VAX Emulator on HP's Latest AlphaServer Products Extends Life of Legacy OpenVMS VAX Systems

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Overview

Strong synergies in the latest technologies from Hewlett-Packard and Software Resources International promise not only a reprieve for remaining OpenVMS VAX systems but also a clear path to 21st century platforms. OpenVMS VAX users can now take advantage of ever-faster chip speeds and massive storage platforms available on the latest HP AlphaServer systems. This article describes tests of the Software Resources International CHARON™-VAX/AXP *Plus* emulator on an HP GS1280, the most powerful of the recently released EV7-based AlphaServer systems. CHARON-VAX/AXP *Plus* emulates an OpenVMS VAX system to replace VAX hardware systems with modern OpenVMS Alpha systems. The emulator runs as an application on the Alpha system, providing a 'virtual' OpenVMS VAX system that can directly execute OpenVMS VAX system operatives, the layered software, and user applications without requiring conversion.

The tests show that the combined strengths of the CHARON-VAX/AXP *Plus* and the HP GS1280 AlphaServer provide server consolidation and multi-architecture cluster support while significantly enhancing the performance of OpenVMS VAX system functions and applications running on the Alpha hardware. The tests demonstrate that a 16-way GS1280 running multiple instances of CHARON-VAX/AXP *Plus* can deliver the equivalent of an OpenVMS VAX 3198 or VAX 7610 on each GS1280 Alpha processor, while achieving nearly linear scaling. In addition, the software/hardware configuration minimizes the floor space required: only one Alpha footprint for up to 15 VAX systems emulated on the 16-way GS1280. Testing also shows that the emulator software running on a GS1280 can replace multiple high-end VAX systems. With the recent release of the 64-way GS1280, the potential for the coupling of the CHARON-VAX/AXP *Plus* and GS1280 products is spectacularly promising.

Background

This article describes the results of tests performed by Resilient Systems at Hewlett-Packard's Littleton, Massachusetts laboratory in the spring of 2003, using hardware and test suites provided by OpenVMS Engineering. The tests were performed on a 16-way GS1280 AlphaServer running multiple instances of CHARON-VAX/AXP Plus.

The test suite was the same one that OpenVMS Engineering used in previous decades to test new VAX hardware designs. To ensure proper execution of the VAX instruction set, the tests verify conformance of the new hardware to expected test results. The comprehensive suite exercises nearly every VAX instruction, including all three-operand VAX instructions as well as single, double, and floating-point calculation speeds. For some instructions, the tests revealed that the CHARON-VAX/AXP Plus emulator was more than ten times faster than any real VAX processor.

In addition to this suite, Resilient Systems used the VUPs Calculator utility to test individual CPU performance in processing a mix of fixed and floating point instructions. To test scalability of CHARON-VAX/AXP Plus on multiprocessor configurations, Resilient used standard Dhrystone tests because the results are much more granular than those produced by the VUPs Calculator. Resilient Systems first determined peak Dhrystones on a single CPU and then ran simultaneous Dhrystone tests on multiple instances of CHARON-VAX/AXP *Plus* in multiple *n-way* GS1280 configurations,

with up to 18 instances on a 16-way GS1280. Resilient Systems repeated these tests over three days, and then calculated the average Dhrystone performance. Resilient Systems then used the standard formula to convert Dhrystones to VUPs, and produced detailed graphs to show the results (the graphs are shown later in this article in Figure 4 and Figure 5).

The complete results from the OpenVMS Engineering test suite; the CPU, disk, and network performance tests; and the CHARON-VAX/AXP *Plus* scalability tests are available from Resilient Systems.

The next two sections describe the benefits of (1) the latest release of HP AlphaServer products (and the GS1280 model in particular) and (2) the CHARON-VAX/AXP *Plus* emulator, respectively. The third section to follow provides details about the cumulative performance benefits of these two products combined.

