

Evolving your HP-UX 11i Environment from HP 9000 to HP Integrity



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Executive summary

Why consider a transition from HP 9000 to HP Integrity?

There are several factors that might prompt you to consider moving your IT infrastructure to HP Integrity:

- Is greater performance needed in the IT infrastructure now or in the near future?
- Is the existing lease on equipment up for renewal, or at a transition point?
- Will your current operating systems or ISV application versions no longer be supported?
- Do you need new applications available only on HP Integrity?
- Do you need more system capacity or performance?
- Do you need a higher level of application or database availability?
- Are there new or on-going business projects that are designed to address specific opportunities, such as Cost Reductions, Server or Data Consolidation, Application or Database Integration?
- Are there business mergers, expansions, downsizing programs?
- Is there an interest in taking advantage of newer technical innovations?
- Is there a need to respond to end-of-life plans for applications, operating systems or hardware?

If the answer is YES to any of these, a platform transition plan to HP Integrity Servers might be the best next step.

What are some of the advantages to moving to HP Integrity?

- The HP Integrity architecture offers superior performance running HP-UX 11i v2. If you have a long-term investment in HP-UX 11i expertise, you have the opportunity to transition to a new platform that will have sustained, improving performance for years in the future. In addition to superior hardware and operating system performance, the HP Integrity architecture and new compiler technology results in superior application performance, and provides long-term reduced TCO by reducing software licensing costs, hardware implementation costs, and infrastructure support costs. This results in the need for less hardware to run almost any application.
- The availability of a large number of native applications means that enterprises with performance-dependent applications can make their move to HP Integrity now rather than waiting.
- The flexibility of HP Integrity servers to run multiple operating systems simultaneously and to be flexibly partitioned and re-provisioned provides a foundation for building an Adaptive Enterprise.

No matter what the motivation for moving off an existing IT infrastructure, it is important to consider the choices available.

Questions about Transitioning

There are many questions that may come up as you consider the transition from HP 9000 to HP Integrity. This paper helps answer a number of those, and provides additional resources or links to answer the more detailed ones

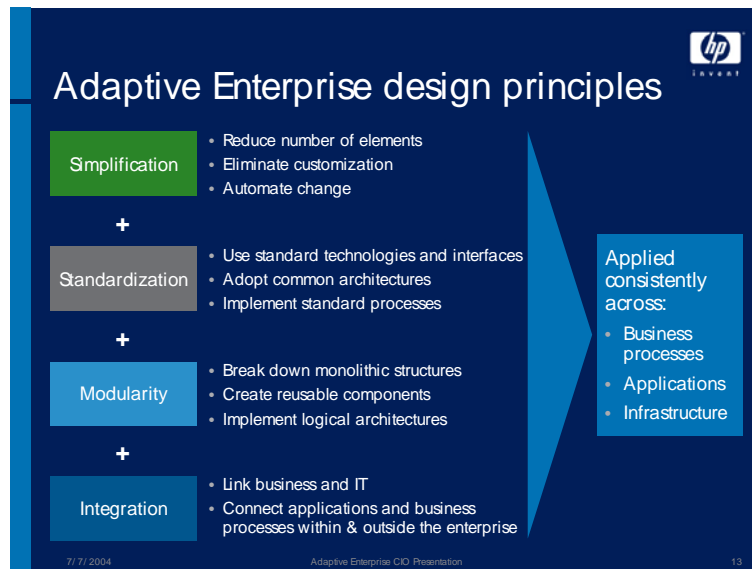
Companies considering the transition often raise two issues. First, for those who are running their IT environments on older versions of HP-UX and HP 9000 servers, there is interest in discussing the upgrade path that needs to be taken to reach HP-UX 11i v2 on HP Integrity. Second, there is interest in binary compatibility for applications that run on older versions of HP-UX, and need to be moved to HP-UX 11i v2 on HP Integrity. This paper will show that HP has worked hard to maintain binary compatibility between the HP-UX 11i on HP 9000 and HP-UX 11i v2 on HP Integrity architectures, and that neither Sun nor IBM can claim that they

have maintained binary compatibility or have worked as hard to maintain it. In fact, moving between successive generations of Sun and IBM operating system and server generations can be treacherous.

How the HP Integrity architecture enables an Adaptive Enterprise

HP Integrity and the Adaptive Enterprise design principles

The basic premise of the Adaptive Enterprise is that it creates an environment where Business and IT are synchronized to capitalize on change. Business change can come as the result of a number of different factors – from new laws (like Sarbanes Oxley or Basel II) to interest rates changes, or the opening of a new market. The point is that winning companies are those with IT infrastructures that react to that change quickly. An Adaptive Enterprise is not one purchased outright, but rather architected and constructed using Adaptive Enterprise design principles. Why are HP Integrity servers excellent building blocks for the Adaptive Enterprise? Because HP Integrity systems incorporate every one of the design principles listed in the following figure.



Simplification – HP Integrity reduces the number of hardware elements required in an enterprise IT environment, by allowing the same architecture to be implemented from 1-way blade systems up to 128-way Superdome servers. With up to four operating systems (Linux®, Windows®, HP-UX 11i, and OpenVMS at the end of 2004), simplification at the hardware level eliminates the need to have heterogeneous platforms or multi-vendor topologies. This results in lower operating costs.

Standardization – HP Integrity servers take advantage of the benefits of Industry Standard Computing, leveraging huge architecture hardware development costs that are spread across the entire computing industry. Standardization has a twofold advantage. Not only does it reduce hardware acquisition and support costs, but it will also result in long-term lower software license and support costs, as software vendors focus their efforts on widely available, standard platforms such as those running Itanium® processors.

Modularity – HP Integrity servers are able to use multiple operating environments, and can be implemented equally in scale-out and scale-up implementations. With enterprise-level UNIX® operating environments such as HP-UX 11i (and by the end of 2004, OpenVMS), tools allow the management of workloads modularly using nPars, HP-UX Workload Manager, and

Processor Resource Manager. This flexibility allows processor resources to be re-provisioned for specific, targeted workloads or brought on to address urgent needs.

Integration – The ability to link business and IT through Integration is significantly enhanced by HP Integrity – a consistent, standards-driven platform that runs industry standard operating systems. There is no need to have expensive, specialized knowledge and capabilities to use HP Integrity. When an IT infrastructure uses HP Integrity as its foundation; integration efforts can be focused on synchronizing business and IT, not on running the infrastructure itself. The key advantage of applying the design principles consistently is that once done, business processes can be consistently and logically implemented using one set of rules and guidelines, without the need to conform to incompatible hardware, operating system, and software restrictions.

HP Integrity: The industry standard server

Industry-standard architectures provide a consistent enterprise-wide approach for deploying IT at the lowest possible cost. For HP, this lower cost is achieved by helping design the Intel Itanium2 processor, then implementing on this processor architecture. HP is able to take advantage of the world-class processor development capability of Intel, and to amortize the cost of the design and manufacture of the processor across the industry.

For an enterprise, reducing IT environment diversity drives down the cost of implementing change. ISVs are able to hold down licensing and support costs, as fewer application versions need to be validated and supported. Industry standards enable different parts of an IT infrastructure to work together more closely, improving integration.. An industry-standard HP Integrity server runs three industry-standard operating systems – Windows, Linux, and HP-UX.

Different parts of an organization can use the same applications and components in an IT infrastructure to work together consistently. Within an enterprise, standards drive efficiencies and economies of scale, lowering the cost of computing when compared to proprietary offerings and enabling business process and logic to be the focus – not supporting and upgrading the IT infrastructure.

