, DIGITAL introduced DECnet, the industry's first general-purpose networking product for distributed computing. One goal was to make networks affordable so that customers could implement them more widely.

DECnet for VAX and VMS V1.0 was available for the first customer shipment of the VMS operating system, and significantly contributed to the success of the VAX-11/780 system.

Unlike earlier networking products—which focused on connecting terminals to hosts—DECnet provided peer-to-peer networking for the first time. This was a major step toward the client/server computing model. DIGITAL had developed the best and least expensive distributed computing solution and became an industry leader with this technology.

DECnet linked DIGITAL systems together in a flexible network that could be adapted to changing requirements. It provided direct communication among computers at the same organizational level, and had no hierarchical requirements or prerequisite host processors. DIGITAL networks were modular and flexible—as opposed to IBM's rigid, hierarchical products—and could connect computers from other vendors, providing a degree of compatibility among different computer systems that was unmatched in the industry.

Over the years, DECnet evolved through five releases, each designed to work with the next and previous phase. DIGITAL also contributed to the major networking standards, incorporating key standards such as OSI and TCP/IP into DECnet.

Enter Ethernet

Ethernet communications capabilities were incorporated into DECnet Phase IV, allowing DECnet users to extend their networks with local area capabilities of Ethernet.

The era of the Ethernet brought an entirely new concept to networking. DIGITAL set the standards with Xerox and Intel by establishing Ethernet as the industry choice for local area networks. The three companies jointly defined the Ethernet standard, which led to the deployment of local area networks. Ethernet became the medium-speed but long-distance network, connecting components as far apart as a kilometer.

CI, NI, and BI interconnects

DIGITAL coined the terms CI, NI, and BI as part of an effort to rationalize the company's strategy for interconnecting the components of computer systems at different levels of implementation.

NI—Network Interconnect. This was the highest level interconnect, connecting computer systems in a network. NI quickly became synonymous with Ethernet. Ethernet allowed the construction of local area networks of up to a thousand connections and a mile and half in size.

CI—Cluster Interconnect. The CI also connected individual computer systems. In contrast to the NI, it allowed much smaller configurations: up to 16 systems spread over a 90-foot radius. What the CI lacked in scale it made up for in speed—allowing communications over 10 times as fast as the NI. DIGITAL developed storage controllers that connected to the CI, providing the basis for clustered VMS systems (see next section).

BI—Backplane Interconnect. The backplane was used to connect components of a computer system within a single cabinet. The BI was built to be a faster replacement for the UNIBUS, used by all PDP-11s and the initial VAX systems. The VAX 8200 and 8300 used the BI as their "native" interconnect (i.e., both I/O and main memory). Later VAXes (other 8000 and 6000 series) used the BI strictly to connect to I/O controllers.

SI—Storage Interconnect. A standardized connection between a storage device (disk or tape) and its controller.

XI—Everything Interconnect. A future interconnect that would replace NI and CI, being both faster and larger than either. Something like the XI was ultimately realized with FDDI, but displaced neither the CI nor NI.

The next logical step of networking was computer clustering—a concept that DIGITAL pioneered. Today, the company continues its position as the industry leader in clustering.

The Second VAX Generation

The VAX 8600

In October 1984, DIGITAL announced the VAX 8600. This system marked the beginning of the second generation of VAX machines—and a new milestone in the VAX strategy. The VAX 8600 offered up to 4.2 times the performance of the VAX-11/780 and increased I/O capability while maintaining I/O subsystem compatibility with the VAX-11/780 and the VAX-11/785 Synchronous Backplane Interconnect (SBI).

It was the first VAX implementation in ECL (Emitted Coupled Logic) technology and the first to include macropipelining. The VAX 8600 represented the confluence of many new concepts and further refined the solid engineering of earlier systems. It was packaged with an extensive portfolio of VMS software products that could run on the VAX 8600, as well on all the earlier models.

The VAX 8600 team.

One platform, one operating system, one network

While DIGITAL had considered as many as eight different approaches to networking, the company crystallized its approach to networking in 1983 and announced its networking strategy at DECworld '83. That strategy was one platform (VAX), one operating system (VMS), and one networking product (Ethernet).

VAX production line and test station.

A new high end: the VAX 8800
In January 1986, DIGITAL introduced its top-of-the-line VAX 8800 and
the midrange VAX 8300 and VAX 8200. These VAX systems were the first
VAX systems to support dual processors. Each machine incorporated a new
high-performance I/O bus, the VAXBI. The high-performance VAX 8800
achieved application throughput that was two to three times faster than
the VAX 8600.

A year later, the company introduced the VAX 8978 and 8974, the most
powerful systems from DIGITAL to date, offering up to 50 times the
power of the VAX-11/780. Both machines included the new 2.5 Gbyte
SA582 Storage Array from DIGITAL. Combined with the HSC70 I/O
processor and the VAXBI bus, the SA482 delivered mainframe-class I/O
subsystem performance array and large storage capacity.

*"From the late 1970s to the late 1980s, DIGITAL moved from being what I
would call a niche mini-computer company to the second largest computer
company in the world. And that growth was entirely driven by our VAX
and VMS business. From that standpoint, VAX and VMS is one of the really
great success stories in the history of computing, in terms of totally trans-
forming a company and totally transforming an industry and playing a
major role as one of the truly major computer architectures. Certainly VAX
and VMS has been a driving architecture for ten years, and is still a very
important architecture at age 20."*

—Bill Strecker

Chief Technical Officer, VP, CST

Don Harbert and Pauline Nist accept The PC Week *corporate satisfaction award for the VAX 6000 from Susan Pasieka for the second year in a row. – Summer 1992*

Ongoing engineering challenge: Evolving the architecture

By all standards, the VAX and VMS architecture was very stable from the late 1970s to the 1980s. The reasons for this stability were two-fold. First, because the architecture was so extensively engineered, it didn't require any architectural changes over that ten-year period of time. Second, it offered virtually everything a customer might want. The architecture had been designed for longevity, and it succeeded in that goal.

Over a 10-year time period, the product line broadened from a single VAX-11/780 to a whole family of products that offered continually improved performance at a lower cost. The next engineering challenge was to make successively faster implementations of the architecture at a lower cost.
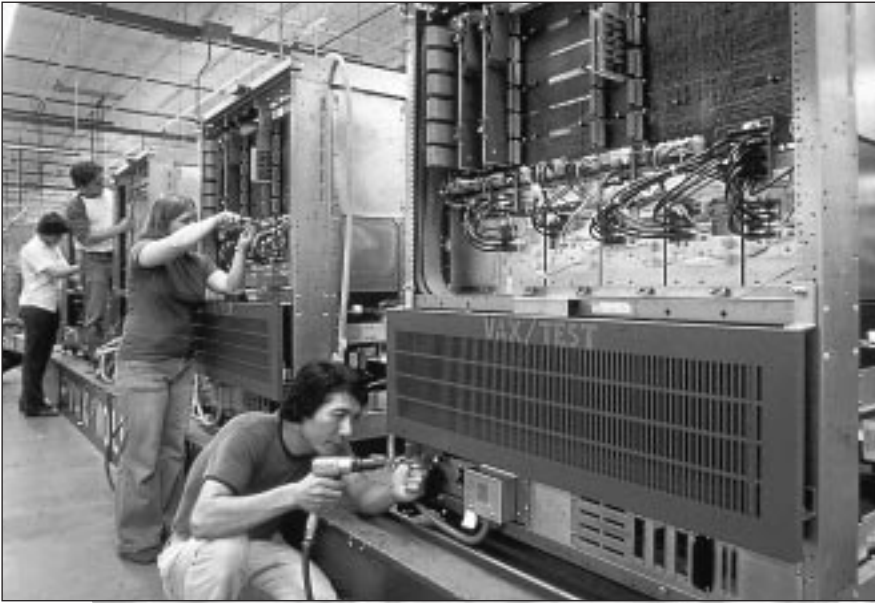
While some development teams were working on the traditional VAX systems, others were developing a new breed of chip-based systems, which eventually became the main line of DIGITAL's products.

Bill Demmer with 2nd generation VAX family members.

VAX assembly line.

VAX 6000

"When we announced the new VAX and showcased it at DECUS, customers would come up and ask, "What is that?" We told them that this is a new VAX. They were pleasantly surprised.

Our customers loved their VAX systems. They just put them in a closet and forgot about them– they're that reliable. It's a tribute to the hardware, the architecture, and the software, because it's bullet-proof. The Catamount was proof that DIGITAL continues to support its Installed Base customers."

– Ed Yee
Senior VAX Product Manager

The VAX 6000 was the first volume SMP VAX. In the first six weeks of production, there were 500 units shipped. The VAX system was the so-called tornado of that time frame—the market just sucked them up. The shipments grew from a rate of zero to 6,000 units a year in about five months, which continued for a couple of years.

VAX 8000

VAX Family

VAX 8600

ALPHA AXP 2100

VAX-11/780

VAX 6230

VAX-11/730

VAX 6200

1977-1997 ...

AlphaServer 4100

MicroVAX II & MicroVAX 2000

VAXstation I

VAX-11/782

VAX 8650

VAXstation 2000

VAX 4000 200/300

VAX-11/750

AlphaServer 8200

and beyond

VAXft 3000

VAX-11/730

VAX-11/785

Bill Demmer and the VAX Family

VAX-11/750 Family

VAX Family

CHAPTER IX

Putting the VAX on a Chip

Roots of the DIGITAL semiconductor group

The inception of the DIGITAL semiconductor group occurred in the early 1970s with the development of the LSI-11 for the PDP family of computers. DIGITAL designed the chip and partnered with other companies for fabrication. By the late 1970s, technological advances in semiconductors had made chips more powerful and less costly to produce. It became clear that semiconductor technology was imperative in order to remain competitive in the computer industry.

VAX quality control inspection of VAX 8600 CPU board.

Developing the V-11: The first VAX chip

In 1981, an advanced development team explored ways to bootstrap capabilities in semiconductors and design a full-scale VAX on a chip. This project, V-11, was intended to be a full-scale VAX CPU, implemented with state-of-the-art semiconductor technology—N Channel or NMOS. As such, it required four different chips in the implementation.

As the project moved forward, it became clear that microcomputer systems were going to be built very differently from the way the V-11 was being built. Microcomputer systems were going to be based on single chip microprocessors aimed at a dramatically lower price.

DIGITAL addressed the question of whether the VAX design could be turned from being a minicomputer architecture implemented in silicon into a true microprocessor architecture that could be competitive with industry microprocessors. The company decided to do the latter.

The V-11 resulted in the VLSI VAX chip, which was shipped in the VAX 8200 and 8300 series systems. The V-11 was replaced by the MicroVAX chip, but it provided the design technology, basic architecture, and many of the building blocks that made up MicroVAX.

Designing the MicroVAX: The first chip-based VAX

The V-11 and the MicroVAX I were developed more or less concurrently. The VAX-11/750 was the first DIGITAL system to be designed with LSI semiconductor technology, using gate arrays. After the 750, DIGITAL designed the MicroVAX I—one of the first DIGITAL projects to include silicon compilers—with the consulting help of Carver Meade, a pioneer in integrated circuit design. Building on the experience of the MicroVAX I, the company soon followed with the more powerful MicroVAX II.

