

HP-UX 11i Knowledge-on-Demand:

performance optimization best-practices from our labs to you

Developer series



HP ARIES technical overview -- Webcast topic transcript

Hello, everyone. This is Rajesh Kumar Chaurasia. I'm software architect with ARIES product team at HP Systems Technology and Software Division, Bangalore. I have been involved with ARIES product during design, development, verification, and performance enhancement for the last ten years. During this period, I have helped many customers adopt ARIES to migrate HP 9000 applications to HP Integrity servers. And during this course of time, I have had opportunity to develop expertise in dynamic binary translation, environment emulation, software security, performance analysis and HP-UX system runtime.

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In this presentation, the topics that we will cover are - ARIES high-level technology overview, base features and advantages, supportability features, items to consider at the time of deployment, performance considerations, limitations, options overview, latest releases and patches, robustness and reliability, support aspects, customer testimonials, officially supported products, HP's own products that run on ARIES and, at the end, the resources for further reading.

[NEXT SLIDE]

Over next few slides, we will go through high-level technical overview of ARIES. We will discuss introduction to ARIES, what it is, how it works, and its major components.

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ARIES is an acronym that expands to Automatic Recompilation and Integrated Environment Simulation. In this context, ARIES is not associated with astrology. ARIES is a compatibility layer on HP-UX 11i for HP Integrity servers, and sits between the HP 9000 application and the HP-UX 11i operating system. ARIES runs the HP 9000 HP-UX 10.20 (and higher) applications transparently on HP-UX 11i v2 (and higher) on HP Integrity servers. ARIES is a dynamic binary translator. Compared to other software emulators, major differentiator for ARIES is, it's built-in capability for environment emulation. On HP-UX 11i for HP Integrity servers, ARIES is packaged as four shared libraries, two each for 32-bit and 64-bit HP 9000 applications. The libraries in the form of `pa_boot[32|64].so` are the ARIES specific dynamic linker and loader, and the libraries `aries32.so`, `aries64.so` are the core ARIES emulation engines.



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This diagram gives a high level overview of ARIES, its components and how it is invoked. In the diagram on the top left is application from HP 9000 HP-UX servers. When the application is invoked on HP-UX 11i on HP Integrity servers the underlying HP-UX operating system recognizes that the executable requires ARIES to be set up to emulate the application. Thus the operating system loads and invokes the ARIES specific dynamic loader `pa_boot32.so`, which in turn invokes ARIES emulation engine. The center of the diagram shows different ARIES components. ARIES consists of two major subsystems, instructions set architecture – in short, ISA emulation, which is shown on the right side, and environment emulation subsystem, which is shown on the left side. The instruction set emulation is achieved by a fast interpreter, which emulates the instructions arranged in basic blocks, instruction by instruction. When a basic block has been executed sufficient number of times, it is considered as a suitable candidate for the dynamic translation. The dynamic translator translates the PA-RISC basic blocks into semantically equivalent IA64 native code. Any further reference to same basic block, by the emulated application directly executes in the translated code and does not require further interpretation or translation. The dynamic translator implements two phase translation; a mechanism in which first pass translated code collects runtime profile information and second pass translation uses the profile information to further optimize the translated code. Coming to environment emulation – environment emulation engine consists of system call manager and exception manager. The system call manager provides emulation of all system calls made by the HP 9000 application. Some system calls are passed directly to the underlying HP-UX 11i operating system, and some system calls are returned from within the ARIES after performing the necessary operation.

System call manager also provides emulation for `ttrace` family of system calls to be able to debug the emulated application using GDB. The exception manager is responsible for delivery of signals to the emulated application. Exception manager differentiates among synchronous and asynchronous signals, set up the emulated context for signal handlers to execute and is responsible for creation of HP 9000 application core file, in case there is an application failure. Exception manager also provides the mechanism to differentiate between signals meant for ARIES and the signals meant for delivery to the application. The interaction among various ARIES modules is facilitated by control system, which provides emulated register context, safe points for receiving asynchronous signals and suspension of threads. Control system also provides mechanism for thread synchronization and emulation of self modifying code. It must be noted, as shown in the top right portion of the diagram that the interpreters, shell scripts from HP 9000 servers run directly on HP-UX 11i on HP Integrity servers, which do not need to go through the ARIES emulation engine.