The transition to HP Integrity: Factors to consider

Superior performance of HP Integrity servers

Comparing other architectures to HP Integrity reveals that processor and system-level performance (as measured by system bus bandwidth, memory bus system speed/width, total I/O bandwidth, and SPECwebSSL) is clearly superior with HP Integrity servers. HP Integrity superiority is also based upon processor-level benchmark performance, as measured by SPECint2000, SPECfp2000, SPECintRATEbase, and SPECfpRATEbase when compared to similar platforms from Sun, IBM, and Fujitsu. If you are looking to upgrade your environment and implement a 1- to 128-way HP-UX 11i system, HP Integrity servers have superior performance and headroom over PA-8700-based and PA-8000-based systems. In addition, HP continues to invest in HP-UX 11i compilers on HP Integrity-based systems, improving application performance by more than 10% per year beyond 2004.

In addition to the performance improvement, the advantages brought by HP Integrity servers and Industry Standard computing are demonstrated by a dramatic reduction in transaction cost when moving from the HP 9000 to HP Integrity. As shown in the table below, when TPC-C is measured on equivalent platforms, the cost savings when moving from an HP 9000 Superdome to the HP Integrity version is significant; there is an immediate cost savings of 29% per transaction, from \$11.66 per tpmC to \$8.33 per tpmC.

| System | tpmC | Price/tpmC | Databas e | Operatin g system | TP monitor | Date submitted |
|--------------------------------------|-----------|-------------|---|-------------------------------|----------------|----------------|
| HP 9000 Superdom e Enterprise Server | 541,673 | 11.66 US \$ | Oracle Databas e 10g Enterprise Edition | HP UX 11.i v1, 64-bit Base OS | BEA Tuxedo 8.0 | 07/30/03 |
| HP Integrity Superdom e | 1,008,144 | 8.33 US \$ | Oracle Databas e 10g Enterprise Edition | HP UX 11i v2 64-Bit Base OS | BEA Tuxedo 8.0 | 11/04/03 |

HP-UX 11i considerations

The first thing an enterprise should do is take a look at the versions of HP-UX that are currently being used within the organization, and decide what the best upgrade strategy will be for both their HP 9000 and HP-UX operating environments. Moving to HP Integrity can be extremely easy in many situations—a matter of purchasing the hardware, the new release of the operating environment, a new application version, then re-attaching the data storage devices. However, in some cases, especially when operating on older versions of HP-UX, more planning is required. The following tables highlight some of the consideration points for an operating environment when moving to HP Integrity.

| Current HP 9000 operating environment version | Possible upgrade choices | Notes |
|---|---|---|
| HP-UX 10.20 | If you want to stay on HP 9000 platform, move to HP-UX 11i v1. If purchasing new, consider HP-UX 11i v2 either on HP Integrity or on HP 9000. | Can upgrade directly to HP-UX 11i v1 from version 10.20. Some very old hardware systems may need to be replaced due to new resource requirements. Check HP's hardware and software trade-in and upgrade incentive programs. |
| HP-UX 11.0 | If you want to stay on HP 9000 platform, move to HP-UX 11i v1. If purchasing new, consider HP-UX 11i v2 either on HP Integrity or on HP 9000. | A system that currently runs HP-UX 11.0 can also run 11i v1, usually with enhanced performance. Can upgrade directly to HP-UX 11i v1 from version 11.0. If moving to HP-UX 11i v2 on HP 9000, upgrade to HP-UX 11i v1 first, then to version v2. |
| HP-UX 11i v1 | HP-UX 11i v1 is available for purchase through at least 2006, and supported through 2010. | HP-UX 11i v1 supports popular features such as virtualization, including pars. If on v1 currently, consider moving to HP-UX 11i v2 for better performance. You should also consider bringing HP-UX 11i v2 in on new projects or when replacing older systems. |
| New - HP-UX 11i v2 | This new release offers HP-UX 11i v2 on HP 9000 servers. This release offers the same performance and scalability features that HP-UX 11i v2 on HP Integrity offers. It is completely source and data compatible with HP-UX 11i v1 on HP 9000 environments. | |
| HP Integrity operating environment version | Possible upgrade choices | Notes |
| HP-UX 11i v1.5 | Upgrade to HP-UX 11i v2. HP-UX 11i v1.5 was the initial HP-UX version available on HP Integrity servers. No longer supported. | It is unlikely that there are systems running version 1.5 in operational settings. Possible some still being used as pilot systems. |

| HP Integrity operating environment version | Possible upgrade choices | Notes |
|--|---|---|
| HP-UX 11i v1.6 | Upgrade to HP-UX 11i v2. HP-UX 11i v1.6 was the second version to run on HP Integrity servers. Will be supported to Oct 2005. | It is unlikely that there are systems running version 1.6 in operational settings. Possible some still being used as pilot systems. |
| HP-UX 11i v2 | HP-UX 11i v2 offers industry-leading performance, and is source code and data compatible with HP-UX 11i v1 on HP 9000. | |

Planning and implementing the transition to HP Integrity servers

All current HP 9000 servers have in-chassis processor board upgrades to the Itanium processor. In addition, HP will continue to produce HP 9000 servers for a number of years, to enable you to transition to HP Integrity servers at the time that's right for your business.

After understanding the starting point of the transition from a hardware and operating system perspective, it is important to take inventory and examine the existing operating software stack environment. This can be done with the assistance of HP, a partner, or by the IT department. The process will vary, depending on the makeup of the software stack to be transitioned to HP Integrity.

For an enterprise that has been running a HP 9000 based environment for a long period of time, it will be important to have a robust planning process in conjunction with HP or a key IT partner to make the transition successful. The objective of the enterprise is to move to HP Integrity to take advantage of the performance gains that can be made. The following are some typical transition questions:

- Are the necessary applications available and what performance should I expect to see?
- What performance should I expect to see?
- What resources and tools are available from HP to help me?
- What will I have to do, and how much effort will be required to move to HP Integrity?

The best place to start when evaluating the transition to HP Integrity is the Business systems evolution website available at:

<http://www.hp.com/products1/evolution/9000>

The website provides an excellent array of tools, guidance, and services to assist in providing information on the latest available applications and partners available on HP Integrity servers, answering part of the question above regarding the availability of necessary applications. Additional areas for your consideration that can be found there include:

- HP/Intel Solution Centers, run by HP and Intel, to assist with testing and migration
- Information on the latest ISV applications available, and system integrators who are familiar with HP Integrity
- Transition engineering services, offering you guidance and direction
- Software engineering services, offering experienced HP resources
- HP support services
- HP education, offering many levels of training
- Tools available in the HP-UX Software Transition Kit (STK)
- Success stories and testimonials

Another place to go for more in-depth technical information is the STK website found at:

<http://www.hp.com/go/STK>

In many cases, it can also help to discuss all the aspects of an existing IT infrastructure with a group of HP experts before starting to plan your transition. To help out with this, HP has set up a Transition Engineering Team, a team of HP Integrity experts who can meet with your IT staff in a one to three day workshop (called a Transition Consulting Workshop) to discuss the transition.

A Transition Consulting Workshop is a working interactive discussion with your IT team. It takes place at your offices and usually lasts one to three hours. The objective is to address and understand your business and IT strategic plans and the key HP products, technologies and services that impact your specific IT environment. HP provides a facilitator, HP business, industry, product and transition consultants, and the appropriate account team members. Quite often, this discussion leads to a more detailed one- to three-day Transition Workshop event. This is a more technically focused technical transition engagement that deals with the more detailed requirements of a specific platform transition. This requires an appropriate investment by the customer and HP to achieve the mutually defined goals and objectives for the engagement. Both the Account Consulting Session and the Transition Workshop programs are developed and delivered by HP's Business Critical Server Product Group, and can be accessed through your HP account representative or authorized HP distributor/partner.