While the V-11 was designed as a full VAX implementation, the MicroVAX I was designed as a VAX subset. The MicroVAX I system was developed in the company's Seattle facility, headed by Dave Cutler. Because the MicroVAX I was a much simpler design than the V-11, and because of the use of the silicon compiler tools, it was completed before the V-11.

DIGITAL explored the option of having one of the industry's semiconductor companies produce the chip, but decided to do the work internally because of the complexity of the task and the aggressive schedule. This proposal was considered radical because it placed a great deal of faith in the then fledgling chip organization for both design and manufacturing.

### Introducing "the first VAX you can steal"

The MicroVAX project was launched in July of 1982 and the silicon was finished on February 4th of 1984—just 19 months later. It was an achievement that was unprecedented in the industry. The entire semiconductor organization rallied around this effort and gave the chip top priority in terms of fabrication and debugging. Thus, they were able to demonstrate the chip running VMS by August of 1984, field test the system in late 1984, and ship it in May of 1985.

Drastically different from any of the earlier VAX systems, the MicroVAX II system was wildly successful. It was the first VAX under $20,000. Commenting on its unprecedented affordability and size, Ken Olsen called it "the first VAX you can steal."

"Bob Supnik had come up with this wonderful scheme to build a VAX on a chip, which became the MicroVAX II chip, ultimately."

—Jesse Lipcon

Senior VP, UNIX and OpenVMS Systems Business Unit
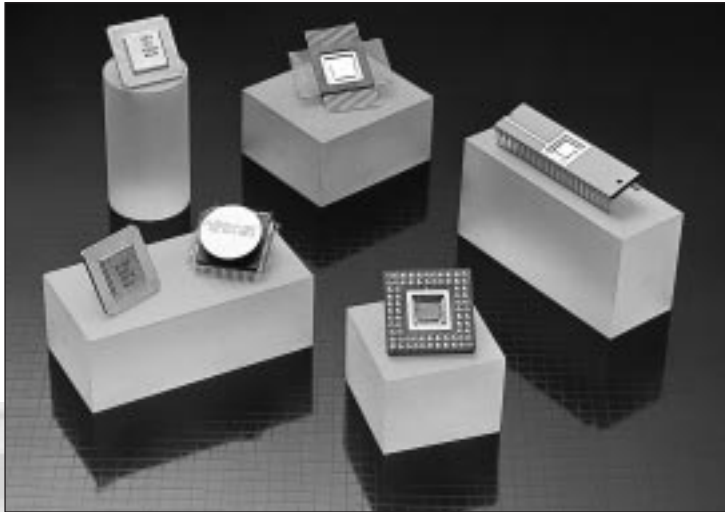
Building on the success of the MicroVAX

The success of the MicroVAX II set the course of development for the VAX chip family for the rest of the 1980s. By reducing the VAX CPU to such a small package and exploiting semiconductor technology, DIGITAL was able to continually improve performance at a dramatic rate.

After the introduction of the MicroVAX II, the company's hardware and software engineers worked together to add back four more instructions out of the commercial instruction set, and the COBOL designers created a version of the compiler that didn't require the complex decimal instructions that had been left out.

The MicroVAX II project would not have been possible if the VMS group had not vigorously supported the whole concept from the outset. When MicroVAX was first put together, it was a more drastic departure from the VAX architecture than the final design—particularly with its simplified form of memory management. But the original VAX memory management was reintroduced back to MicroVAX II to make it a machine with complete functionality.

The MicroVAX II was the system that put the VAX CPU on a chip. With powerful VAX virtual memory, 32-bit computing power, and software compatibility across all VAX processors, the MicroVAX II microsystem provided functionality and flexibility that was unparalleled in the industry.

Skyrocketing sales

DIGITAL was showing the largest volumes of VAX systems sales ever. Up to that point, a highly successful VAX system sold 2,000 units in its lifetime. MicroVAX sold 20,000 units in its first year.

The VAXstation 2000

The VAXstation 2000 was a step down in size from the MicroVAX II. Like the MicroVAX II system, it was built around the MicroVAX II chip. Where the MicroVAX II was housed in a small, desk-side cabinet and supported a variety of PDP-11 peripheral devices, the VAXstation 2000 came in a shoebox-sized cabinet. All the essential functions—CPU, graphics display controller, disk controller, and two serial ports were integrated on a single circuit board. Its peripherals were limited to a keyboard, monitor, and mouse, plus up to two fixed disks, and a floppy disk and tape drive. In return for those limitations, it delivered near VAX-11/780 performance for a $5,000 entry price. Customers called it "a MIP on a stick."

In its first year, the VAXstation 2000 sold 60,000 systems. This demonstrated the principle of elasticity—showing that if you have a capability and you bring its price down, you enhance its marketability. Now, with unprecedented affordability, everybody wanted a VAX.

CVAX

The company's second chip was called CVAX—the C stood for CMOS. A conversion in technology from the earlier NMOS (N channel, metal oxide semiconductor) to CMOS (complementary metal oxide semiconductor) was due to the market's relentless climbing power requirements.

This second-generation VLSI VAX microprocessor offered 2.5 to 3.5 times the power of its predecessor. It was the company's first internally manufactured CMOS microprocessor. High performance came from features such as a macro-instruction pipeline, 1 K Byte onchip datacache, and a 28 entry onchip translation buffer.

The CVAX chip was also much more complicated than the MicroVAX chip. The engineers had to develop the CPU/Floating Point functionality in VLSI and develop separate VLSI chips for Memory Control, the Q-Bus Interface, and a Support Chip which included the Time of Year Clock and Serial Line Interfaces. The number and complexity of these chips added significant challenges to the project.

The CVAX chip was introduced in the MicroVAX 3500 and 3600 systems in September 1978. Another CVAX-based system, the VAX 6000 platform, was announced April 1988.

Incorporating SMP

The CVAX-based VAX 6000 series was the company's first venture into symmetric multiprocessing (SMP).

DIGITAL believed that SMP would require tearing VMS up by the roots and starting over again. However, DIGITAL engineers found a simpler approach. The places where VMS did interlocking against interrupts were located and determined to be the points where VMS had to put in a more formal lock structure for multiprocessors. A very small team produced a working prototype of VMS SMP in nine months.

SMP was introduced in VMS version 5.0, announced April 1988.
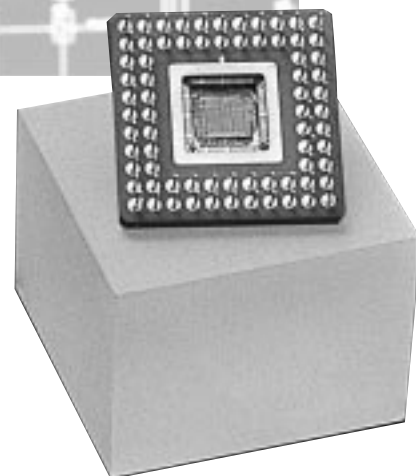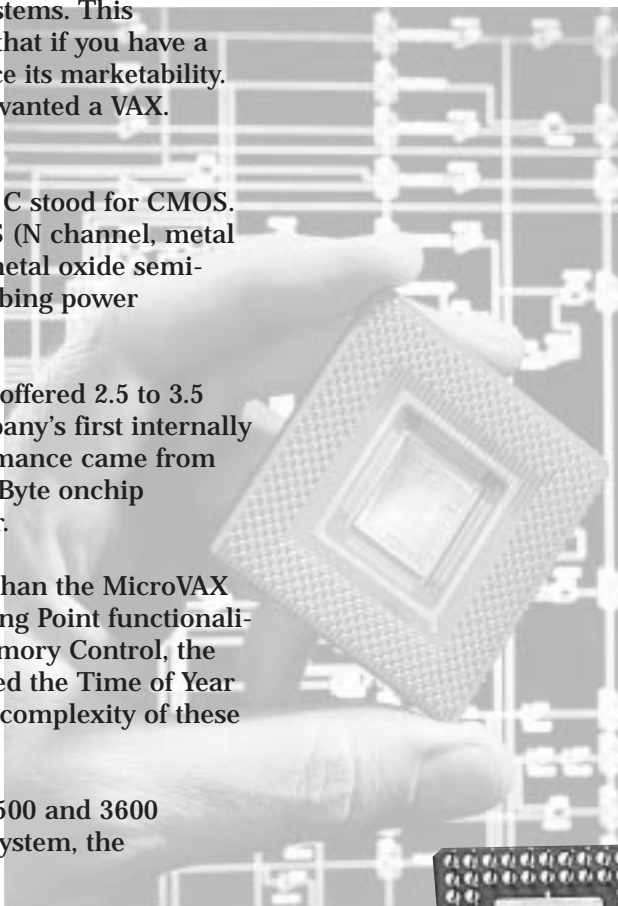
"The sense I always had was that there were four key technical visionaries at the beginning of MicroVAX: Dave Cutler, with his creation of the MicroVAX I system for early software development; Bob Supnik, who headed up MicroVAX chip development and also wrote the microcode; Jesse Lipcon who headed up MicroVAX II Server Development; and Dick Hustvedt, who drove the MicroVMS Software Strategy."

—Jay Nichols

Computer Special Systems, Manager of Engineering

The VAX 6000 and plug-in power upgrades

Introduced in April of 1988, the VAX 6000 system was the most successful midrange system in the company's history, with the fastest time-to-market and the most units sold.

The most significant attribute of the VAX 6000 was that it introduced the concept of rapid technology-based upgrades. With previous DIGITAL systems, it wasn't possible to increase power simply by replacing processor boards. The VAX 6000 introduced the concept of plug-and-play. In other words, as a faster processor became available the customer could unplug the old processor, plug in the new processor, and the original equipment would never have to be thrown away. This allowed customers to increase power as they needed—and protect their investments in hardware and software.

Rigel

The CVAX chip was soon followed by the Rigel chip, the company's third 32-bit microprocessor. DIGITAL engineers considered two options for this chip. One proposal was to base the Rigel chip on the VAX 8800, which was the company's most successful machine. The other proposal was to produce a more elaborate design that would have required multiple chips and more coordination, thus involving higher risk but higher performance.

Ultimately, DIGITAL chose to replicate the circuit design of the 8800 CPU board on a single chip—Rigel.

The Rigel chip was manufactured in 1.5-micron CMOS technology. Introduced in July 1989, the Rigel chip shipped in the VAX 6400 system and later, in the VAX 4000 system. Rigel also included the first implementation of the vector extension of the VAX architecture.

Mariah

In October 1990, DIGITAL introduced the Mariah chip set, which shipped in the VAX 6500. An improvement on the Rigel chip set, the Mariah chip set was manufactured in 1.0-micron CMOS technology. The VAX 6500 processor delivered approximately 13 times the power of a VAX-11/780 system, per processor. The VAX 6500 systems implemented a new cache technique called write-back cache, which reduced CPU-to-memory traffic on the system bus, allowing multiprocessor systems to operate more efficiently.