The Marvels of the GS1280 AlphaServer

Based on the new EV7 processor, the GS1280 AlphaServer, as well as the smaller ES47 and ES80 models, deliver an unprecedented combination of performance, scalability, and system reliability. The products deliver numerous architectural advancements over previous switch-based, non-uniform memory access (NUMA) systems such as the 32-way GS320.

High-Performance Chip Technology and Scaling Advancements

All elements required for symmetric multiprocessing now reside on a single chip. In addition to an on-chip L2 cache, two on-chip memory controllers provide exceptional memory bandwidth. In an industry-first achievement, an on-chip router connects AlphaServer processors directly to one another. This "switchless" mesh design results in a very high interconnect bandwidth of up to 64 CPUs. SPEC_rate 2000 tests on a 32-way GS1280 system proved that the GS1280 can achieve nearly 100% linear scalability. In other words, as the number of processors used on the GS1280 increases, the performance increases at a constant rate.

The I/O performance and scaling improvements of the GS1280 over the GS320 are equally impressive. The GS1280 provides flexibility in configuring I/O, from one I/O chip per system to one I/O chip per processor. The result is a platform with linear scaling in I/O, yielding eight times the I/O bandwidth of the GS320. Moreover, the GS1280 Lego™ block design of hot-swappable components results in a robust platform with 15% to 30% improvement in Mean Time Between Failure (MTBF) over the previous generation of AlphaServers. Available in multiple processor (*n*-way) configurations, the enterprise-scale AlphaServer GS1280, along with the departmental and workgroup ES80 and ES47 models, provide significant performance and reliability improvements over the earlier GS320 and ES45 models.

Partitioning Enables Support of Mixed-Architecture Clusters in a Single AlphaServer Box

With the new ES47, ES80, and GS1280 AlphaServer products, HP introduced support for hardware partitions. Hardware partitions permit multiple instances of the OpenVMS operating system to run concurrently in physically separate parts of the computer. Such a configuration facilitates the dedication of partitions to specific applications, with the ability to tune and secure each partition to the specific demands of its application set. By effecting the partition of the system into multiple independent Alpha processors, this new feature facilitates the deployment and execution of multiple instances of CHARON-VAX/AXP *Plus*. CHARON-VAX/AXP *Plus* can be run as an application on one or more of the CPUs in a processor partition, or across multiple CPUs in multiple partitions.

This allows construction of a variety of mixed VAX and Alpha configurations, all within a single system cabinet. For example, by using the 8-way AlphaServer depicted in Figure 1, we can partition it into three separate Alpha systems, forming a consolidated mixed-architecture

configuration as shown in Figure 2. The Alpha system constructed from the five CPUs (shown in yellow) could be configured to run multiple CHARON-VAX/AXP *Plus* instances.

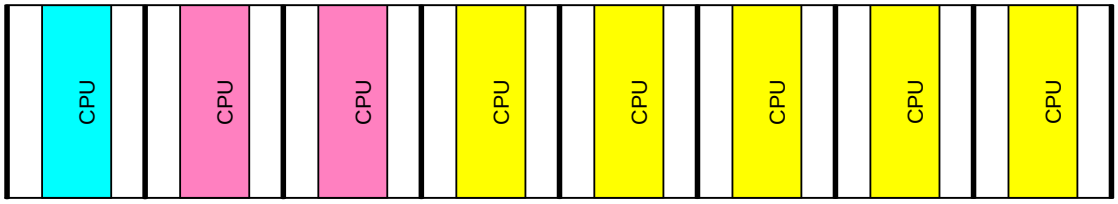

Figure 1 Multi-CPU Alpha Processor

The other two AlphaServer partitions could be added to create the 6-node, mixed-architecture cluster, shown in Figure 2. In this configuration, three of the eight available CPUs would run as actual Alpha nodes — one single CPU node (blue) and one dual-CPU multi-processor node (pink). The remaining five CPUs (yellow) would run four instances of CHARON-VAX/AXP *Plus* as four VAX nodes, with the fifth CPU (labeled in the figure as the "Alpha Management CPU") fielding user interrupts and managing disk and network I/O as described in the next section.