- Seminars, User's Groups, Advisory Councils
- Account Consulting Session
- Papers
- Web portals and web-based training

- BCS Transition Workshop
- Planning Tools
- Planning Methods
- Software Transition Kit (STK)
- Porting Guides
- Training

- BCS Transition Workshop
- Transition Assessments
- Transition Tools
- Best Practices White Papers
- Design Engagements

- Transition Services
- Self-Service tools
- Tuning Guides
- References/ Success Stories

- Performance Monitoring Tools
- Ongoing relationship
- Training
- Identify next opportunity

The Transition Engineering team can be engaged through your HP account sales team, and can provide your IT organization valuable advice. HP has helped numerous customers through the transition to HP Integrity from HP 9000 already, and can share many of these experiences. The results of the discussions that occur can be used by your enterprise team directly, or as input for other HP services teams. At the conclusion of the planning session where the discussions take place, the key individuals will have an excellent concept of the impact of the transition, and of bringing HP Integrity into your IT environment.

Additional information about HP planning services can be found at:

<http://www.hp.com/products1/itanium/services/index.html>

It also may make sense for you to use the HP and Intel Accelerator Program in conjunction with the HP/Intel Solution Center for your transition to the HP Integrity architecture. This program is designed to accelerate your deployment of Itanium 2-based solutions for your enterprise.

The types of questions the Transition Engineering Team can help answer are:

- We want to move to HP-UX 11i v2 on HP Integrity, but have older applications and tools that we've developed ourselves that work fine and we don't want to rewrite. In fact, we've lost some of the old source code. We just want the application to operate – we don't care as much about performance. Can we still move to HP Integrity today?
- Can I move a complex software stack running natively on HP 9000 directly over to HP Integrity?
- We're ready to purchase new systems and upgrade our environment, and are considering HP Integrity as a target platform. However, we've talked to our ISVs, and a

few of the applications are not going to be available on HP Integrity until the end of the year. Should we wait until then, move to HP Integrity now, or look at other vendors?

- HP's competitors say that moving from HP 9000 based systems to HP Integrity is just as difficult as moving to any new architecture. What are the facts?

Example HP-UX upgrade situation case with the Transition Engineering Team

Situation

Customer environment is currently running 600 HP 9000 systems running HP-UX 10.20. There is a mix of older and newer HP 9000 systems. The software environment is a combination of older third party applications, databases, and C-development tools.

Objective

Upgrade HP-UX 11i versions and ultimately upgrade to an HP Integrity server environment over time.

Recommendations

Upgrade the HP 9000 system environment first from HP-UX 10.20 to HP-UX 11i v1.

- Applications are binary compatible between HP-UX 10.20 and HP-UX 11i v1.
- If using ANSI C compilers, software developed on HP-UX 10.20 is binary compatible with HP-UX 11i v1.

Most applications should be supported on HP-UX 11i v1, and for the 10.20 customer, this is the first step that needs to be taken. Some applications may be old enough that they are no longer supported by the vendor or are incompatible with other ISV applications. HP can help identify these dependencies. These will require an application version upgrade.

Some of the customer's applications may require new or different tuning parameters on HP-UX 11i v1. And some older HP-9000 servers may not support HP-UX 11i v1. These systems will then require firmware upgrades before moving to HP-UX 11i v1. Use HP's HP-UX compatibility matrices for this background information (HP's STK website, at <http://fchpdrvig.fc.hp.com/drc/STK/index.jsp>).

Perform an audit of systems, applications, and application version levels to determine which systems and applications can be directly upgraded to HP-UX 11i v1. This will help to identify situations that will require additional work before an upgrade can take place.

For the upgrade to HP Integrity, moving from HP-UX 11i v1 to HP-UX 11i v2 is a well-understood process, and it may be an excellent opportunity to consider conducting server and application consolidation projects simultaneously. With potential 10x performance gains when moving from an HP-UX 10.20-based environment to an HP-UX 11i v2-based environment, reducing the server count to 100 or less from 600 is a real possibility. The reduction in hardware and operating system support costs may financially justify the whole migration project.

The HP Intel Solution Centers

These centers, run by HP and Intel together, are another source of resources available to assist you with proof-of-concept services as well as performance tuning, migration, benchmarking, and capacity planning. Centers are in Cupertino, California (co-located with the Capacity Planning Center), Grenoble, France, and Shanghai, China. Each offers a complete Itanium 2-based platform data center environment with the latest in server, storage, and networking technologies across HP-UX 11i, Linux, and Windows operating systems. For detailed datasheets, solution blueprints, and white papers describing their capabilities, visit the website at:

<http://www.hpintelco.net/>

You may find that working with the HP Software Services Program Office (SSPO) and using input from previous planning sessions will make the most sense. The SSPO helps you with all aspects of software transition planning by offering expert engineering services for the migration to HP Integrity servers.

Taking a step-by-step approach with HP Services

To address the challenges and help reduce risk during the transition, HP Services professionals offer project-based porting and migration services with a fixed price, scope, and timeframe—backed by the ability to rapidly mobilize resources for on-site service delivery. The HP Services engagement can be done as a follow-on to HP's Transition Engineering Team customer session discussed earlier. HP's proven approach hinges on two key services:

- Application survey—To gain a clear understanding of your current application environment, architecture, and functionality, HP submits a questionnaire to your organization that's designed to help HP get a comprehensive view of the current situation. The completed survey provides the basis for determining the desired future state and the alternative paths to be explored.
- Porting and migration assessment—The experts at HP Services then provide a detailed assessment of your business applications, databases, data, and platforms. The information gathered is then shared through one or more workshops where you can take a closer look at business drivers and the impact of change. The outcome includes specifics on migration strategies, applications to be ported, an application integration plan, resources needed, gap analysis, and systematic deliverables.

Customer transition experiences

The following quotes are from enterprise executives who have successfully moved their environments to HP Integrity.

"Across Airbus, we're running over 10,000 applications on the HP Integrity server solution. These were transferred seamlessly from the old PA-RISC architecture to the new HP Integrity server solution. We're using the Integrity solution from HP to perform these simulations. And what we're finding with the Integrity solution is that it's effectively an off-the-shelf solution. So, the total cost of ownership comes down. Basically, that means we can do more for less."

Martin Allen
IS National Coordinator
Airbus UK

"In an effort to maximize business continuity and reliability in support of our expanding business, the Internet Services Group at Cogeco migrated from a HP 9000 system to HP Integrity servers by conducting an inbox upgrade with the latest HP Itanium processors. The Integrity servers deliver optimal performance at a competitive price point so we can produce stellar results on our web and customer front-end applications. Today, our data center has 15 HP rx5670 Itanium-based servers that support the complete user base."

Chris MacFarlane
Vice president engineering
Cogeco Cable Canada Inc.

Architecture and performance

Large on-chip cache and lots of registers

HP Integrity servers are built with Intel Itanium 2 processors, which have the largest on-chip cache of any merchant processor available in the market today. The Itanium processor gives a large performance advantage in many implementations. It allows applications with large instruction or data blocks to take advantage of fewer cache misses, which results in much lower memory latency. The Itanium processor contains on-board L1, L2, and 6 MB of L3 cache. Future iterations of the Itanium processor are expected to have even more on-chip memory. Small on-chip caches (L1) backed by slower off-chip (L2 or L3) caches may perform adequately for small benchmarks and applications. But when faced with demanding applications such as data warehousing, online transaction processing (OLTP), or technical computing, designs with off-chip caches result in poor performance. That is one of the key reasons that larger caches were built into the Itanium processor.