NVAX

The NVAX chip was introduced in November of 1991. The company's fourth VAX microprocessor, the NVAX chip was implemented in 0.75-micron CMOS technology and shipped in the VAX 6600. The NVAX incorporated the pipelined performance of the VAX 9000 and was the fastest CISC chip of its time—delivering 30 times the CPU speed of the VAX-11/780.

The NVAX chip is the current technology used in VAX systems shipping today.

Moving at breakneck speed

Chip development at DIGITAL was remarkably speedy. The timeframe from MicroVAX to CVAX was about two and a quarter years. From CVAX to Rigel was less than two years. From Rigel to Mariah was about a year. Mariah to NVAX was 15 months.

Growing the business through silicon

The VAX chip set launched the company's product development in a new direction. In the first full fiscal year, the VAX chip business grew into a billion-dollar business. Ultimately, it grew to a two to three billion-dollar business.

When MicroVAX was introduced, less than 10 percent of the company's systems revenue came from products based on microprocessor chips. By 1990, microprocessor chips were responsible for 90 percent of the systems revenue. By the early 1990s, the DIGITAL semiconductor group was the largest and most profitable business in the company.

Major performance increases

Powered by MicroVAX chips, VAX systems increased in performance from one MIP, to 2.5 MIPS, to 7 MIPS, to 11 MIPS to over 30 MIPS in five generations of design. The VAX system had established a worldwide reputation as the fastest, highest-performance machine on the market.

DIGITAL measured the performance of its chips against the competition from the time MicroVAX was introduced. The company's goal—to produce the industry's fastest microprocessors—was achieved with CVAX, which was the fastest chip of its time.

"Reflecting on the different chip sets, from MicroVAX II through CVAX, Rigel and NVAX — the primary focus of architectural energy was processor performance, with the NVAX architecture pushing creativity to its limits."

—Jay Nichols
Computer Special Systems,
Manager of Engineering

VAX 9000 chip manufacturing clean room.

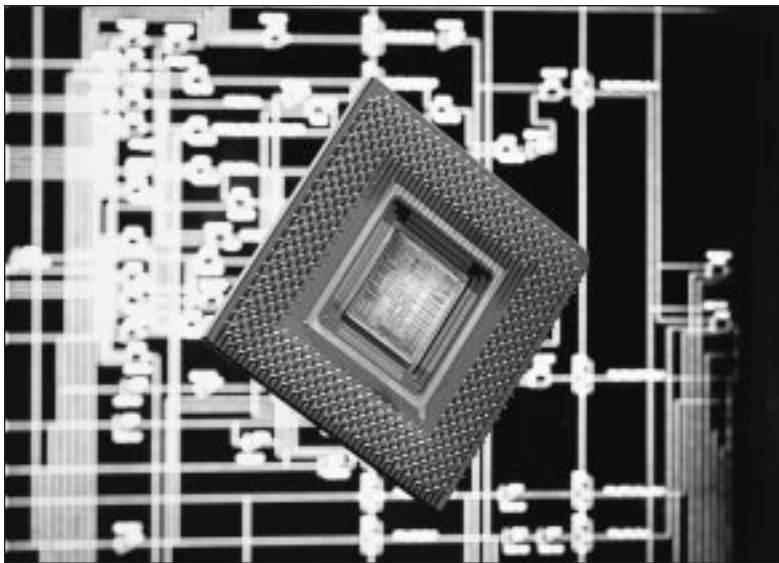# Building the Bridge to Alpha

Prism: VMS on RISC technology

DIGITAL began working on RISC technology in 1986 when Jack Smith, VP of Operations, tapped Dave Cutler on the shoulder and said, "You will be RISC Czar for DIGITAL. Organize a program." The program, code named Prism, was to develop the company's RISC machine. Its operating system would embody the next generation of design principles and have a compatibility layer for UNIX and VMS.

The team discussed such issues as: Should it be 32 or 64 bits? Should it be targeted for the commercial or technical market? The proposed implementation of Prism was an ECL machine. While known for being particularly power-hungry, ECL was the fastest semiconductor technology available during the 1970s and '80s. The VAX 8600, 8800, and 9000 series were built using ECL. However, with the NVAX chip in 1991, CMOS technology surpassed ECL's performance at a much lower power cost.

There were already two other ECL projects underway, the VAX 9000 and a successor to the VAX 8800. Would these machines be competitive or overlapping in the marketplace? What would be their comparative performance? What about cost? Obviously, it made no sense for DIGITAL to be developing three projects of the same magnitude.

In April of 1988, a group of workstation engineers made a counter proposal to get DIGITAL into the technical computing market via existing RISC technology. They started building a RISC workstation that would run ULTRIX—the company's port of UNIX—using microprocessors from a startup company called MIPS. Prism was canceled in favor of using MIPS technology.

February 1991, DIGITAL announced Alpha, programming for the 21st century.

The speedy MicroPrism chip

Meanwhile, the semiconductor group in Hudson, Massachusetts, was working on the MicroPrism chip—a single-chip CMOS implementation of the Prism architecture. After the Prism program was canceled, the Hudson group was allowed to complete the MicroPrism chip, since it was very near completion. The small batch of MicroPrism chips produced ran successfully at 45 MHz—a speed that was unheard of at that time, and that far surpassed the performance of any RISC chip available on the market.

The birth of Alpha

The Prism program was significant for DIGITAL because of the legacy it left for Alpha—the company's future 64-bit technology. A small team formed in July of 1988 to determine what RISC technology could do for VMS. First the team asked themselves, "What do we have to do to get VMS up on RISC?" Then they turned the question around. "If the customers have to go through a transition, how do we get the maximum performance and minimize their pain?" That's when Alpha was born.

Alpha was very much the "son of Prism." The primary changes made to produce Alpha were for VMS compatibility. The original Prism design had serious compatibility problems with the VAX and VMS in two areas— numerical data types and privileged architecture.

The Alpha architecture was built on four premises. First, it had to be a very long-lived architecture. Second, it had to deliver the highest performance for both technical and commercial applications. Third, it had to be very scalable in terms of both implementation size and range of systems supported. And fourth, it had to support customers' applications and operating systems, VMS and UNIX. Windows NT had not yet entered the scene.

"We've done a lot of work to make sure that moving from VAX to Alpha is very easy. If a customer doesn't want to move their entire environment to Alpha at one time, they don't have to. We support mixed architecture clusters, which allows VAX and Alpha to run together in a cluster. They can stay on VAX as long as they'd like to. We'll continue to do releases of OpenVMS Alpha and OpenVMS VAX at the same time."

—Rich Marcello
Vice President, OpenVMS Systems Software Group

Asking the right questions

The team made decisions about the product by asking questions. "If the objective is to create a 20-year target, will a 32-bit machine be viable 20 years from now?" The answer, "No." So it became a 64-bit machine. That part was easy. "What would it take to drive performance over 20 years via clock rate improvements, multiple instruction issues, internal organization, and multi-processing?" The architecture reflects exactly what it takes to do that.

They looked at the issue of scalability from small to large, and therefore had a model of what could be the minimum implementation. Research done on Prism helped the team solve operating system, data flexibility, and code handling issues. Another critical development issue was the notion of VAX-to-Alpha binary translation to ensure a smooth migration for DIGITAL customers who would eventually move to 64-bit computing.

Ken Olsen visits manufacturing facility during the power-up of the first Alpha system.

Determining Alpha's building blocks

The basic building blocks of Alpha were: an architectural commitment to move to 64 bits with the highest levels of performance that would preserve DIGITAL customers' investments, a matching commitment on VMS to preserve customers' operating environments, and silicon that would stand the industry on its ear. The design team studied high-speed implementation techniques discovered through the MicroPrism project. The team concluded that a chip could be built that would run two to three times faster than anything else in the industry—one that would run at 200 MHz when competitors were talking about 50 MHz.

Bringing the company on board

The Alpha program ran as a loose confederation of people who shared the vision of putting DIGITAL back on top with leadership systems. There was an Alpha project in VMS, and an Alpha project in DIGITAL semiconductor group. These team members went out and proselytized to the rest of the company and convinced it group by group to participate, until eventually the Alpha program consumed roughly a third of the company's engineering resources.

Getting business partners on board

In order for the partners at DIGITAL to take advantage of this record-breaking technology, Vice President Bill Demmer set up the Alpha AXP Partners Office six months before the announcement so that the company's business partners would be signed up and on board at announcement time. Early Alpha partners included Andersen Consulting, Cray Research, Encore, Kubota Pacific Computer, Raytheon, and Olivetti.

By September 1992, DIGITAL had shipped more than 1,000 Alpha systems to software developers.

Bringing on the customers

To meet customer needs, DIGITAL developed programs and services to support this new technology. For two years prior to the 64-bit announcement, a group of customers met regularly to review plans for the Alpha AXP program. The group, the ALPHA AXP Customer End User Advisory, included representatives from communications, manufacturing, technology, government, the university community, and other potential markets for the Alpha technology.
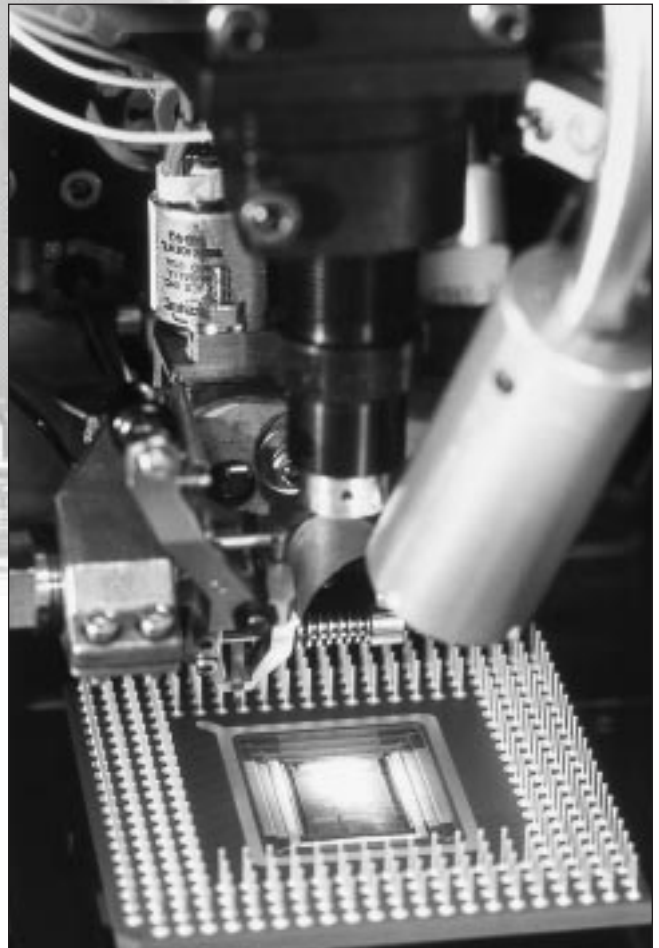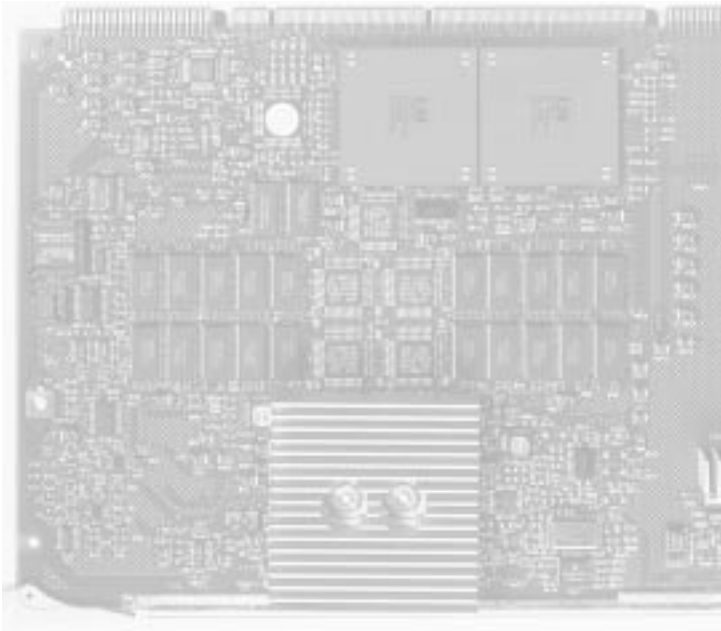
With peak execution rates of up to 2 BIPS, these top-performing Alpha 21164 chips push the performance envelope for visual computing applications such as video conferencing, 3-D modeling, video editing, multimedia authoring, image rendering, and animation.