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This diagram shows the operation of dynamic translator. The HP 9000 application sites like data in memory, and ARIES is the actual entity that runs on behalf of the application. In the diagram on the left-hand side is shown the HP 9000 executable text and data segment. On the right-hand side is the ARIES dynamic translator. The dynamic translator translates basic blocks or a trace of basic blocks, and stores the translated code in memory. Further references to such blocks are not interpreted or translated. Instead, the translated code is reused. The branch targets of translated code are back-patched such that the execution happens inside the translated code most of the time.

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Here we capture the major ARIES components that we have just discussed in the previous slides. The major ARIES components are – ARIES specific dynamic loader, the control system which facilitates interaction among various ARIES modules, interpreter – which is instruction by instruction emulation of the instruction stream of the application, dynamic translator, code cache region – which stores the translated code, system call manager, exception manager and threads management.

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In this section, we will discuss ARIES base features and advantages. In the next couple of slides, we will cover

few points to address some of the inhibitions in using ARIES to migrate HP 9000 applications to HP-UX 11i on HP Integrity servers.

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Use of ARIES does not require user intervention. Users do not need to invoke ARIES explicitly. It is invoked by the operating system automatically. ARIES provides binary compatibility for HP 9000 applications and thus no re-compilation is required. And to be able to use ARIES, users need not have access to the source code. ARIES provides binary compatibility for all user space, 32-bit and 64-bit HP 9000 applications built for HP-UX 10.20 (and later). One of the design goals of ARIES is high reliability to make it suitable for serious application deployments. ARIES provides exact HP 9000 HP-UX-like interface to ensure same user experience in using the HP-9000 applications under ARIES compatibility mode. ARIES is bundled with HP-UX 11i operating system on HP Integrity servers, and kernel support to automatically detect an HP 9000 executable and invoke ARIES, provides transparency. Thus you can run the HP 9000 application under ARIES compatibility mode on HP Integrity servers exactly in the same way as you would do on an HP 9000 server. To ensure good return on investment, ARIES delivers good performance for a wide range of HP 9000 applications.

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For application vendors ARIES provides time to market advantage before the native port of application on HP-UX 11i for HP Integrity servers, is completed. Most HP 9000 applications work out of the box and do not require additional steps. Exception to this, are the applications which require some changes during the installation and configuration time. The application dependencies on operating system interfaces and language runtime are automatically handled. Third party dependencies are automatically handled, but not the support issues. ARIES is well suited for HP 9000 applications that depend on legacy shared libraries that will never be ported to HP-UX 11i on HP Integrity servers. For example, user space threads library - libcma. Similar scenario also includes old versions of HP 9000 applications, which will not be ported to HP-UX 11i on HP Integrity servers by the respective application vendors. ARIES is a fully supported product from HP. While deploying the HP 9000 applications in ARIES compatibility mode, users can continue to use same debugging tools and utilities that they have been using on HP 9000 servers.

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In this section, we will discuss ARIES supportability features. While the primary aim of ARIES is to provide binary compatibility for HP 9000 applications on HP-UX 11i on HP Integrity servers, it is important to provide access to same debugging tools and utilities as on HP 9000 servers while the application is deployed under ARIES compatibility mode.

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ARIES provides supportability features for quick and easy diagnosis of faults for situations like - application crashes, core-dumps, incorrect behavior, application runs infinitely. It is important to isolate ARIES faults from that of the application faults, and identification of situations when ARIES fault leads to application crash.

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ARIES supportability features include - generation of core file for HP 9000 application in case of application crash with a signal, debugging of HP 9000 applications using GDB, attaching GDB to an already running emulated process, memory leak detection of HP 9000 applications using GDB, using system call tracer utility - tusc for tracing HP 9000 application activities.

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ARIES generates core file in the file name pattern, core dot application name - in same situations when the



application would have generated core file while running on an HP 9000 server. ARIES generated core file is compatible with GDB for debugging on same HP Integrity server or on HP 9000 server. You should refer to GDB help on packcore command if you wish to debug the core file on a different server than where it was generated. ARIES follows all standard HP-UX conventions for core file writing. For example - file permission, file ownership and file size limits. You can use the core file with GDB in same way as you would do on HP 9000 servers. The command will read like - GDB followed by application name followed by the core file name. For more details, you can refer to ARIES man page or follow the URL for online ARIES man page.