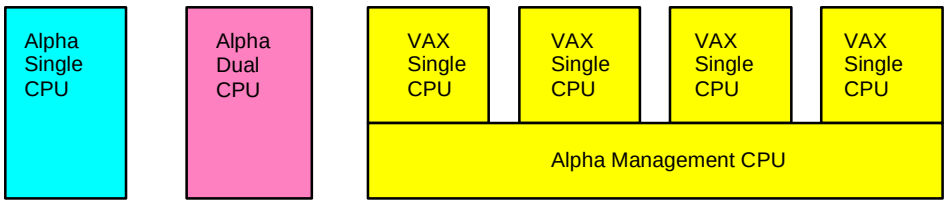

Figure 2 Mixed VAX and Alpha Cluster Example

The CHARON-VAX/AXP *Plus* Benefits for OpenVMS Customers

The new VAX-on-Alpha emulator from Software Resources International takes full advantage of the revolutionary improvements of HP's EV7-based AlphaServer systems. Software Resources International specializes in migrating operating systems and applications to modern platforms (for example, migrating OpenVMS Alpha systems to OpenVMS I64 systems based on the Intel Itanium architecture) and developing hardware emulators for PDP and VAX processors. The emulators are mathematical models of the hardware architecture; written in C, they run as ordinary applications on modern platforms.

Figure 3 illustrates how the Software Resources International CHARON-VAX/AXP *Plus* emulator running on an OpenVMS Alpha system replaces the OpenVMS VAX hardware, providing the same operating system functionality and application support. The OpenVMS VAX software, layered software, and user applications are installed onto the CHARON-VAX/AXP *Plus* emulator which is running on the AlphaServer, which in turn is running its own copy of OpenVMS. With CHARON-VAX/AXP *Plus*, no conversion of code is needed. Simply use BACKUP/IMAGE to transfer existing OpenVMS system and application binaries to the CHARON-VAX/AXP emulator running on the OpenVMS Alpha system, as if you were simply moving from one VAX model to another.