Chapter XI

AlphaChip—The 64-bit Breakthrough

On February 25, 1992, DIGITAL introduced another significant technology advance: the world's first 64-bit architecture. This revolutionary architecture was based on the AlphaChip 64-bit RISC technology and 150 MHz DECchip 21064 microprocessor.

Announcing the Alpha AXP family of systems

In November 1992, DIGITAL announced a complete family of ALPHA AXP systems. It included ALPHA AXP workstations, departmental servers, data center servers, mainframe-class servers, and system software, as well as services, layered products, peripherals, and upgrade programs. Four hundred software partners announced availability dates for nearly 900 Alpha applications.

Alpha AXP achieved record-breaking status. In April, ALPHA AXP performed the world's fastest sort and fastest transaction processing to date. The company announced the industry's highest-performance workstations in the less than $5,000, $10,000, and $15,000 price categories.

Above to the left; Bill Demmer, VP, discusses AlphaChip in 1992 announcement.
Above; Ken Olsen visits Alpha manufacturing facility.

"Today is the beginning of a new revolution in computing. With nearly limitless 64-bit computing power and the applications of three major operating systems, the path ahead leads wherever the imagination can take it. ALPHA AXP computing will enable customers to invest in profitable new ways to serve people."

—Robert B. Palmer
Chairman, President and CEO of Digital Equipment Corporation
Q2 FY93

VAX—enjoying life after Alpha

Many people thought that after DIGITAL announced its family of 64-bit Alpha computers, there would be no more VAX systems introduced. Not so.

In 1995, DIGITAL announced the Catamount project, which was responsible for producing the VAX 4000 Model 108 system and MicroVAX 3100 Model 88 and 98 systems. DIGITAL added new functionality into the product set, including an increased memory capacity by a factor of four. Engineers increased the memory capacity in response to customer requests for more memory to meet prior increases in CPU performance. The Catamount products were designed to be both rack mountable and used on the desktop. The focus was lowering the customers' cost of ownership and allowing customers to take advantage of lower cost memory and storage technology.

Beyond the product enhancements, the real significance of this new line of VAX systems was the fact that DIGITAL was continuing to make investments to support the company's Installed Base of VAX customers.

Ken Olsen and Bob Palmer discuss future technology.

Destination Alpha: Removing the barriers

To help ensure that customers have a risk-free transition from VAX systems to Alpha systems, DIGITAL launched the Destination Alpha program in 1995. Under this program, DIGITAL opened 34 application migration centers around the globe to help customers migrate their applications. In addition, an engineering hotline is available to help customers resolve their most critical migration issues.

DIGITAL also developed a program called Project Navigator that addresses any financial or technical barriers that customers may face. Through these programs and services, DIGITAL has provided customers with a smooth transition to the Alpha platform.

"When we were designing the Destination Alpha Program, we realized that we needed to develop customized solutions so customers could move from VAX to Alpha at their own pace."

—Janet Darden
Destination Alpha Program Manager

VMS becomes OpenVMS

The 64-bit Alpha system became the most powerful system in the industry. Major developments included strategic Alpha software combined with the availability of Microsoft's Windows NT on the Alpha platform. During this time frame, DIGITAL officially changed the name of VMS to OpenVMS to reflect the ease of portability and openness of this operating system. With OpenVMS, VMS now supported the widely accepted POSIX standards of the IEEE. The VAX operating system was also "branded" by X/Open, the non-profit consortium of many of the world's major information system suppliers.

OpenVMS supports key standards such as OSF/Motif, POSIX, XPG4, and the OSF Distributed Computing Environment (DCE). Extensive support for standards in the operating system helps when building an open systems environment using OpenVMS as the base. Supported open systems standards include networking, data, document, systems, software development, and user interface. OpenVMS supports all major open systems standards, including those for networking, data, document, systems, software development, and user interface.

VMS becomes OpenVMS.

With this name change came the introduction of 13 Alpha-ready OpenVMS VAX systems and servers. Alpha-ready was the term coined to indicate that these VAX machines were easily upgraded to incorporate the new 64-bit technology.

In February 1993, the company shipped 26 OpenVMS ALPHA AXP products ahead of schedule to provide a software suite for developers, system integrators, and end users. In May, more than 2,000 applications were available for OpenVMS ALPHA AXP.
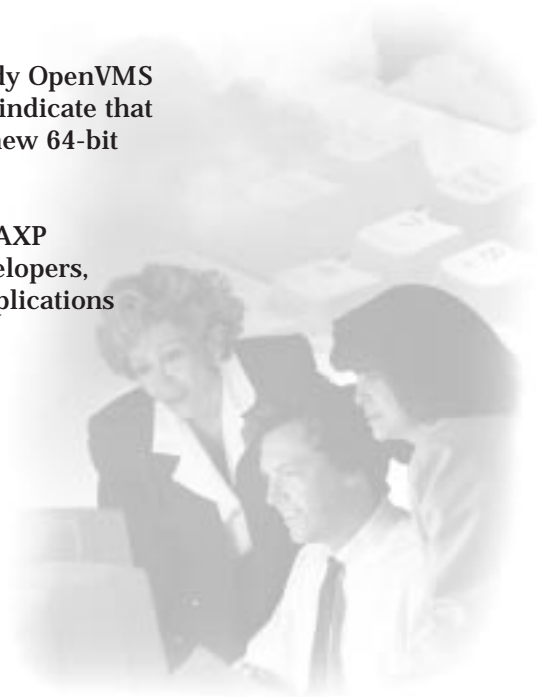
ALPHA AXP family members.

Inaugurating the King of Clusters

Throughout the industry, increasing demands were placed on computers as customers' applications grew. One way to provide more computing power was to build bigger, faster systems up to the current technical limits. DIGITAL came up with an alternate solution that provided more power—without sacrificing the benefits of distributed computing customers wanted. That ideal was clustering.

Cluster computing, invented by DIGITAL, has become a widely accepted alternative method of providing higher system availability and scalability using mainstream computing products than can be provided by a single computer system. In fact, in the eyes of our customers, DIGITAL's OpenVMS Clusters became the standard by which all other clusters are measured. Cluster computing provides a dimension of scalability as an alternative to extending or upgrading a single system, and allows older installed systems to be coupled into the cluster to provide an economical way to increase computing power and deliver higher availability of data and applications.

Introducing VAXclusters

In May 1983, DIGITAL announced VAXclusters. VAXclusters tied VAX processors together in a loose processor coupling that allowed VAX computers to operate as a single system—extending VAX characteristics to high-capacity and high-availability applications.

OpenVMS Clusters

Over the years, VAXclusters evolved to VMSclusters, and today are OpenVMS Clusters for VAX and Alpha Systems. OpenVMS Clusters are unparalleled in the industry today. Most of the world's stock exchanges and electronic funds transfer activities run on OpenVMS Clusters.

An OpenVMS Cluster is a highly integrated organization of VAX and Alpha systems, application and systems software, and storage devices. Systems sized from the desktop to the datacenter can be connected into an OpenVMS Cluster. OpenVMS Cluster software enables the system to work an easy-to-manage virtual system that shares printing resources, storage devices, and print and batch queues.

OpenVMS Clusters offer the best benefits of both centralized and distributed systems with the added benefit of power that can surpass that of a mainframe—at a fraction of the cost. And they can be added to or divided as customer requirements dictate.
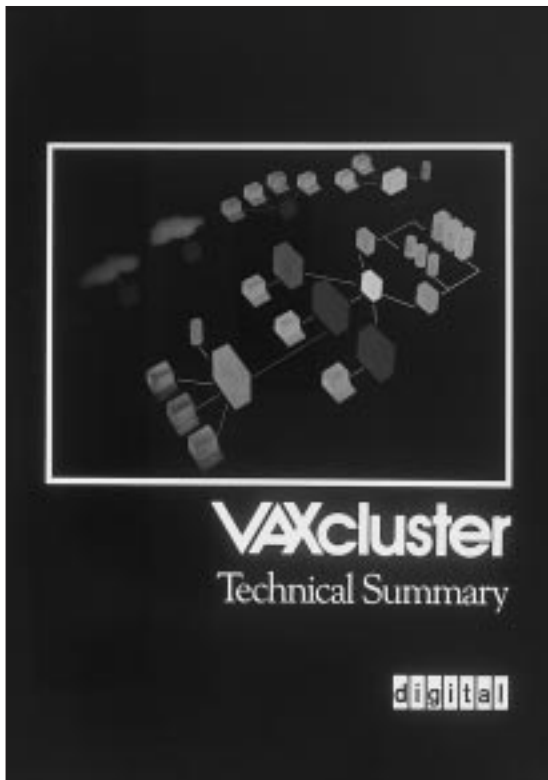
VAXclusters was the first clustering capability in the industry! VAXclusters tied VAX processors together, which allowed VAX computers to operate as a single system, extending the characteristics of VAX to high-availability applications.

"(Open)VMS remains King of the Clusters. DIGITAL's technology is still the high bar against which other clustering schemes are measured."

—Datamation, August 15, 1995

Local Area VAXclusters

In 1986, DIGITAL introduced Local Area VAXclusters, which extended distributed computing capability to the workgroup and used a standard Ethernet network as the cluster interconnect.

With Local Area VAXclusters, VMS extended its cluster technology to the NI. The CI interface was a large, expensive controller available only on large, expensive VAX systems. That fact, plus the limit at that time of 16 systems on a CI, limited CI clusters to the large "computer room" VAX systems. Also, all cluster-accessible storage had to be connected directly to the CI. However, the advent of the MicroVAX and VAX workstations (concurrent with clusters in 1984) created the demand to connect larger numbers of smaller VMS systems into the cluster.

To answer this demand, DIGITAL modified VMS to allow the cluster communication protocols to operate over the NI, which was the only interconnect available on small VAX systems. In addition, software was introduced to allow all storage devices on the cluster to be served to all cluster members. This allowed the NI cluster members access to the HSC-based storage even though they had no direct connection.