The advantage that large on-chip caches bring to application performance is that when a processor is executing instructions or looking for data, it will first go to the closest location—in the L1 cache. If it does not find the instruction or data, it's looking for there (a cache miss) it goes to the next level of cache—L2. This keeps occurring until the processor goes to L3 cache (if it exists), to RAM, and eventually to the disk drive looking for instructions or data. The problem is there is always a clock cycle delay during a cache miss, and that impacts performance. If the program goes to the L1 cache, it's a one-clock-cycle delay; if it needs to go to L2 cache, it is five cycles or more for Itanium processors, 15 cycles or more for SPARC processors, and so on. By the time the processor needs to go out to disk to find an instruction or some data, the delay may be hundreds or thousands of clock cycles. This can significantly impact application performance. Applications can be written to take advantage of larger caches, which is what HP anticipates will happen now that the Itanium architecture is moving into full commercial adoption.

The concept of large on-chip or on-board caches near the processor is carried even further with the recently announced mx-2 dual-Itanium processor module. The mx2 fits 2 processors and a 32MB L4 cache onto a daughter board that is pin-compatible with the current Itanium2 processors. This allows HP to double the number of processors in a given server; up to 128 CPUs in a HP Superdome server.

Another feature of the Itanium architecture is the massive number of registers. This is directly reflected in the floating point and integer performance of Itanium processors. The large number of registers enables greater parallelism used in the Itanium processor when executing instructions. Itanium processors have a high number of issue ports, a large number of execution units, a high-sustained instruction issue rate, and a short instruction pipeline length. All of these features are related to the greater parallelism built into the HP Integrity server family. This use of parallelism for performance gain reinforces the need for a strong family of compilers, backed up by an equally strong compiler development roadmap. Compiler development and maturity play a much bigger role with HP Integrity architecture than with other architectures, since compilers have a greater impact on application performance with Itanium.

Competitive performance comparisons

When comparing benchmark performance levels with competitors, one can see in the table below that HP Integrity systems running Intel Itanium2 processors show superior capability. Clock speed, then, becomes less a measure of chip performance when instructional parallelism, maturing compilers, and large on-chip caches are part of the processor design. The kind of performance superiority noted translates into lower software licensing costs, fewer hardware systems that need to be deployed, and lower overall infrastructure costs.

| | | | | | | | | | |
|------------------------------------|---|---|---|---------------------------------|------------------------------|------------------------------|--|------------------------------|------------------------------|
| Processor type | HP mx2 Processor Modules (dual core Itanium 2) | Itanium 2 6M | PA-8800 (dual core) | PA-8700 + | Fujitsu SPARC6 4 V | UltraSPARC III Cu | UltraSPARC IV (dual cores) | POWER 4+ | POWER 5 (dual cores) |
| Operating systems | HP-UX, Windows, Linux | HP-UX, Windows, Linux, OpenVM S | HP-UX | HP-UX | Solaris | Solaris | Solaris | AIX 5L | AIX 5L V5.3 |
| Clock speed | 1.1 GHz | 1.5 GHz | 1000 MHz | 875 MHz | 1.35 GHz | 1.2 GHz | 1.2 GHz | 1.7 GHz | 1.9 GHz |
| L1 cache (1+ clock cycle) | 32 KB (per processor) | 32 KB | 2 x 750 KB (inst) 2 x 750 KB (data) | 750 KB (inst) 1500 KB (data) | 128KB (Inst) 128KB (Data) | 32 KB (inst) 64 KB (data) | 32 KB (inst) 64 KB (data) (per processor) | 32 KB (inst) 64 KB (data) | 32 KB (inst) 64 KB (data) |
| L2 cache (5+ clock cycle latency) | 256 KB (per processor) | 256 KB | 32 MB (off-chip, 40+ clock cycle latency) | N/A | 2 MB (on-chip) | 8 MB off chip) | 16 MB off chip (8 MB per processor) | 1.5 MB (shared) | 1.9 MB (shared) |
| L3 cache (12+ clock cycle latency) | 3 MB (on-chip, per processor) | 6 MB (on-chip) | N/A | N/A | 16 MB (off chip) | N/A | N/A | N/A | N/A |
| L4 cache | 32 MB (on board) | | | | | | | | |
| Issue ports | 11 | 11 | 4 | 4 | 8 | 4 | 6 | 8 | 8 |
| Execution units | 11 | 11 | 4 | 4 | 6 | 4 | 6 | 8 | 8 |
| Sustained issue rate | 8 | 8 | 4 | 4 | 8 | 4 | 6 | 5 | 5 |
| Pipeline depth | 8 | 8 | 7 | 7 | 7 | 14 | 14 | 12 | 12 |
| Registers | 264 (128 general purpose, 128 floating point, 72 specific function) per processor | 264 (128 general purpose, 128 floating point, 72 specific function) | 32 | 32 | 96 | 96 | 96 | 73 | 73 |

| Performance | Intel Itanium m2 | Intel Itanium m2 6M | PA-8800 | PA-8700+ | Fujitsu SPARC64 V | UltraSPARC III Cu | UltraSPARC IV | POWER4+ | POWER5 (1.9 MHz) |
|-----------------------------------|------------------|---------------------|---------|----------------|-------------------|-------------------|--------------------------|---------|------------------|
| SPECint2000 (Base) | | 1500 | -- | 642 | ~776 | 632 | 1.14-1.6x UltraSPARC III | 1077 | -- |
| SPECfp2000 (Base) | 1427 | 2161 | ++ | 464 | ~1096 | 854 (1.28 GHz) | not yet tested | 1642 | 2576 |
| SpecINRateBase (best 4way result) | - | 63.4 | 35.5 | 24.3 (750 MHz) | 34.5 (1320 MHz) | 25.0 (1050 MHz) | not yet tested | 48.4 | 74.4 |
| SpecFPRateBase (best 4way result) | - | 66.4 | 32.0 | 18.4 (750 MHz) | 42.7 (1320 MHz) | 37.5 (1200 MHz) | not yet tested | 66.6 | 125 |

The SPECint2000 and SPECfp2000 benchmarks can be found at www.spec.org and represent integer and floating-point processor performance. SpecINRateBase and SpecFPRateBase are throughput measurements for integer and floating-point applications (www.spec.org/cpu2000/).

The benchmarks by IBM were run with 1 of 2 processors in a dual-core POWER4+ package. The dual-core package contains 1.5 MB of on-chip cache that is usually shared between the two processors. This benchmark reflects the corner case of having only one active processor using all of the shared memory. This would not typically be the case when handling actual workloads. Real commercial application performance is likely to be lower than HP Integrity architecture performance.

Taking advantage of the HP Integrity architecture

In traditional RISC architectures, the processor is often underutilized because of the compiler's limited ability to organize instructions. Branches (instructions that change the flow of execution within the program) and memory latency (the time for data to arrive from memory) compound the already limited ability of today's processors to achieve parallel execution.

To overcome the limitations of the RISC processor design, Intel and Hewlett-Packard jointly defined a new architecture technology called EPIC (Explicitly Parallel Instruction Computing), named for the ability of the software to extract maximum parallelism in the original code and "explicitly" describe it to the hardware.