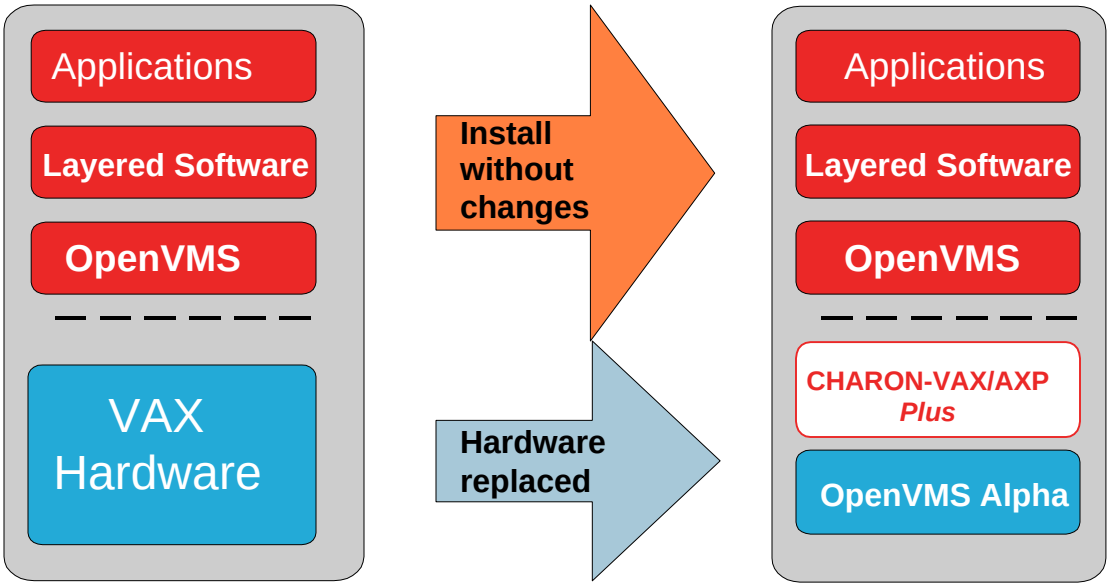

Figure 3 CHARON-VAX/AXP *Plus* on an HP AlphaServer Easily Replaces VAX Hardware

The software architecture of the CHARON-VAX/AXP *Plus* emulator consists of two threads — one thread to execute the emulator and a second thread to field interrupts, run the scheduler, manage resources, handle I/O to storage devices, and manage network I/O. While you can run both threads on the same processor, for optimum performance the emulator thread should have 100% of a CPU available to it. The second thread, automatically assigned to a separate CPU when one is available, requires a fraction of the compute power available to it.

CHARON-VAX/AXP *Plus* is the second-generation of Software Resources International's VAX hardware emulator for Alpha. The first emulator modeled a MicroVAX 3600. The new emulator provides the functionality of a VAX 3100 Model 98 hardware system, complete with up to 512 MB memory, dual SCSI storage buses, and a 10/100 Mbps Ethernet network.

Combined with the scalability and reliability of the ES47, ES80, and GS1280 AlphaServer products, the sophisticated instruction preprocessing now provided by the CHARON-VAX/AXP *Plus* emulator has significantly increased the viability of preserving business-critical VAX applications by means of VAX emulation. As a result, one or many low to mid-range MicroVAX processors can be replaced by entry-level ES47s. Testing has now shown that the CHARON-VAX/AXP *Plus* emulator running on an *n-way* GS1280 can replace one or more high-end VAX processors, such as VAX 77*xx*'s or VAX 78xx's.

Significant Results: Proven Performance Worth Emulating

Specifically, the testing conducted by Resilient Systems at HP's Littleton, Massachusetts laboratory proved that a 16-way GS1280 running CHARON-VAX/AXP *Plus* delivers the equivalent of a VAX 3198 or VAX 7610 (over 36 VAX units of performance (VUPs)) on each CPU of the AlphaServer system.

Even more impressive, the remarkably efficient CHARON-VAX kernel (0.5 MB) achieved the same scalability as the underlying GS1280 hardware when running multiple instances of CHARON-VAX/AXP *Plus*. As the graph shows in Figure 4, the compute power (measured in VUPs) obtained by running multiple instances of the VAX emulator scaled nearly linearly. In other words, each additional emulator instance adds nearly the same amount of compute power to the cumulative

stacked bar graph even though the instances are all competing for resources from the same Alpha management CPU.