Local area VAXCluster systems extended VAXCluster technology to Ethernet. Bringing the software advantages of the VAXCluster environment to the MicroVAX II and VAXstation II systems.

Supporting clusters via more interconnects

In the years since, DIGITAL added more interconnects to support cluster connections:

- **FDDI**—an industry-standard, optical fiber interconnect approximately ten times faster than an Ethernet. The FDDI also provided access to bridges to a number of common carrier communications media, allowing cluster connections over great distances.

- **DSSI**—a low-cost CI that allows connection of up to three VMS systems and a limited number of directly attached disks.

- **Memory Channel**—a very fast direct memory access path between VMS systems located close together.

"The high-availability characteristics of OpenVMS and clusters are very important to us...the scalability and clustering capability of OpenVMS allow us to provide our clients with technology as they need it."

—Scott Fancher
Vice President and Product Line Executive, Cerner Corporation

Fault Tolerant and Disaster Tolerant Systems

Just as clustering was an outgrowth of networking, fault tolerant and disaster tolerant systems were an outgrowth of clustering.

Clusters offer high availability; they are not fault tolerant. Clustering enabled the development of fault tolerant and disaster tolerant systems by providing availability that guaranteed 24x365 days of service. Fault tolerant systems provide what is considered five nines of availability, meaning that the system would be available 99.999 percent of the time. Fault tolerant systems allow applications to continue computing in the event of equipment failure. The system does not have to wait to restart or boot after encountering a failure. Rather, the failed piece of equipment drops off while the redundant pair continues to run from the time of the fault. In certain situations this kind of availability is needed—such as 9-1-1 emergency services, financial/stock market transactions, air traffic control, and nuclear reactor monitoring. Fault tolerant applications are needed where the consequences are disastrous if the computer is out for a few minutes or more. Fault tolerant failover occurs in a minute or less, with no loss of data.

Multi-site clustered systems are used in disaster tolerant applications. Disaster tolerant systems are set up to prepare for man-made or environmental disasters including terrorism, fires, earthquakes, floods, etc. All these situations have the potential to take out a computer room. If there is a back-up system that can send out data to another location, the systems will remain functioning to prevent losses of data and business that an interruption would cause. Two fault tolerant systems clustered together in two different locations provide site diversity and automatic failover to a site distanced from the disaster. If one site goes down, the other takes over and continues operating—without missing a beat.

VAXft 3000 Announcement

OpenVMS Clusters continue to reign as the King of Clusters

Today, more than 65,000 OpenVMS Cluster systems are found at the heart of continuous computing solutions for such critical applications as stock exchanges, electronic funds transfers, healthcare, telecommunications, and process manufacturing. No other solution can match OpenVMS Cluster systems when it comes to our over 14 years of providing a continuous computing environment. Only OpenVMS Cluster systems can span up to 500 miles to enable continuous operation through even large scale natural or man-made disasters ensuring optimal data and transaction integrity and fast recovery. OpenVMS Cluster system support "rolling upgrades", enabling system processors, boards, peripherals, operating software, databases, and program modules to be replaced, upgrades, or updated without interrupting the operation.

The Fault Tolerant Group

CHAPTER XIII   OpenVMS Today

OpenVMS is a general purpose, multi-user operating system that runs in both production and development environments. OpenVMS Alpha supports the DIGITAL Alpha series of computers, while OpenVMS VAX supports the VAX series of computers. The software supports industry standards for facilitating application portability and interoperability. It also supports symmetrical multiprocessing (SMP) support for multiprocessing Alpha and VAX systems.

An integral part of three-tier computing

Today, the core of the OpenVMS strategy is to leverage the inherent affinity between Windows NT and OpenVMS by combining the unequaled strengths of OpenVMS with the emerging power and application library of Windows NT in a seamless computing environment.

OpenVMS is the environment of choice in the most demanding of continuous computing situations. The high levels of availability, integrity, security, and scalability of OpenVMS make it a natural unlimited high-end for Windows NT in a three-tier client/server environment. OpenVMS is the number one operating system in healthcare today. It also enjoys a major presence in the financial, funds transfer, and stock exchange industries, as well as manufacturing, education, and government.

OpenVMS Ambassador Team (Business Partners)

"The OpenVMS operating system environment holds a special place in the computer industry. It was the centerpiece of the minicomputer revolution, the first operating system to prove that scaling from desktop to data center was practical, and the first to demonstrate that clustered systems could achieve levels of availability well beyond mainframes or 'fault tolerant' systems. It was, and continues to be, a huge market success."

—Wes Melling
VP of Windows NT and OpenVMS Systems Group

Unparalleled availability

OpenVMS provides immunity to planned and unplanned downtime with proven 24x365 availability, including disaster-tolerant multi-site clusters spanning 500 miles.

OpenVMS systems scale to meet the performance, availability, and data requirements of the largest enterprise applications through 64-bit, Very Large Memory (VLM), and Very Large Data Base (VLDB) support, and clusters of up to 96 nodes.

OpenVMS provides enhanced performance, clustering flexibility, easy Internet connection, and 64-bit VLM for business-critical applications. New features have been incorporated to further performance in OpenVMS Clustering and to improve system management. Memory Channel clusters, extended VLM capability, cluster failover, and the OpenVMS Internet Product Suite are also provided by OpenVMS.

"It is important to emphasize the significance of the Installed Base to DIGITAL. With over 700,000 systems installed worldwide, it is more critical than ever before for us to continue to nurture the base.

We brought a bright future to our OpenVMS Installed Base customers with the Affinity strategy. OpenVMS continues to be one of three strategic platforms from DIGITAL."

—Wally Cole
VP, Installed Base Marketing

Enhanced support for clustering

OpenVMS Cluster technology enables customers to configure disaster-tolerant multi-site clusters located up to 500 miles (800 kilometers) apart.

OpenVMS provides features specifically designed to improve performance and expand OpenVMS Cluster configuration flexibility. OpenVMS supports mixed architecture clusters and allows customers to connect up to 96 Alpha and VAX systems and storage controllers to share common data and resources across systems, as well as architectures. OpenVMS Cluster systems can utilize FDDI, CI, DSSI, Ethernet, and Mixed-interconnect transports.

Two powerful features of OpenVMS Clusters are Memory Channel and the Business Recovery Server. Memory Channel comprises a high-performance interconnect technology for PCI-based Alpha systems that improves OpenVMS Cluster performance and reduces costs. Business Recovery Server Cluster support allows businesses to withstand disasters—floods, fires, earthquakes—at any site, without loss of access to data or applications.

OpenVMS Cluster systems can be managed centrally, as a single system, providing a single domain for data, users, queues, and security.

"Marketing for OpenVMS is really fun activity. We have the most loyal, most enthusiastic customer groups out there. They appreciate the technology. They appreciate the ease of use. They appreciate the value of an operating system that has become tried and true over a number of years and has evolved to the state where many of the world's largest banks, stock exchanges, healthcare organizations, and production manufacturing environments are trusting their business to the true 24x365 capabilities of OpenVMS."

—Mary Ellen Fortier
Director, OpenVMS Marketing

Supporting 64-bit environments

In November 1995, at DECUS, DIGITAL announced OpenVMS Version 7.0—supporting 64-bit virtual addressing. 64-bits of address space is 18 exabytes. That's four billion times the 32-bit address space of four billion bytes. Using 64-bit addressing allows developers to map large amounts of data into memory to provide high levels of performance and to support very large memory systems.

The current Alpha memory management architecture allows actual address space usage of eight terabytes. On the VAX, only half the address space is available for applications (2GB), so the currently available Alpha address space is 4,000 times that on the VAX.

As ever larger memory becomes available, the Alpha memory management architecture can be extended to support more of the theoretical maximum of 18 exabytes. This was the largest incremental release in the OpenVMS operating system since the introduction of VMSclusters.

CHAPTER XIV

Serving Customers Worldwide

Supporting the family–global services

DIGITAL realized that a key factor in the success of VAX and VMS was customer services. Almost from its founding, the company has supported customers worldwide from strategically located field service facilities.

Educational services provide software and hardware training—providing DIGITAL customers with the necessary skills to implement and work with the company's system effectively.

DIGITAL developed its Services group to ensure that the first release of VMS could be supported by field support services. This group formulated strategies for support of VMS, and learned the software in depth to be able to support it and train people in the unique features of the new software. A back-up support group called VAXworks was also formed to address customer needs. The VAXworks group received phone calls and telexes from people all over the world.

DIGITAL set out to have the best support and field service operations as well as the best education and training organization. These services have always been a vital part of the company's success and have contributed greatly to the business.

Field service engineer repairing customer CPU board.

Bringing in the voice of the customer

From its inception, DIGITAL has believed that two-way customer communication was necessary to ensure that the company was building products to solve real-world needs. That strategy exists today, as DIGITAL takes a comprehensive approach to working with customers at all levels of their organizations.

DIGITAL listens to customers through a variety of forums, including:

Customer visits—DIGITAL makes more than 500 visits to OpenVMS customers annually.

Technical Direction Forums— Twice a year, DIGITAL presents new strategies and technologies to 12 top customers at the Director of MIS level. This feedback has a direct impact on future directions.

OpenVMS Executive Counsel— Every six months, DIGITAL meets with 35-40 CIOs in various customer organizations to look at overall strategies of business and direction.

DECUS—Founded in 1961, the Digital Equipment Computer Users Society (DECUS) is an opportunity for people who work with OpenVMS on a day-to-day basis to receive training on all technologies and provide valuable feedback.

"A big part of the success at DIGITAL was the support and the service. We gave enormous service to the customer. And without that, even VAX and VMS wouldn't have been so successful."

—Ken Olsen, 1997

Service strategy today

The range of DIGITAL Service spans the spectrum from systems integration to hardware and software maintenance. The company's service effort focuses on three areas. The first area is to support the company's strategic growth areas: high-performance 64-bit computing, NT across the enterprise, and Internet connectivity. The second area is multivendor service. DIGITAL is the only major vendor that has declared a vendor neutral strategy. The third area is value-added services and innovation in the marketplace.

DIGITAL has an investment in global resources and infrastructure that's second to none in the industry. The worldwide DIGITAL Services Organization—between its Multivendor Customer Services and Systems Integration Organization—includes more than 25,000 Service Professionals worldwide and over 450 locations around the world. At the company's Solution Centers, System Integration Specialists and Network Consultants help customers successfully solve their most challenging information technology problems.

Strategic partnerships

To ensure continued growth and to meet the changing business needs of its customers, DIGITAL has established strategic partnerships with industry-leading companies such as Microsoft Corporation, Oracle Corporation, and others.

"We find that customers are using information technology to get greater access to their data. They want to spend more time on the analysis of this information and its distribution using the Internet to create competitive advantage. They don't want to spend a lot of time becoming information technology experts. More and more they're relying on key service partners to take responsibility for the management of this information infrastructure."

—John Rando
VP and General Manager,
Multivendor Customer Services Organization

Getting the bugs out. Or, using cockroaches as semiconductors

A VAX-11/780 installed at the Carling Brewery was crashing several times a day with no pattern at all. Field services reps had replaced everything and they couldn't figure it out. Every time the machine crashed, accidents would happen, usually spilling large quantities of beer.