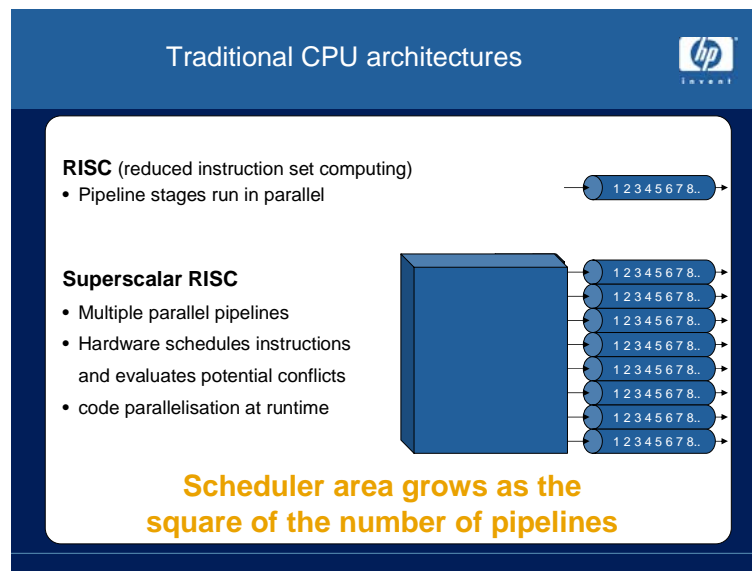
The complexity of the situation can be remedied by moving the task of uncovering and exploiting potential parallelism from the chip to the compiler, where much of the task can be done at compile time. Importantly, it also requires a mechanism to allow the compiler to communicate the parallelism of the code to the chip — a mechanism which has not been feasible with RISC designs. This is a key feature of the Explicitly Parallel Instruction Computing or EPIC technology that forms the basis for Itanium.

Three architectural features that are most relevant to application performance improvement on HP Integrity are *predication*, *speculation*, and explicit *parallelism*.

- **Predication** is the conditional execution of an instruction based on the setting of a Boolean (true or false) value contained in a predicate register. Without predication,

parallelism would be impossible. Instead of waiting for each section of a complex calculation to finish, it is faster if the processor can predict the outcome and proceed on the basis of that prediction. These prediction points are at branches and current processors try to guess which branch to take. If it predicts right, the whole calculation is validated. If it predicts wrong, the string has to be thrown out and the calculation starts over. The HP Integrity architecture provides 64 predicate registers that can be used to control the execution of nearly all instructions. Explicit parallelism allows the compiler to communicate dependence information to the hardware.

- **Speculation** – Speculation is the execution of an instruction or dependent instruction stream before it would normally be executed in the program order specified by the application developer. Memory latency, the time to retrieve data from memory, is another performance limitation for traditional processor architectures. Memory latency stalls a processor, leaving it idle until the data arrives from memory. Because memory latency is not keeping up with processor speed, loads (the retrieval of data from memory) need to be initiated earlier to ensure that data arrives in time for its use. The new 64-bit architecture uses speculation, a method of allowing the compiler to initiate a load earlier- even before it is known to be needed.
- **Parallelism** – In the past, traditional RISC microprocessor architectures have been implemented with attributes that limit performance. To achieve higher performance, processors would not only have to execute instructions faster, but also execute more instructions per cycle, referred to as "parallel execution". Greater parallel execution allowed more information to be processed concurrently - thereby increasing overall processor performance.



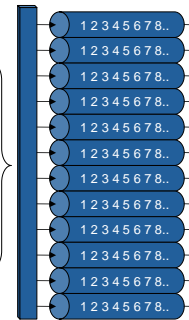
One of the key objectives for the new instruction set architecture was to enable a wide range of implementations to balance different performance and cost requirements. As the Itanium architecture evolves, additional execution units (part of the processor that performs calculations) and other processor resources can be added to increase the width of the machine (number of instructions executing simultaneously) and thereby increase performance.

EPIC**(Explicit Parallel Instruction Computing)**

- Compiler schedules instructions and guarantees independence
- very large number of parallel pipelines possible
- code parallelisation at compiling

EPIC
compiled
source
code

.....
.....
...



HP 9000 to HP Integrity binary compatibility

Using Aries and the HP-UX 11i Software Transition Kit

The process for transitioning HP-UX applications from HP 9000-based to HP Integrity-based systems can be found on the Software Transition Kit (STK) website at:

<http://devsrc1.external.hp.com/STK/index.html>

All the information you need to take advantage of the HP-UX 11i v2 for HP Integrity architecture environment can be found there. In a discussion around HP-UX 11i transitioning, it is important to consider two things:

- The approach to binary compatibility that HP has taken to ensure the greatest investment protection possible
- **Qualifying** an application on the new architecture or porting an application to ensure maximum performance.

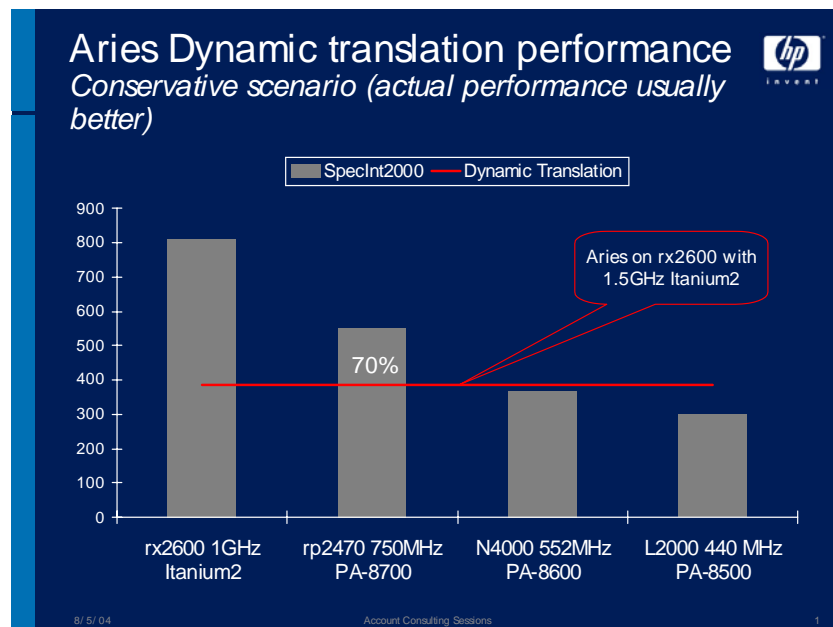
The HP approach to binary compatibility

A discussion regarding transitioning applications and using the STK must first involve a brief description of how HP approaches binary compatibility between HP 9000 and HP Integrity-based systems. HP's binary compatibility is superior to IBM's, and similar to Sun's approach with respect to moving customer environments between generations of processors and operating systems. This is extremely important to understand as you look at your options.

The HP strategy for binary compatibility between HP 9000-based and HP Integrity-based systems is done in a way to protect your enterprise's investment. First, understand that HP has done everything possible to allow you to transition your existing HP 9000 environment to HP Integrity servers with only the smallest amount of effort. Second, if you need to migrate your environments to HP Integrity for performance or other reasons, HP offers excellent tools and capabilities that help you move your code over to HP Integrity.