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HP 9000 applications can be debugged at source level using GDB on HP-UX 11i on HP Integrity servers. GDB user interface remains unchanged. There is negligible loss of performance in interactive debugging. HP 9000 GDB is included by default as part of HP Integrity WDB package. That means you do not need to copy GDB from HP 9000 server to the HP Integrity server. For MxN threads applications, ARIES supports debugging in traditional 1x1 threads model. While emulating such applications, ARIES forces the applications to run in compatibility mode - that is 1x1 threads model. For long running applications or for application hang, GDB can be attached to an already running emulated process. For more details on how to set up environment to be able to debug the application in ARIES compatibility mode using GDB, you should refer to ARIES man page or, follow the URL for online ARIES man page.

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Memory leak detection of HP 9000 applications using GDB under ARIES compatibility mode - HP 9000 application cannot leak memory under ARIES unless it does so, on an HP 9000 server. HP GDB real time check feature (RTC feature), can be used to detect memory leaks of the emulated HP 9000 application. Refer to HP GDB documentation for details about how to detect memory leaks of an application using GDB.

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HP 9000 system call tracer utility tusc can be used to trace emulated application activities like system calls, arrival of signals and actions like that. The system call tracer can be used both in command line invocation and attach mode. Using HP-UX 11i HP Integrity native system call tracer, it is not useful for tracing the emulated application activities, as some of the system calls are returned from within ARIES. With current implementation of tracing an emulated process, it is not possible to trace more than one level of child process. This means if the trace process creates a child, the child can be traced, but if child creates another child process, then the second level of child process cannot be traced in current implementation.

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In this section, we will discuss situations and class of applications where ARIES is the recommended solution, only solution or, not a good solution.

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ARIES is a recommended solution in situations when - porting the application is time consuming and time-to-market is critical. The application does not use any of the undocumented or unsupported HP-UX features - to say the application is well behaved. The performance under ARIES emulation mode is good. The third party dependencies for the application do not yet have a native port for HP-UX 11i for HP Integrity servers.

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ARIES is the only solution when - the source code is not available for legacy applications to be able to port, this can happen for applications that were developed long ago and went out of support and development. Application depends on legacy libraries that will not be ported to HP-UX 11i on HP Integrity servers. For

example, user space threads library - libcma. Application uses legacy versions of software that will not be ported by the respective application vendors to HP-UX 11i on HP Integrity servers. Third party application(s) vendors do not have plans to migrate to HP-UX 11i on HP Integrity servers. Application porting cannot complete within a reasonable time with satisfactory quality. Under these circumstances, ARIES becomes the only recommended solution.

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Due to performance reasons, there are certain situations in which ARIES is not the recommended solution because of the performance implications. This does not mean if you run this class of applications in ARIES compatibility mode they're not supported. They are well supported, but there will be performance degradation. This class of applications are - floating point intensive applications, applications which are Java based short running process and use JNI (Java Native Interface) code, application has constraints on resident memory footprint - under ARIES emulation mode, the process memory footprint can increase by about thirty MB per process. Application start-up time is critical - the process needs to run for some time before ARIES overhead for dynamic translations can be amortized. High availability or mission critical applications, application is typical serial code, which has poor code locality for example, parsers, shells and interpreters. We advise this class of applications to be deployed in native mode on HP-UX 11i for HP Integrity servers.

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ARIES is not the recommended solution when - you want to optimize your application to take advantage of HP-UX 11i v2 or v3 and Itanium architecture features. You are concerned that the application may not behave as well in ARIES emulation mode. The application vendors may not support the application in ARIES emulation mode officially.

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Many a times, our customers have apprehensions about how well their HP 9000 applications would perform under ARIES emulation mode. In this section, we will analyze situations when ARIES performance is good and when to expect performance slowdown.