One day, a software specialist was in the booth with the machine pouring over the last dump. All of a sudden there was the familiar rhythm of another crash. He looked out the windows and saw people scurrying for cover. The capping machine had run amuck and was spitting out bottle cap blanks, which in their raw state are like little two-inch diameter, razor-sharp, aluminum frisbees. The software specialist couldn't take it anymore. He walked over to the VAX-11/780 and kicked the front panel as hard as he could. A bunch of cockroaches came scurrying out.

Naturally, cockroaches are attracted to beer dregs. And it was warm and dry inside the machine, so they moved in. He figured that cockroaches are at least somewhat conductive. As the insects ran up and down the backplane, every once and a while one of them would get two legs across—a pair of contacts. And the machine would crash.

The software specialist went out to the local store and bought Roach Motels which installed in the bottom of the machine. The problems ended. After that, changing the Roach Motels became a part of the monthly product maintenance.

"When we were about up to Version 3 of VMS, I was at DECUS and a customer came up to me and she said "You won't believe this, but we're still running Baselevel 5 and we love it. We think it's the best thing ever. and we're never going to change it because it does just what we need." So I said, "Well, if it does just what you need, I think you're right, don't ever change it."

—Kathy Morse
VMS Engineer

VAX: Built to last

780 drops off a forklift and lives

In 1978, a VAX-11/780 was shipped to the National Computer Conference in Anaheim. At the loading dock it dropped off of a forklift—which was hard on something this big. A replacement machine from a nearby local office was brought to the show, and the carcass of the dropped system was shipped back to New England. The engineers took it apart, straightened the frame, and replaced the backplane. Other than that, it worked perfectly, and was put in service for years, many years. It was called the Phoenix.

Another VAX-11/780 slams into the side of a building and keeps on ticking

Another VAX-11/780 was shipped to a customer in Washington, D.C. It was too big for the elevator, so the customer decided to lift it on a crane and swing it in through a window. Instead of going into the open window, the system slammed into the side of a building. The machine looked very damaged.

At that time, VAX-11/780 systems were on a six-month backlog and the customers didn't want to wait for a new one. So the feild service engineers put new skins on it and replaced a slightly bent backplane, offering a replacement if necessary. That machine always worked perfectly. And the customer was delighted because he got a six-month lead.

"The customers were members of the family, and there was a strong dialogue at all levels between engineers and customers. We spent a lot of time hanging around listening to customers, and DECUS was very active and effective as a lobbying committee for new product requirements. We built what the customers told us they needed."

—Larry Portner
VP of Software Engineering

"The VAX-11/780 has always held a lot of sentimental value for me. Like your first love, you never forget your first computer. An VAX-11/780 was the first computer I programmed on in the early '80s. My very first program, a test of a FORTRAN subroutine, I jokingly called 'FAST.EXE' so that I could 'RUN FAST' under VMS. Noteworthy because it was the first in the very popular VAX line of computers from DIGITAL, the VAX-11/780 is also one of the few computers that can actually be considered a classic. Not only did it play a pivotal role in the mini-computer revolution, but it also evolved into a standard.

So when a VAX-11/780 donated to the HACKS computer club was on the loading dock headed for the dump after its CPU and memory boards were stripped for parts to get two other 780s working, I persuaded fellow HACKS members to let me have it and find another use for it. My ideas were either a bookcase for the 'Grey Wall' of VMS books, or a wetbar. Since I didn't have my own copy of the VMS documentation at that time, the wetbar idea was the obvious choice!

—Vance Haemmerle

Top; Mastermind of the VAXbar, Vance Haemmerle. Bottom; Old VAX-11/780 systems never die, they just find new ways to serve humanity.

DECUS—Digital Equipment Computer Users Society
DECUS, the Digital Equipment Computer Users Society, is an association of Information Technology professionals interested in the products, services, and technologies of Digital Equipment Corporation and related vendors. The Association's purpose is to promote the unimpeded exchange of information, with the goal of helping its members and their organizations to be more successful. The Chapter provides members with the means to enhance their professional development, forums for technical training, mechanisms for obtaining up-to-date information, advocacy programs, and opportunities for informal discussion and interaction with professional colleagues of like interest.

"It was extremely exciting in the early days of marketing VAX and VMS because the company was growing so fast. I remember the first DECUS that I attended. Each time I went to DECUS, the audience doubled. The first time, there were about 300 people in the audience, the next time there were 600, the next time there were 1,200, and the next time there were over 2,000. That was the momentum that we had in the market. In many cases we would learn from our customers about different applications using 32-bit."

—Marion Dancy
VP of Marketing, UNIX and OpenVMS,
Systems Business Unit

CHAPTER XV The Affinity Program

Bill Gates and Robert Palmer.

Leveraging the natural affinity of OpenVMS and Windows NT

On May 8, 1995, at DECUS in Washington, D.C., Digital Equipment Corporation and Microsoft Corporation announced the Affinity for OpenVMS Program to help customers implement the complementary strengths of OpenVMS and Windows NT in a three-tier client/server environment. OpenVMS provides the ultimate high-end, tools, and applications to ensure a seamless integration with Windows NT.

This integrated systems environment brings the bulletproof capabilities of OpenVMS to the world of Windows NT applications. The program includes new software, tools, middleware, and services from DIGITAL and its partners that build on the natural affinity between OpenVMS and Windows NT— making it increasingly easier to develop, deploy, and manage applications across both platforms.

"When our customers had beta copies of Windows NT, they told us that it felt like they were revisiting an old friend. That's not surprising because the chief architect of both operating systems was Dave Cutler. So there is a natural affinity from a technical perspective between the two environments. Wes Melling is often quoted calling it the 'Cutler effect.'"

—Mary Ellen Fortier
Director, OpenVMS Marketing

Since May of 1995, DIGITAL has consistently announced new products, capabilities, features, and services that support the OpenVMS Affinity environment.

Key examples include OpenVMS V7.0 for 64-bit computing, new products for system management, World Wide Web hosting, enterprise messaging, and application development. In addition, software vendors have responded to user demand with new applications and tools. Each year, more DIGITAL business partners are bringing application development, data warehousing, and healthcare applications to the Affinity portfolio.

In the two years since its inception, the Affinity for OpenVMS Program has helped more than 20,000 organizations around the world integrate the two platforms in three-tier client/server environments across their enterprises. Customers include worldwide banks and stock exchanges, healthcare providers, manufacturing facilities, educational institutions, government organizations, and more.

"The magnitude of what we are doing here—the clustering agreement, joint engineering, joint field teams—is much bigger than what we have done in the past with other alliances."

—Bill Gates
President and CEO, Microsoft Corporation
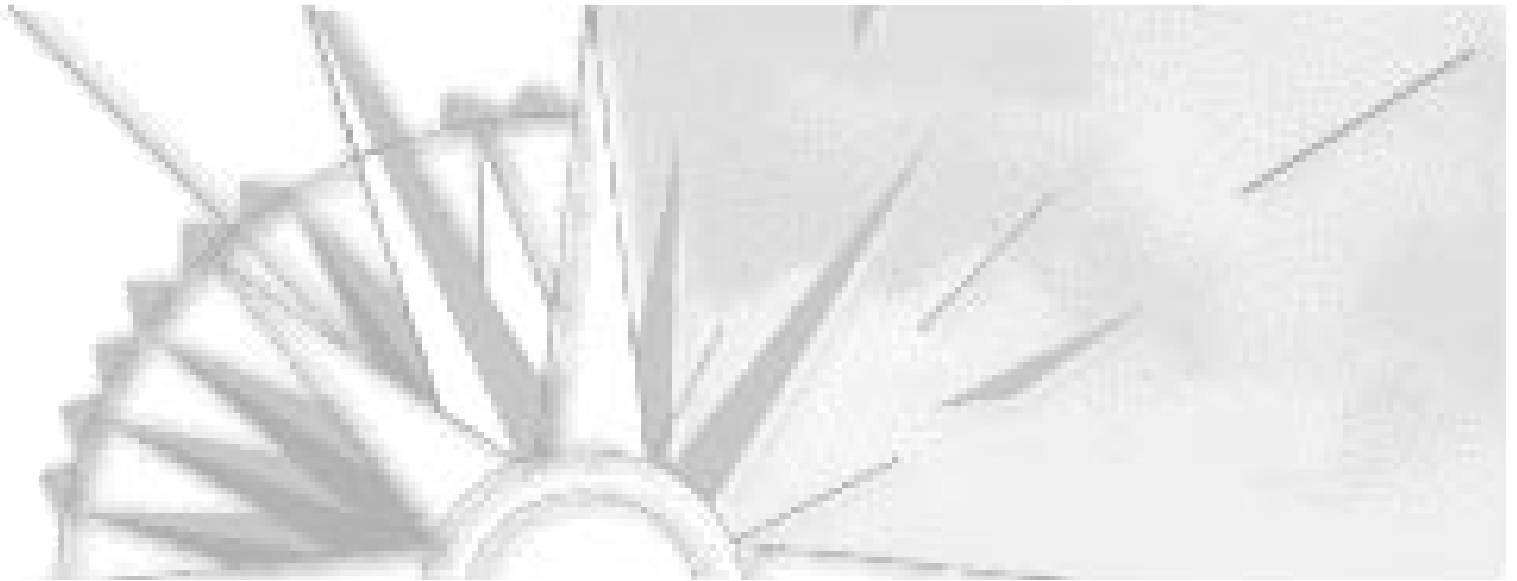
"With the DIGITAL Affinity for OpenVMS Program, OpenVMS and Windows NT integration brings Corning the richest operating environments. It provides superior overall functionality and the most complete set of applications and tools. We've selected Forté—the industry's premier three-tier client/server software—which draws on the strengths of both OpenVMS and Windows NT, making it possible to create and deploy applications with multi-tier, enterprise-wide functionality."

—Mark Joyce
Supervisor of Fiber Systems Engineering
Computer and Information Services, Corning, Inc.
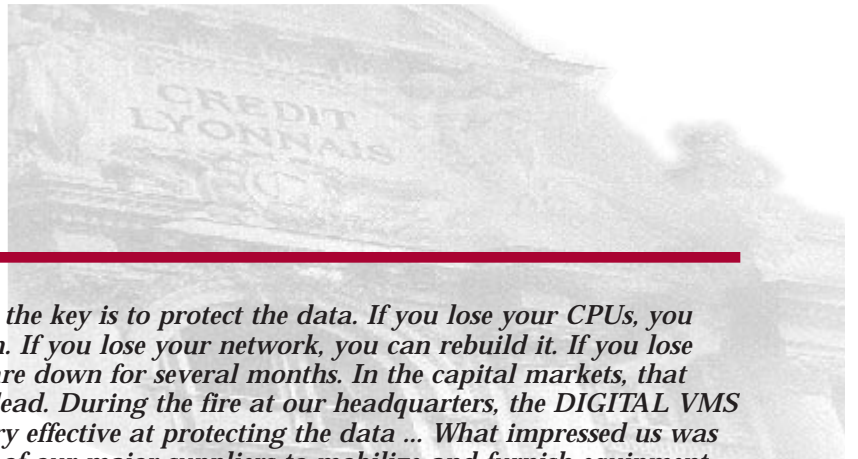
Credit Lyonnais

"In any disaster, the key is to protect the data. If you lose your CPUs, you can replace them. If you lose your network, you can rebuild it. If you lose your data, you are down for several months. In the capital markets, that means you are dead. During the fire at our headquarters, the DIGITAL VMS Clusters were very effective at protecting the data ... What impressed us was the ability of all of our major suppliers to mobilize and furnish equipment and services. DIGITAL managed this very well indeed. They were everywhere with us."