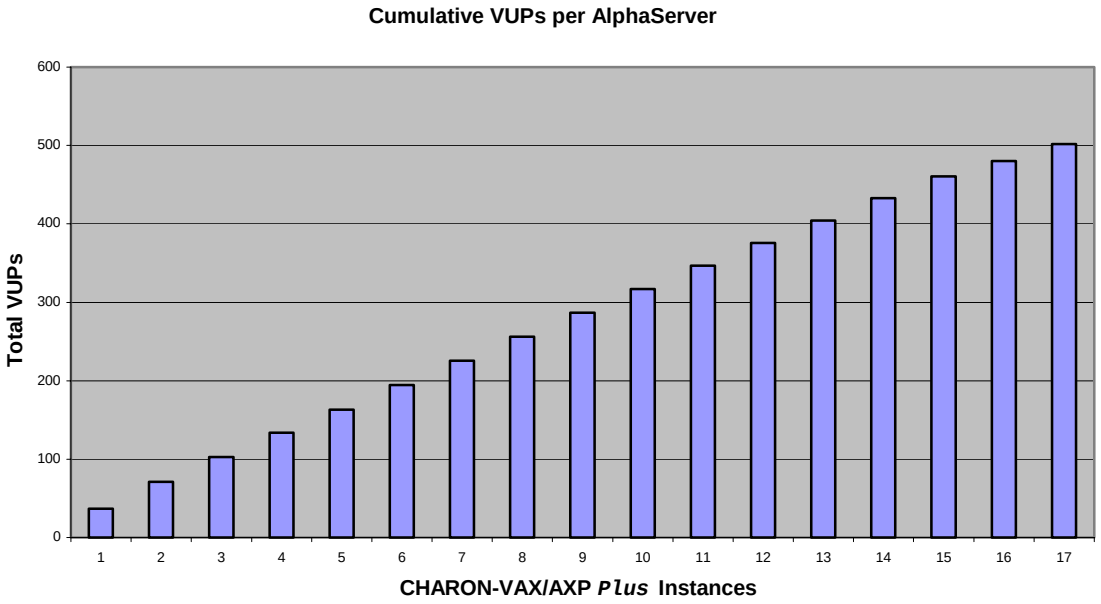

Figure 4 Compute Power of Multiple Instances of CHARON-VAX/AXP *Plus* Scales Nearly Linearly

The remarkable synergy between the hardware architecture of the HP GS1280 AlphaServer and the software architecture of CHARON-VAX/AXP *Plus* produced an optimum configuration of 15 instances of the emulator on a 16-way AlphaServer, with the 16th CPU managing resources for the other 15.

Specifically, tests proved each instance of CHARON-VAX/AXP *Plus* delivers an average of 32 VUPs on an AlphaServer with 16 CPUs, each CPU independently running an instance of the emulator. As the graph demonstrates in Figure 5, performance remained above 30 VUPs per CPU except when the number of CHARON-VAX executables exceeded the physical number of CPUs.

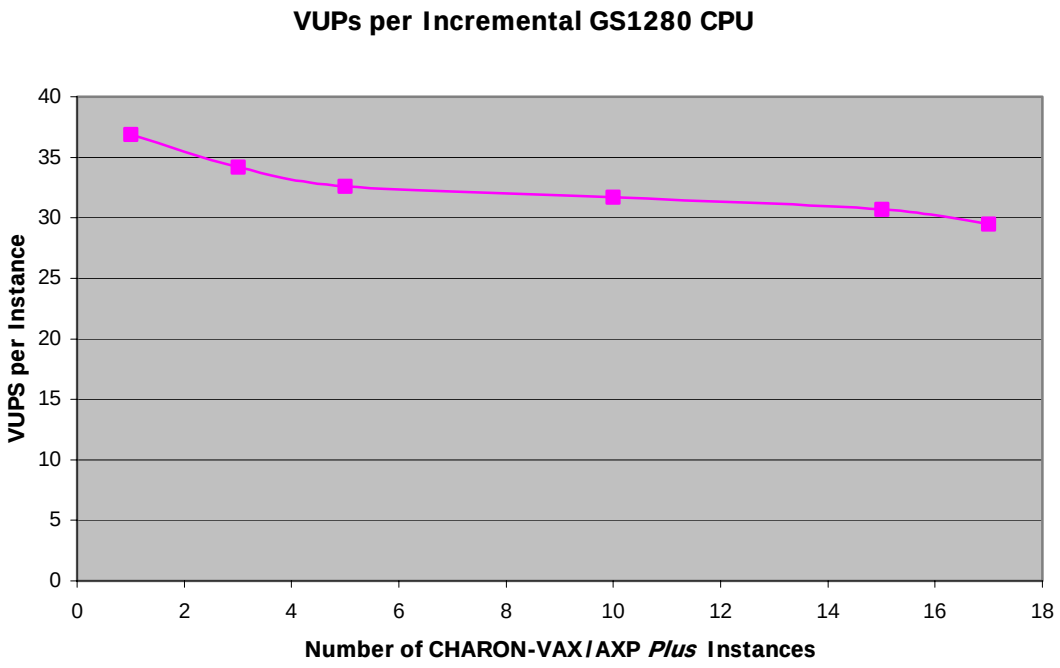

Figure 5 Incremental VUPs per Instance of the CHARON-VAX/AXP *Plus* Emulator

The Practical Benefits of Consolidated Power

The results of these tests clearly indicate that multiple individual VAX servers or VAXstations could easily be consolidated on the same GS1280 AlphaServer host. Server consolidation offers many benefits to VAX sites with multiple systems, including reduced footprint and power consumption, and greatly reduced hardware maintenance costs. In addition, the superb reliability and MTBF of the GS1280 AlphaServer reduces staffing requirements and dependence on increasingly scarce VAX/VMS system engineers, while also reducing the risk of business disruption due to malfunction of aging hardware.