The existing transition capabilities are as follows:

- Same source code compiles on HP-UX 11i for HP Integrity-based and HP 9000 based servers.
- Data compatibility between HP 9000 and HP Integrity- no need to convert data. In most cases, database migration is a simple reconnect.
- On HP Integrity-based systems, well-behaved¹ HP 9000 applications run in emulation mode via dynamic code translation, sometimes at higher performance levels than seen on the HP9000. An application can be taken from an HP 9000 server and run directly on an HP Integrity-based system without alteration. Because dynamic translation is transparently invoked and performance is close to native levels, you may not always realize that an application is running in dynamic translation (an advantageous situation since there is no need to actively invoke a tool).
- An application can be recertified using HP's HP-UX Software Transition Kit (STK), available online. This is a relatively simple process that involves scanning the source code for binary exceptions and altering the code by recompilation on HP 9000 so that the new executable runs on both the source and target platforms. While not necessarily gaining full native-level performance for an application, if you are running applications that are not performance critical, it will be sufficient. The figure below is a good illustration of the expected performance when operating in emulation as compared to the benchmark SPECint2000.



Ultimately, almost all applications should be recompiled to take maximum advantage of the HP Integrity architecture. You can re-compile your applications easily using the HP-UX STK. In addition, HP provides tools, guidance, services, and porting centers to customers and ISVs who want to do recompilation.

¹ A well-behaved application is one that does not make specific assumptions about the machine it is operating on, does not use undocumented features, and does not use non-portable extensions.

Qualifying a well-behaved application

Note: The term “well-behaved application” is used throughout the industry to describe, in general, software code that is written to be transportable between hardware or operating systems environments. Well-behaved applications do not make assumptions about run-time architecture, platform architecture, or object file format.

The qualification process provides a single executable that runs on both source and destination platforms. In a few cases, it may be necessary to do minor source-code changes and recompile on the source platform. The tool is used to only check for binary compatibility impacts – it does not alter anything.

Qualifying an application requires the following:

- Setting up your environment
- Finding binary compatibility impacts
- Finding impacts in scripts and makefiles
- Building and testing the application on the source platform
- Building and testing the application on the destination platform (NOTE the implication here is that there will be an executable created that runs on both source and destination platforms. The additional implication is that this new executable is different from the previous version, which ran only on the source platform)

If significant performance or binary compatibility impacts are discovered and fixing them causes the application to not run on either the source or the destination platforms, the software cannot be qualified and must be ported instead.

Note: The term “well-behaved application” is used throughout the industry to describe, in general, software code that is written to be transportable between hardware or operating systems environments. Well-behaved applications do not make assumptions about run-time architecture, platform architecture, or object file format.

Porting an application

Porting an HP 9000-based application to run on HP Integrity involves recompiling it – but not a rewrite as is required with other architectural transitions. The duration of the porting activity will depend upon the size of code being moved and the amount of testing planned.

To port the application:

- Set up the user environment as described in *Configuring the HP-UX STK Tools*
- Scan the source files using `scansummary` and `scandetail`
- Resolve impacts in the source files
- Set up the new development and build environments
- Upgrade the compiler (if required)
- Build and test the application on the source platform
- Build and test the application on the destination platform

Operating in a mixed native and emulated environment

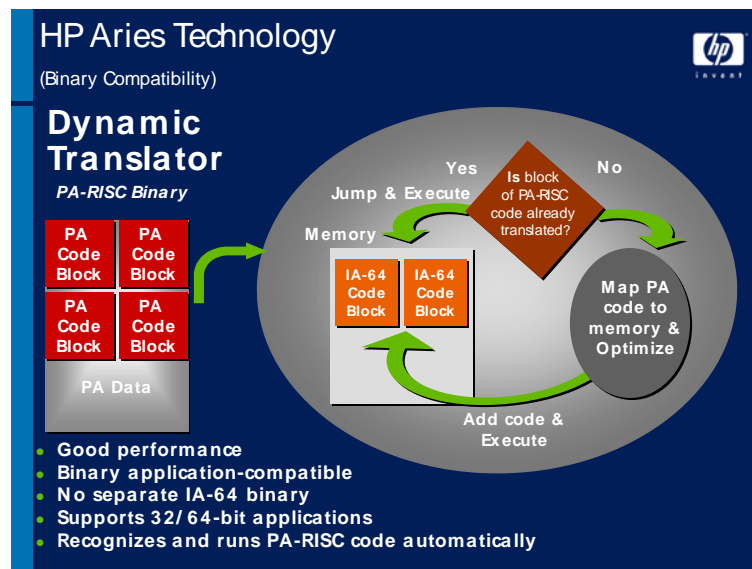
As you begin to integrate HP Integrity systems into your IT environments, you will find that most, perhaps all, of your HP 9000 applications will function correctly on your HP Integrity

platforms without recompilation. This is primarily due to the great source code compatibility between HP-UX on HP Integrity and HP 9000. You may also find that some of your code is operating natively on the HP Integrity architecture, and some is operating with use of the dynamic translator Aires (described in more detail later). HP built Aires with quality in mind, so be confident that you can transition your hardware environment immediately and have a software stack quickly operable on the HP Integrity architecture.

Aries: Binary translation on HP Integrity systems

The HP 9000 software emulator, Aires, is shipped with every version of HP-UX 11i v2 for HP Integrity-based systems. The HP Aires dynamic translator allows HP 9000-based code to operate on HP Integrity-based systems. For commercial applications, the majority of enterprises will experience equivalent or even better performance than what they had with their HP 9000 environment.

The basic operation of Aires is that as it is invoked, it translates the HP 9000-based code into HP Integrity-based code on the fly. If certain sections of code are repeated, Aires will translate and keep the repeated code for usage. What that means is that if code is being translated and executed on the fly, and reaches a point in the execution where a repeated code block exists in memory that was previously translated, Aires will understand this and execute the repeated code block as if it were native HP Integrity instructions. One can imagine that over time, as an application operates in binary translation, many repeated blocks of code will be saved and then used during execution. Thus, you may experience binary translation that actually improves with time and approaches native performance levels.