—Patrick Hummel
IT Director Capital Markets Division, Credit Lyonnais

CHAPTER XVI

Vision of the Future

Looking skyward: Galaxy

DIGITAL knows that a company's need for computing resources can fluctuate significantly for certain applications at certain times.

For example, let's consider a scenario of a system manager for a large cluster in a telecommunications company. Once every three months, a communication satellite might send enormous quantities of vital data to his receiving station. Transmission time is only two hours, and it's critical that all the data are processed immediately. He gets no second chances. But his systems are already busy crunching day-to-day information. Short of buying, or leasing, new CPUs, memory, and disks, what can he do?

That's where Galaxy will come in. DIGITAL is developing an evolution in OpenVMS functionality that will include a new model of computing that allows multiple instances of OpenVMS to execute cooperatively in a single computer. For companies looking to improve their ability to manage unpredictable, variable, or growing IT workloads, the DIGITAL Galaxy software solution for OpenVMS provides the most flexible way to dynamically reconfigure and manage system resources. Galaxy is a powerful software solution that allows system managers to easily reallocate individual CPUs or memory through a simple drag-and-drop procedure.

Enhancing OpenVMS

After 20 years, OpenVMS still has tremendous growth potential. OpenVMS is a key component of the DIGITAL strategy to satisfy its customers' computing needs well into the next century.

Alpha System, the path to the 21st Century.

The five-pronged OpenVMS strategy

1. DIGITAL will maintain all current OpenVMS capabilities and will ease the migration to a 64-bit environment.
2. The company will continue to invest in OpenVMS development to ensure the long-term future of the operating system.
3. The disaster tolerant, 24X365 strengths of OpenVMS will continue to be enhanced.
4. The company will provide seamless integration with Windows NT.
5. OpenVMS will continue to provide an unlimited high-end to Windows NT. Current OpenVMS engineering projects are upholding the same high standards of engineering excellence that have characterized OpenVMS from its inception.

DIGITAL will continue to focus on 64-bit computing in such areas as the Internet, continuous computing, Windows NT integration, and data warehousing. To meet the demand for the integration of enterprise computing with Windows NT, DIGITAL will develop enterprise applications, visual computing, and mail and messaging that are NT-integrated. Internet business growth will support the marketplace need for the development of customer intranets, Internet commerce, and ISP/Telco support.

"OpenVMS plays a critical role in our customers' operations. It's a very vibrant, vital operating system, with exceptional performance and high availability."

—Bruce Claflin
Senior VP and General Manager,
Sales and Marketing

"If OpenVMS engineering continues the type of innovation we're doing now, we'll be here for another 20 years, and then we'll be asking ourselves again: what's next?"

—Steve Zalewski
Technical Director of OpenVMS systems software group

VMS to OpenVMS: Major Releases

VMS V1 August 1978
- Multiuser, multifunction virtual memory operating system
- ODS-1 and ODS-2 file systems
- Integrated DECnet
- ANSI magtape support
- Languages
- VAX-11 FORTRAN IV-PLUS
- VAX-11 MACRO generates native code
- BASIC-PLUS 2 and COBOL
- DCL and MCR command language interpreters
- Supported hardware
- VAX-11/780 with a minimum of 256 KB of memory, up to a maximum of 2 MB
- 2 RK06 disks, or MASSBUS disk and tape
- DMC-11 communications interface
- CR11, LP11, and LA11
- DZ11 with VT52 and LA36 terminals
- Floating point accelerator

VMS V2 April 1980 ~3000 licenses
- Support for new processor – VAX-11/750
- More native languages
- EDT screen editor
- SET HOST
- MAIL, PATCH and SEARCH utilities
- Shared sequential RMS files
- Support for multiport shared memory and DR780
- Connect-to-interrupt driver
- User written system services
- VAX FORTRAN (77)

VMS V3 April 1982 ~10,000 licenses
- Support for new processors – VAX-11/730, VAX 11/725, VAX-11/782
- Asymmetric multiprocessing (ASMP) for VAX-11/782
- Support for new architectures, protocols, busses
- System communication architecture (SCS)
- Mass storage control protocol (MSCP)
- Lock management system services
- MONITOR utility for performance monitoring
- BACKUP
- Command definition utility for DCL
- Terminal autobaud detection, CTRL/T, and hangup on logout
- SPAWN and ATTACH

VAX V4 September 1984 ~ 40,000 licenses
- Support for new processor – VAX 8600 MicroVAX I/II (v4.1) VAXstation I/II (v4.1)
- VAXclusters
- Connection manager
- Distributed lock manager
- Distributed file system (F11BXQP)
- Security enhancements
- Command line editing and command recall
- Local area terminal server
- Access control lists implemented
- Cluster wide operator control
- Variable prompt strings

VMS V4.4
- Support for new processors – VAX 8200, VAX 8250, VAX 8300, VAX 8350 VAX 8500, VAX 8550, VAX 8700, VAX 8800
- ASMP support for VAX 83xx and VAX 88xx systems
- Cluster packages VAX 8974 & VAX 8978
- Disk volume shadowing and HSC support

VMS/ V5 May 1988
- Support for new processors – VAX 6210, 6220, 6230, 6240, 8810, 8820, 8830, 8840, 8842, VAXserver 6210, 6220
- Symmetric multiprocessing (SMP) support
- Mixed interconnect VAXclusters
- License management facility
- Terminal fallback utility
- Modularized executive
- Structured DCL: IF-THEN-ELSE, GOSUB and CALL
- System Management enhancements
- Dynamic failover of dual pathed disks
- New batch and print queue features
- AUTOGEN Feedback

### DEC Windows (v5.1) VMS V5.2 September 1989, ~300,000 licenses
- Support for new processors – VAX & VAXserver 6400 series, VAXserver 3100
- Clusters of 96 nodes
- Hardware release
- V5.2-1 October 1989
- MicroVAX 3100
- VAXstation 3100 Model 38/48
- VAXstation 6000 Series 4XX

VMS V5.4 October 1990
- Support for new processors – VAX 6000-510,520
- Vector processing option for VAX 6000-4xx
- DCL commands for Fault Tolerant (VAXft) systems
- TPU enhancements
- DECwindows enhancements
- MSCP load balancing and preferred path
- Password history. Dictionary and site specific password filters
- Hardware releases
- V5.4-0A October 1990
- VAX 9000
- V5.4-1, December 1990, replaced
- VAX 9000 SMP
- VAXstation 3100 Model 76
- VAX 4000 Model 200
- VAXft models 110, 310, 410, 610, 612

VMS V5.5 November 1991
- Support for new processors – MicroVAX 3100 Models 30, 40 & 80 VAX & VAXserver 6000-6xx series VAX 4000 Models 60, 500 & 600 VAXstation 4000 Model 60 & VLC
- New queue manager
- New licensing features
- LAT enhancements (SET HOST/LAT, LATmasterfeatures)
- Phase II Shadowing (host based shadowing)
- Cluster wide tape service (TMSCP)
- New RTLs - DECthreads and BLAS fast-vector maths library
- Hardware releases
- V5.5-2HW September 1992
- MicroVAX 3100 Model 90,
- VAX 4000 Models 100 & 400
- VAX 7000 Model 600
- VAX 10000 Model 600
- VAXstation 4000 Model 90
- V5.5-2 September 1992
- VAX 7000 Models 610, 620, 630, 640, 800 through 860
- VAXstation Model 90A
- V5.5-2H4 August 1993
- MicroVAX 3100 Models 85,88,95,96
- VAX 4000 Models 100A, 105A, 106A, 108, 500A, 505A, 600A, 700A, 705A, 800A
- VAXstation 4000 Model 96
- V5.5-2HF August 1993
- VAXft Model 810
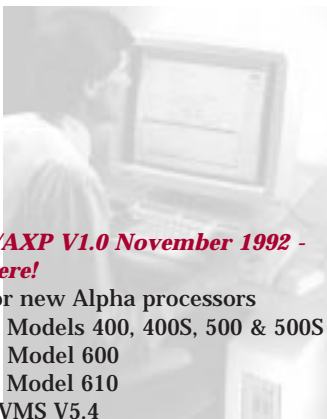
OpenVMS/AXP V1.0 November 1992 - Alpha is here!

- Support for new Alpha processors
  DEC 3000 Models 400, 400S, 500 & 500S
  DEC 4000 Model 600
  DEC 7000 Model 610
- Based on VMS V5.4
- DECmigrate for translating VAX images
- MACRO-32 compiler
- No clusters, no RMS journaling, no shadowing, no SMP

OpenVMS/VAX V6.0 June 1993

- Support for new processors – VAX 7000 Model 650/660, VAX 10000 Model 650/660
- Rationalized and Enhanced security (Level C2 compliance)
- Multiple queue managers across cluster
- HELP/MESSAGE utility
- Support for ISO 9660 CD-ROM format
- Adaptive Pool Management
- SYSMAN cluster wide SHUTDOWN and startup logging
- Cluster wide Virtual I/O cache
- Extended physical and virtual addressing
- Protected subsystems
- DECnet/OSI
- DECwindows XUI replaced by DECwindows Motif

OpenVMS/VAX V6.1 April 1994 & OpenVMS/Alpha V6.1 May 1994

- VAX and Alpha
- Support for new processors – AlphaServer 2100 4/200 & 4/275
  DEC 3000 Models 700 & 900
  DEC 7000 Model 710 & 7xxx
  VAX 7000 Models 7xxx
- PCSI Product installation utility (PRODUCT command)
- Shadowing and RMS Journaling for Alpha
- DECamds bundled with operating system
- CLUE Crash dump utility
- DPML standard maths library
- C++ support
- DECnet/OSI Extended Node Names

OpenVMS/VAX V6.2 May 1995 & OpenVMS/Alpha V6.2 June 1995

- Support for new processors – AlphaServer 2100 5/250, 8200 5/300, 8400 5/300
- Freeware V1.0 CD distributed with operating system
- Automatic foreign commands (like UNIX PATH mechanism)
- RAID subsystem support
- DCL TCP/IP functions e.g.: COPY/FTP and SMTP transport in MAIL
- OpenVMS Management Station
- SCSI clusters
- SCSI-2 Tagged Command Queuing
- BACKUP Manager - Screen oriented interface
- Hardware releases
- V6.2-1H1 (Alpha) November 1994
- AlphaServer 1000A 4/266
- AlphaBook 1
- AlphaServer 2100A 4/275, 5/250 & 5/300
- AlphaStation 255/233 & 255/300
- V6.2-1H2 (Alpha) January 1995
- AlphaServer 300 4/266
- AlphaServer 1000A 5/266, 5/333 & 5/400
- AlphaServer 4000 5/300E
- AlphaServer 4100 5/400, 5/300, 5/400 & 5/466
- AlphaServer 8200 5/440
- AlphaServer 8400 5/440
- AlphaStation 500/300, 500/400 & 500/500
- AlphaStation 600 5/266, 600 5/300 & 5/333