Similarly, single platform clusters can now be created — an entire cluster of existing VAX processors could be recreated as multiple cluster members of the same cluster, all residing and managed on a single GS1280 host.

Alternatively, the configuration could be aggregated and then spread over redundant GS1280 systems to attain the highest possible availability through the independence of separate hardware systems. The benefits would include all the benefits of server consolidation described above, plus the failover capability inherent in OpenVMS Clusters.

Note that in either scenario — server consolidation or single platform clusters — you must carefully calculate your VUP performance needs to ensure that the number of CHARON-VAX/AXP *Plus* instances on the GS1280 stays within the recommended limits. The chart in Figure 6 illustrates the cumulative capacity (in VUPs) of the various AlphaServer platforms, with the maximum capacity being provided by the GS1280 (16 instances producing approximately 460 VUPs).

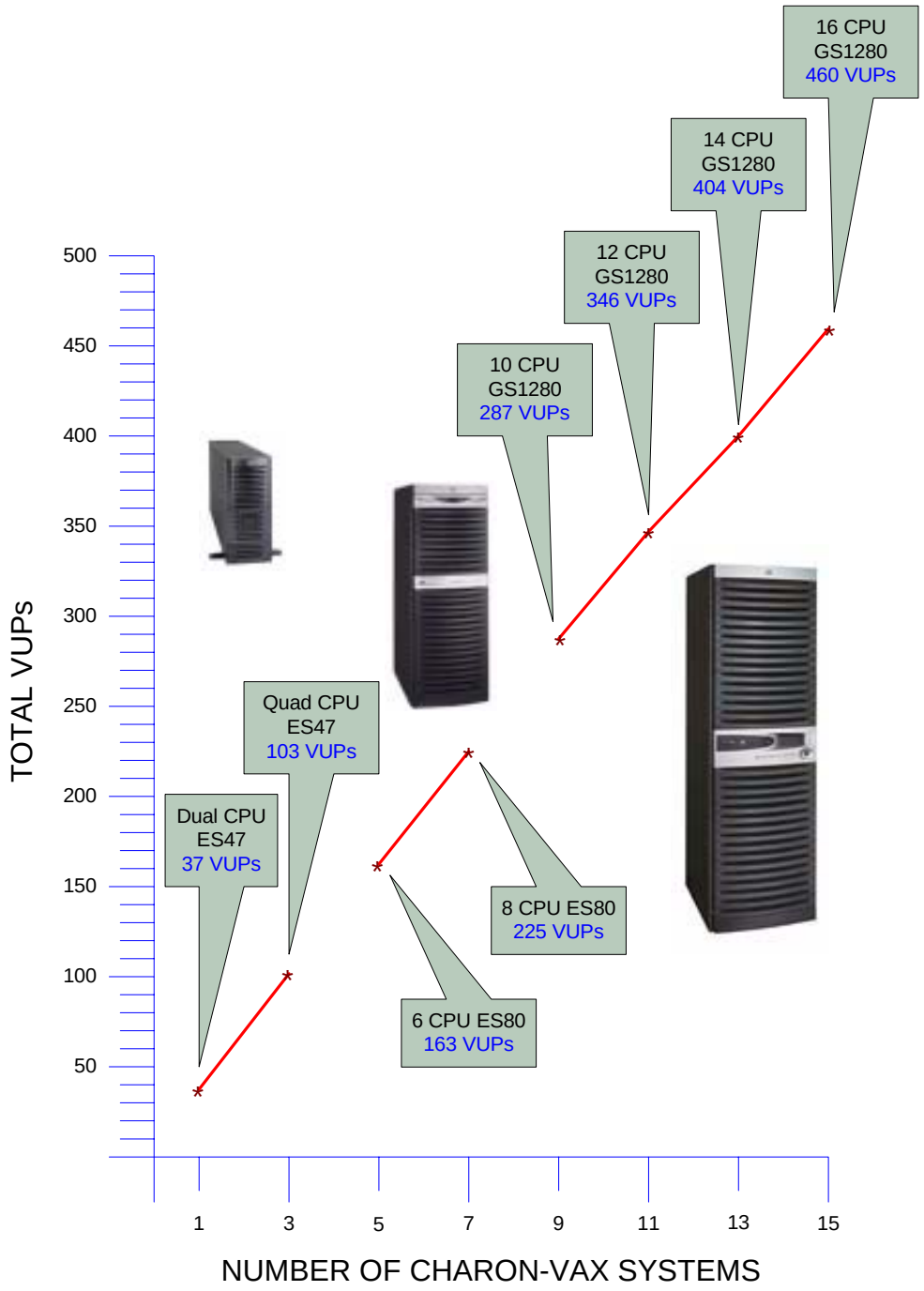

Figure 6 Cumulative Capacity of Various AlphaServer Platforms Running Multiple Instances of CHARON-VAX/AXP *Plus*

CHARON-VAX/AXP Emulator I/O Capacity Keeps Pace with Hardware

As more evidence of the synergy between the GS1280 hardware and the CHARON-VAX/AXP *Plus* software, tests show that the bandwidth available to the emulator is nearly identical to what is physically attached to the AlphaServer host. Repeated testing showed that native Alpha disk transfers achieved 4.47 MB/sec when accessing a local SCSI disk versus 4.45 MB/sec for the CHARON-VAX/AXP *Plus* emulator when accessing the same physical disk. In other words, emulator

overhead is less than 1% for tasks such as disk-to-disk file copy operations or OpenVMS backup transfers.