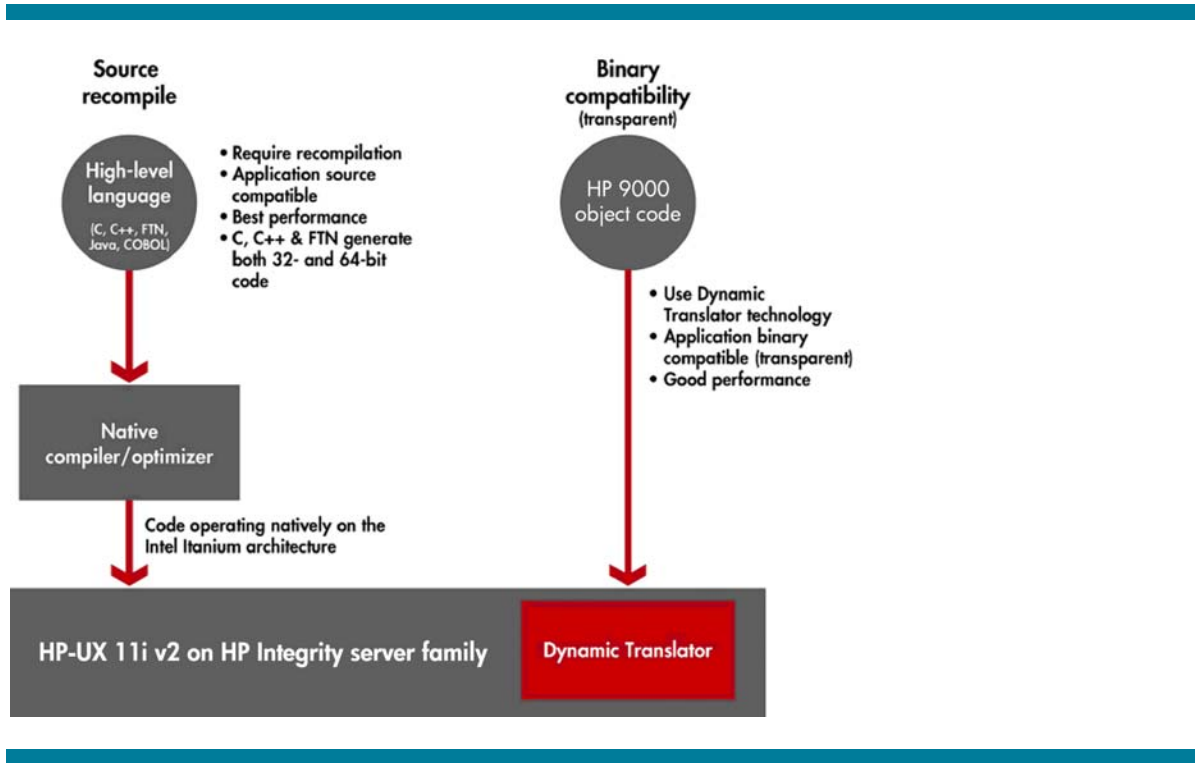


(At the end of the execution process, the translated code is discarded.)
The major components of Aires are:

- The interpreter (*f1em*), which emulates each RISC instruction
- The translator (*dynT*), which translates RISC instructions into 64-bit instructions
- The system call manager (*scm*), which emulates all the system calls made by the RISC application
- The exception manager (*exc*), which deals with all issues related to signals, such as setting up signal handlers, receiving signals, and so on.
- The low- and high-level control systems, which handle the control flow across various components of Aires

As you build software environments using HP Integrity-based systems, the ability to use a dynamic code translator to run applications during a period of transition is important, since not every application may be available to operate natively on the HP Integrity architecture. The great advantage of Aries is that it allows you to use your HP Integrity-based hardware while doing a parallel software move to run natively on HP Integrity-based systems.

A block diagram of how native and translated applications operate together is shown in the figure below.



The Aries software emulator allows HP 9000-based HP-UX binaries to run transparently on HP Integrity-based systems.

The following table describes important features of Aries.

| Aries feature | Description |
|---|--|
| Transparent operation | The HP-UX kernel automatically invokes Aries when an HP-UX on HP 9000 binary is launched. The invocation and usage model for HP-UX on HP 9000 applications on HP-UX 11i v2 on HP Integrity-based systems remains unchanged. |
| Hardware levels of reliability | Aries achieves hardware levels of reliability. This is the result of over three years of HP's investments in verification and validation methodologies for Aries. |
| Support for 32-bit and 64-bit addressing models | Aries fully supports applications built for the 32-bit and 64-bit addressing models. Aries is embodied as two separate shared libraries: one library emulates 32-bit applications and the other emulates 64-bit applications. The HP-UX kernel automatically invokes the appropriate shared library. |
| Built-in support | Aries makes it possible to debug an HP 9000 application that is running on HP Integrity. If such an application fails and generates a core file, Aries will generate an HP 9000 style corefile, and is debuggable using gdb. |
| Reasonable performance | Aries offers levels of performance to make it a viable compatibility solution. Aries' performance varies depending on the nature of applications. For user- |

interactive/system-intensive applications, Aries performance is comparable to the native HP 9000 run of the applications. For other, commercially-oriented applications, performance may be equivalent or even better than on equivalent HP Integrity platforms.

While Aries is extremely versatile, there are a few restrictions to it:

- Aries does not support emulation of privileged HP 9000 hardware instructions. Privileged instructions are used in operating system code to perform certain system management operations. This limitation will not affect user applications.
- Aries does not support HP-UX applications on HP Integrity-based systems that attempt to use HP-UX HP 9000 shared libraries, or vice versa. Aries only supports pure HP-UX on HP 9000 applications. A pure HP-UX on HP 9000 application is one that consists of only HP-UX on HP 9000 libraries (archived or shared). This warning is for precautionary purposes. An HP 9000-based application already written to correctly operate on HP 9000 hardware would not invoke any HP Integrity server family shared libraries. It would only be as a result of inconsistent coding techniques that a new HP 9000 or HP Integrity-based system application would attempt to use a cross-architecture shared library. If you are still unsure, it is advisable to run the following command:

```
chatr library >> $PLAN_DIR/stk.libs
```

It will determine the shared libraries used by the executable. Refer to “Determining library dependencies” at:

<http://devsrc1.external.hp.com/STK/libscan.html>

- Aries may not support some implementations of `ttrace()`, `ptrace()`, or `profil()`. Aries emulates the `ttrace` system call in order to enable `pa-gdb` (the HP 9000 debugger) on HP Integrity-based systems (both 32- and 64-bit Aries). Aries does not support applications that use the `ptrace()` or `profil()` system calls. This limitation would impact only debugger programs, which are normally not portable between environments.
- Aries supports both `fork()` and `vfork()` system calls. However, Aries does not support applications that rely on differences between `fork()` and `vfork()`. Most applications that use the `vfork()` system call do use it with a purpose that is well known to the programmer. It is an extremely rare situation that a standard application would have any such reliance on the differences between `fork()` and `vfork()` calls.
- Aries does not support identical SigNaN and QNaN. Not-a-Number (NaN) is an IEEE floating-point bit pattern. Compaq Fortran identifies NaN values with the letters “NaN” in output statements. A NaN can be a signaling NaN or a quiet NaN. Note that this is an advanced issue that will only impact a limited number of floating-point implementations.
- The version of Aries shipping with HP-UX 11i v2 supports HP-UX on HP 9000 applications that run on HP-UX 11i. Aries does not support applications compiled on HP-UX v8.x or earlier. However, such applications should work if they run on a contemporary version of HP-UX (that is, HP-UX 11i v2 and earlier).

Aries does not support privileged HP 9000 instructions. Hence, device drivers and loadable kernel modules are not supported.

- Aries consumes a small amount of an application’s virtual memory address space. Therefore, Aries does not support applications that are nearly or completely out of virtual address space. Such applications, in practice, have been found to be extremely rare.
- When an emulated program makes any system call that returns the processor-related information, under emulation Aries returns information pertinent to a HP 9000 2.0 processor even as the emulated application runs on an HP Integrity system. For instance, a call made to `sysconf(2)` with `SC_CPU_VERSION` will return `CPU_PA_RISC2_0`. This is an Aries policy that an emulated program sees a complete HP 9000 environment on an HP Integrity-based system. If the application requires that it be able to determine that it is running on an HP Integrity-based system, then one method is for the application to use

the `system(3S)` call and utilize the HP Integrity server-native command, `getconf(1)`, to get the required fields API and ABI compatibility.

API and ABI compatibility

API compatibility

Rather than let applications access operating system resources directly, open systems such as UNIX and Linux have a portability layer to which applications are coded. This is the source-code compatibility layer to which all well-behaved applications should be written. In general, this coding layer is the set of POSIX application programming interfaces (APIs).

There are UNIX-branded systems to ensure source-code compatibility for applications among UNIX systems, and there are LSB-branded systems to ensure binary compatibility for Linux applications. However, applications must be coded to use the APIs or application binary interfaces (ABIs) within the scope of the compatibility definition. Applications must not use private interfaces of the operating system or subvert the portability layer by accessing operating system resources directly.

ABI compatibility

An ABI is the interface with which an application program gains access to a particular operating system upon which the application has been implemented to execute. Most often the term ABI refers to a UNIX system ABI that is a specification of common header files, data structures and system interfaces for UNIX and Linux implementations, which define binary compatibility for applications between compliant systems.