OpenVMS/VAX V7.0 & OpenVMS/Alpha V7.0 December 1995

- Process affinities and capabilities from DCL (Set PROCESS/AFFINITY)
- HYPERSORT High performance SORT utility (Alpha)
- Ingegrated network and internet support
- New MAIL utility (rewritten)
- Timezone and UTC support
- 64-bit addressing – new system services
- Kernel threads
- Spiralog high performance file system
- Dump file compression (Alpha)
- Wind/U – Windows Win32 API
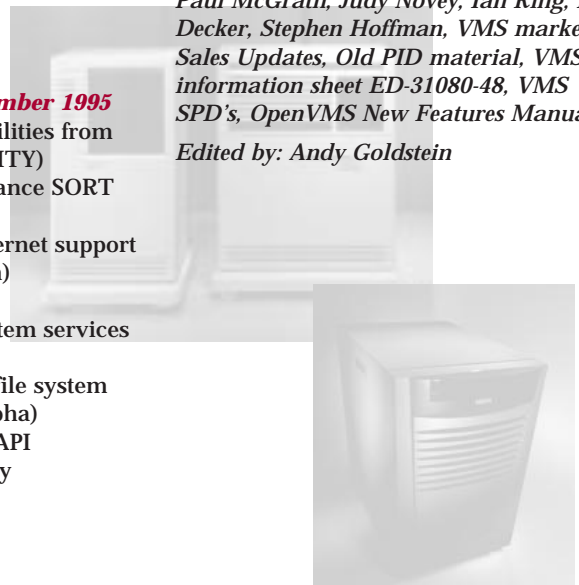- Fast I/O and Fast Path highly optimized I/O

OpenVMS/VAX V7.1 & OpenVMS/Alpha V7.1 December 1996

- Support for new processors – AlphaServer 800 5/333 & 5/400
- Pipes
- Windows NT Affinity
- PPP protocol
- Internet product suite
- Dump Off System Disk for Alpha
- External Authentication (LAN manager single signon)
- 100BaseT Fast ethernet support (Alpha)
- Memory channel high performance cluster interconnect
- Very Large Memory (VLM) support
- BACKUP API
- CDE interface for DECwindows
- 64 bit system services
- Scheduling system services

VAX and VMS History

1975

- VAX architecture committee formed with goal of "building a computer that is culturally compatible with PDP-11, but with increased address space of 32-bits." The result: VAX, the "Virtual Address eXtension" of the PDP-11's 16-bit architecture.

- VMS, the "Virtual Memory System" operating system was developed simultaneously, allowing complete integration of hardware and software.

1981

- VAX information architecture introduced, which included VAX-11, FMS, DATATRIEVE, CDD, RMS, and DBMS.

1979

- DECnet Phase II announced.

- Fortran IV announced.
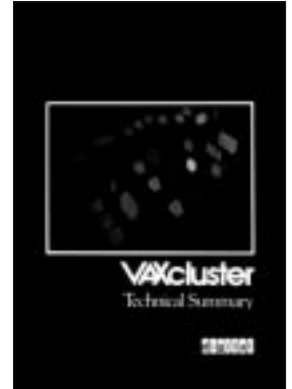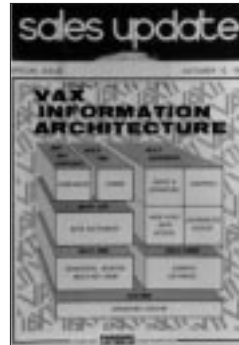
1977

- Introduction of VAX 11-/780, the first VAX system.

- VMS V1.0 announced.

1983

- DIGITAL announced VAXclusters: the capability of tying VAX processors together in a loose processor coupling that allowed multiple VAX systems to operate as a single system.

- VAX-11/725 announced.

- CI connectivity introduced.

1980

- VMS V2.0 shipped, offering the industry's largest array of languages on one system.

- DECnet Phase III announced.

- VAX-11/750 introduced, the second VAX family member and the industry's first Large Scale Integration (LSI) 32-bit minicomputer.

1978

- VMS V1.0 shipped. The development goal was to achieve compatibility between PDP-11 and VAX systems so information and programs could be shared.

1984

- VAX-11/785 introduced, the most powerful single VAX computer to date. CPU cycle time was 133ns, 50% faster than the 200ns cycle time of the VAX-11/780.

- VMS V4.0 announced.

- VAX 8600 announced, the first of a new generation of VAX systems. Offered up to 4.2 times the performance of the VAX-11/780; increased I/O capability while maintaining I/O subsystem compatibility with the VAX-11/780 and VAX-11/785 systems.

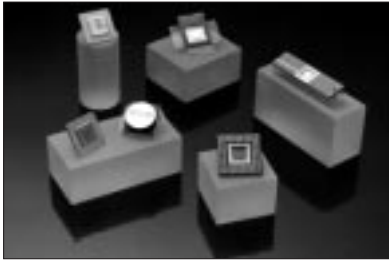- VAXstation I announced, DIGITAL's first 32-bit single-user workstation.

1982

- VAX- 11/730 announced, the third VAX family member, the first low-cost VAX processor to fit on 3 hex boards, the first VAX to fit into a 10.5-inch-high rackmountable box.

- VMS V3.0 shipped.

- RA60 and RA81 disk drives shipped.

1985
- MicroVAX chip introduced for the MicroVAX II, DIGITAL's first 32-bit microprocessor. First chip manufactured with internally developed semiconductor technology. "VAX-on-a-chip" had the highest level of functionality of any 32-bit processor in the industry.
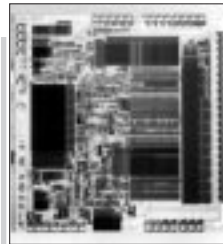- VMS V4.2 shipped.

1987
- VAX 8978 and 8974 systems introduced, DIGITAL's most powerful systems to date, offering up to 50 times the power of the VAX-11/780 system.
- VAXstation 2000 announced, the first workstation costing less than $5000, which ultimately became the highest volume workstation in the industry.
- New generation of MicroVAX computers unveiled: the MicroVAX 3500 and 3600.
- CVAX chip introduced, the second-generation VLSI VAX microprocessor, offering 2.5 times the power of its predecessor. The company's first internally manufactured CMOS microprocessor.

1991
- OpenVMS name change announced.
- NVAX, DIGITAL's fourth VAX microprocessor, implemented in 0.75-micrometer CMOS technology; shipped in VAX 6600 systems.
- OpenVMS V5.5 shipped.
- DIGITAL and Microsoft Corporation announced alliance allowing Microsoft Windows to retrieve and exchange data with local area network servers running DIGITAL PATHWORKS software.
- DECnet Phase V announced.

1989
- Introduction of the VAX 6500 System, DIGITAL's most powerful and expandable VAX system in a single cabinet.
- VMS V5.1 and V5.2 shipped.
- Rigel chip set introduced. Shipped in VAX 6400 system and later in VAX 4000 system.

1986
- Top-of-the-line VAX 8800, midrange VAX 8300, and VAX 8200 announced, the first VAX systems to support dual processors. Each machine incorporated VAXBI, a new high-performance bus.
- VMS V4.5 shipped.
- Local Area VAXclusters systems introduced, extending distributed computing to the Workgroup via the Ethernet and bringing the software advantages of the VAXcluster environment in MicroVAX II systems.

1988
- VAX 6000 System platform announced. Built on 3 key technologies: the DIGITAL CMOS VLSI VAX processor (CVAX chip), a symmetric multiprocessing hardware and software environment, and the VAXB1 I/O interconnect.
- VMS V5.0 shipped in concert with the VAX 6200 system.

1990
- DIGITAL announced VAXft 3000 system. The first fault-tolerant system in the industry to run a mainstream operating system (VMS); first system in which every component, including the backplane, was mirrored.
- VAX 6500 shipped with the Mariah chip set. The processor delivered approximately 13 times the power of a VAX-11/780 system, per processor.
- VMS V5.4 shipped.

1993
- OpenVMS AXP V1.5 shipped; OpenVMS VAX 6.0 shipped.
- DIGITAL 2100 Alpha AXP Server announced.
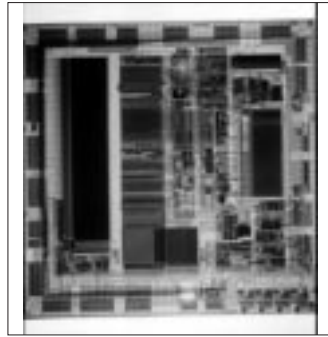
1995
- Affinity for OpenVMS and Windows NT program announced.
- Affinity Wave I announced – Application Vendor Partnering.
- OpenVMS Alpha V6.2 shipped; OpenVMS VAX V6.2 shipped.
- VAX4000 Model 106A and VAXstation 4000 Model 96 announced.
- Turbolaser AS8400/AS8200, AS 400 announced.
- MicroVAX 3100 Model 96 announced.

1997
- Wave IV announced – Future strategy for unlimited high-end
- OpenVMS VAX V7.1 shipped; OpenVMS Alpha V7.1 shipped.
- AlphaServer 800 announced.
- AlphaServer 1200 announced.

1994
- OpenVMS VAX V6.1 shipped; OpenVMS Alpha V6.1 shipped.
- VAX4000 Model 505A/705A. announced.
- MicroVAX 3100 Model 85 announced.

1992
- DIGITAL announced Alpha, 64-bit processor architecture for 21st century computing, Engineered to support multiple operating systems and designed to increase performance by a factor of 1000 over its 25-year life. The first Alpha chip was the 21064, which provided record-breaking 200-Mhz performance.
- First-generation Alpha systems included the DEC 3000 Models 400 and 500 workstations, DEC 4000 system, DEC 7000 System, and DEC 10000 System.
- MicroVAX 3100 Model 40 announced.
- OpenVMS AXP V1.0 shipped.

1996
- Affinity Waves II and III announced.
- Wave II – Real World Deployment.
- Wave III – Advanced Partner Deployment.
- OpenVMS Alpha V7.0 with 64-bit VLM/VLDM support shipped; OpenVMS VAX 7.0 shipped.
- VAX 7000 Model 800, VAX 4000 Model 108, and MicroVAX 3100 Model 88 & 98 announced.
- AlphaServer 4000/4100, AlphaServer 1000A and AlphaServer 300 announced.

In the very long term, we see OpenVMS as the huge, bullet-proof, 24x365, disaster-tolerant data store for NT applications, in general. That kind of absolute no-excuses availability isn't going to be matched for a long time by anybody. In an Internet world, more and more of our customers need that availability right now.

—Wes Melling
VP of Windows NT and
OpenVMS Systems Group

CELEBRATING

VAX
OPEN
VMS
AT
20

NOTHING STOPS IT.