The tests prove that customers are now able to assimilate high performance storage subsystems, such as Fibre Channel, into a legacy OpenVMS VAX configuration. The CHARON-VAX/AXP *Plus* software increases storage capacity by transforming VAX physical disks into disk image files on the replacement platform. Now, with the HP AlphaServer's support for robust storage technologies, the CHARON-VAX/AXP *Plus* software enables critical VAX applications to take advantage of both storage and I/O throughput capacities that were unimaginable in the heyday of the VAX processor.

The integrated Ethernet adaptor emulator provided with the CHARON-VAX/AXP *Plus* product is pivotal to integrating an instance of the emulator with other DECnet nodes and cluster members, or by means of IP, with corporate LANs and WANs. This channel also provides user connectivity through Telnet and third-party terminal emulators. Thus, it is a key component of a VAX replacement configuration. When the adaptor emulators were set in tests to match the 10baseT adapter of a VAX system, Resilient Systems observed data rates through the network device at over 1.8MB/sec for sustained data transfer, and near the full 10MB/sec possible for message transfer. You can use 100 Mbps Ethernet adapters with the current version of CHARON-VAX/AXP *Plus*, but these were not tested. Operation at 100 Mbps requires an Alpha SMP host with a CPU frequency of at least 1 GHz. Network throughput can be tuned individually for specific protocol classes (for example, DECnet, TCP/IP, or OpenVMS Cluster communication).

Summary

The combination of HP's AlphaServers and Software Resources International's CHARON-VAX/AXP *Plus* software opens the way for many OpenVMS VAX owners to achieve the performance and reliability experienced using modern-day server hardware platforms. OpenVMS VAX owners can now consolidate servers and clusters to preserve critical OpenVMS VAX applications and maximize performance and reliability while minimizing the space required for hardware.

For more information about Resilient Systems, Inc., go to http://www.resilientsys.com.