ABI compatibility is represented by the set of supported run-time interfaces available for applications to use (as opposed to the API, which is the set of build-time interfaces). The most important part of a system's ABI is the set of interfaces provided by its shared libraries.

Restricting development to the source API specification is not enough for binary compatibility because different releases and different systems have different versions of the libraries. To become binary compatible, you must develop to the ABI.

Validation of applications on Aries

HP has verified the functionality of a large number of functions and applications on the HP 9000 software emulator. Although the list in the following table is not comprehensive, it is an example of the breadth of testing and validation that has been performed.

| Category | Applications tested functionally on Aries (many of these applications may have native versions at this date) | Native application examples |
|-------------|---|---|
| Web servers | Apache Web Server version 1.3.12 iPlanet Web Server Enterprise Edition version 4.1 sp2 Netscape Enterprise Server version 4.02/4.15 Squid Cache Server version 2.3.STABLE4 Netscape Proxy Server version 3.5x | Zeus Web server See Beyond e*gate |
| Middleware | | BEA WebLogic Server 6.1, 7.0 BEA Tuxedo 6.5, 8.0 Borland Visibroker TIBCO Rendezvous |

| Category | Applications tested functionally on Aries (many of these applications may have native versions at this date) | Native application examples |
|-----------------------------------|---|--|
| Tools, applications, and commands | xfig netglance echoping finder gnuplot gperf gzip/gunzip ls tar xtar acrobat reader xgas gslots | Rational Clearcase Service Control Manager for centralized management System Administration Manager (SAM) for HP-UX system administration HP-UX Kernel Configuration for self-optimizing kernel changes Ignite-UX for installation and deployment of the operating system Software Distributor-UX (SD-UX) for software and patch management System Inventory Manager for change and asset management Event Monitoring Service (EMS) for fault management Security Patch Check for protecting servers against new vulnerabilities Management Processor for powerful remote management over the web |
| Development tools | softbench gcc | |
| Debugger | gdb | |
| Web browser | Netscape version 3.0, 4.7x, 6 Internet Explorer version 4, 5 | |
| Search engines | Inktomi search software version 4.1.1 | |
| File sharing servers | Samba (CIFS/9000 server-rev a.01.02 and client) version 2.0.7 Netscape Directory Server version 4 | |
| Scientific applications | Many | Many, see seehttp://www.hp.com/go/dspp |
| Databases | Oracle version 8.x Sybase | Oracle9i |
| System administrator utilities | SD utilities (swinstall, swremove...) revision 5.1 SAM revision 73.2 | |
| Multimedia | Real Server version 8 Real Player Basic version 8 | |
| Performance tools | TOP 82.1.1.15 SAR 82.1.1.7 ITO OpenView node manager EMF HA Monitor | Process Resource Manager (PRM) for workload management |

| | | |
|----------------------|--|---|
| Category | Applications tested functionally on Aries (many of these applications may have native versions at this date) | Native application examples |
| | SAS version 11e hpwebqos | |
| Benchmarks | Alaska benchmark spec95, 2000 (int and fp) version 95, 2000 mth | |
| Shell | expect tosh tcl hpterm | |
| Programming language | Perl (32, 64) version 5.x | |
| Java™ | Java plug-ins | Java 1.3.1.8 |
| Java applications | Forte version 4 JBuilder version 3.5 JProbe version 2.8.1 Together version 4.2 HPJmeter version 1.1.1 | |
| Java benchmarks | CaffineMark version 3.0 SwingMark JVM version 98, 2000 Firehunter DiningPhilosopher JCK (with JVM 1.2.2.04H, 1.2.2.08, 1.3.0.00, 1.3.0.1) version 1.22, 1.3 | SPECInt2000 SPECfp2000 SPECjAppServer2002 TPC-C SpecJBB |
| Editors | Emacs version 20.7.x XEmacs version 19.14 vi/vim version 5.5 | |
| Security | | RSA Security Bsafe Encryption |

Expected performance in dynamic translation

Once it is understood whether a given set of HP 9000 applications will function correctly in Aries, it is important to understand what the expected level of performance will be for the given application. For many applications, operation in dynamic translation may be good enough—recertification or recompilation may be unnecessary. In addition, if you are operating on older HP 9000 hardware, running an application in dynamic translation on an HP Integrity based system may result in better performance than you are getting currently.

If you have older HP 9000 systems, expect performance for HP 9000 applications operating on HP Integrity in binary translation mode to be in the range of PA-8600 to PA-8700 levels. For example, if you had an older HP-9000 N4000 system (which use PA-8600 processors), and were operating a custom application on it, expect performance on an HP Integrity system in binary translation mode to be about the same or better.

Why is dynamic translation necessary? Many hardware architectures require some type of emulation to enable binary compatibility of applications or to maintain performance levels between generations of processor implementations. In the case of the Itanium processor, the processor architecture is different from HP 9000, but it was designed with HP-UX as its operating system. Thus, as HP-UX for HP 9000 applications originally designed to work on HP 9000 begin to interact with the Itanium microprocessor, they need to be given some “direction” on how to operate within the processor.

For system-intensive applications, such as those with intensive disk I/O, and interactive, GUI-based applications, minimal performance degradation should be expected. The table below shows examples of those.

| Application | Relative Aries performance on 733 MHz Itanium-based server (% of native performance) |
|-----------------------------|--|
| Multimedia (SAM) | 90% |
| Web browser (Netscape) | 90% |
| Web server (Apache, Zeus) | 85% |
| Application server (XEmacs) | 85% |

Compute-intensive applications, such as floating-point-intensive applications, applications with poor code locality, or applications that have undergone optimization using inlining, may have less optimal performance. Performance in binary translation mode will be, on average, close to that of native HP 9000 applications running on a PA-8700 processor. It is recommended that if a compute-intensive application is part of a critical business process, it should be recompiled to run natively on HP Integrity-based systems. For more detail on running HP 9000 applications in binary translation mode, please contact your HP account representative.

HP Integrity education and training

Effective training can be crucial in accelerating your transition to HP Integrity servers. HP has tapped the knowledge of its Itanium processor experts in HP Labs as well as its external partners to develop the best training available for this new technology. HP offers an online curriculum that covers overview and administration on all three operating systems: HP-UX, Windows, and Linux. HP can help you make more informed decisions and move forward more quickly.

Web-based classes include:

- Introduction to Itanium (H8361aae)
- New Features and Functions of HP-UX for Itanium (H8362aae)
- Linux on Itanium (H8363aae)
- Windows on Itanium (H8364aae)
- Migrating Applications to Itanium I (H8365aae)
- Migrating Applications to Itanium II (H8366aae)
- Software Functions and Algorithms on Itanium (H8367aae)
- HP-UX 11i on the Itanium 2 Architecture (U2391aae)
- Customizing Your Apache Web Server on HP-UX (H4291s)

Specific training for HP-UX 11i v2 can be found at:

<http://www.hp.com/products1/itanium/services/education.html> or

<http://www.hp.com/education/courses/u5523s.html>

For more information

HP offers collateral and documentation on transitioning HP-UX environments from HP 9000-based to HP Integrity-based systems. Customer-viewable information can be found at the locations below:

- HP-UX Software Transition Kit documents: <http://devsrc1.external.hp.com/STK/docs.html>
- Release notes for HP-UX 11i v1.6 and v2 can be found at:
<http://docs.fc.hp.com/hpux/os/11iV1.6/index.html> and
<http://docs.fc.hp.com/hpux/os/11iV2/index.html>

(release notes is one of the choices at the top of the page in the right-hand column)

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