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ARIES performance is good when - the application is I/O intensive, memory intensive and spends good amount of time in selected parts of code, static rendering graphics applications. Certain database clients have good performance under ARIES. For such applications, the transaction response times under ARIES may vary. We recommend performance benchmarking of high availability applications in ARIES emulation mode to make sure that all critical parameters like throughput, response time, memory pressure, CPU utilization are within acceptable limits.

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ARIES performance is not good when - the application is floating point intensive, java based short running process or multi-threaded applications which spend significant amount of time in thread synchronization activities like thread suspension, thread resume, examining the thread context. Application was compiled with +Ovolatile compiler option. In such cases, all memory accesses will become strongly ordered memory operations. For such strongly ordered memory operations, the performance of ARIES translated code is not very good. OpenGL based applications when emulated under ARIES send their graphics data through an emulated virtual memory driver to the graphics card, and thus do not experience good performance. Such applications can work with good performance if they could use display lists and communicate with the OpenGL daemon process using the GLX protocol mode. Applications, that typically have flat profile, for example parsers, shells and interpreters. We advise this class of applications to be deployed in native mode on HP-UX 11i for HP Integrity servers.

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Transaction processing applications comprising of several hundred processes to handle requests - in such cases, each process runs for a short duration, allowing not enough time for ARIES to benefit from the dynamic translations. These applications can work well in single server mode or by limiting the number of server processes. Large number of processes leads to system pressure on memory, as ARIES adds to process resident memory size by about thirty MB per process.

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In order to compare the ARIES mode performance with respect to native HP Integrity server and the HP 9000 server, we chose two servers as close in configuration. But, due to inherent architecture differences of the two server lines, it is not possible to provide an apple-to-apple comparison. We have selected PA8800 based rp4440 HP 9000 server and Itanium2 Madison 6 MB L3 cache based rx4640 HP Integrity server for performance comparison. For performance comparison, we selected Integer and Floating Point intensive SPEC CPU benchmark and two Java benchmarks SpecJVM98 and SpecJBB2000. As depicted in the table, ARIES mode performance varies between 50 to 80 percent compared to HP 9000 server and between 20 to 70 percent compared to HP Integrity server native performance. Your actual application performance under ARIES may vary depending on the application execution profile. For a wide range of HP 9000 applications, ARIES mode performance is comparable or better than HP 9000 server performance. While deploying the HP 9000 applications under ARIES on HP Integrity server, the performance gain would also depend on how old the already deployed HP 9000 servers are, and the configuration of HP Integrity servers. If you wish to experiment with ARIES performance tuning, you should refer to Performance Tuning section in the ARIES man page.

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ARIES encounters certain situations which are not possible to handle. In this section, we will go through ARIES limitations and exceptions.

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All HP 9000 user mode applications will work fine under ARIES, with certain limitations. Currently, loading of HP Integrity native shared libraries by HP 9000 application is not supported. ARIES can handle pure PA-RISC applications, statically or dynamically linked. No support for very old applications, that use page size lower than 4 KB. Such applications cannot be loaded by HP-UX 11i on HP Integrity servers. ARIES is meant for pure user space applications, and does not provide emulation of privileged instructions. Thus, HP 9000 kernel modules are not supported under ARIES. If the application is timing dependent such that it makes assumptions about time taken to execute certain piece of code, it may encounter incorrect behavior under ARIES. But note that such applications are not portable. Applications that use profil() or ptrace() system calls are not supported. However, HP 9000 GDB is supported through emulation of ttrace() system calls. ARIES consumes a small amount of memory from applications data segment. Applications that are maxed out on their data segment virtual address space usage are not supported. ARIES handles fork() and vfork() system calls identically. Applications which depend on the differences between these two system calls may experience incorrect behavior. ARIES emulates MxN applications as traditional 1x1 threaded applications by forcing the compatibility mode. There is no impact on the application functionality.

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Under ARIES mode, it does not matter whether the application was built for the same HP-UX version on HP 9000 server, or on an older version. ARIES emulates applications in same HP-UX model as the underlying HP-UX 11i version on HP Integrity servers.

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ARIES works well for a wide variety of applications with default configuration. However, there can be situations when options or parameters need to be passed to ARIES. This section provides an overview of ARIES options. ARIES options, is an advanced topic and is suitable for users who want to control ARIES memory management or performance tuning. This section is primarily for reference and complete details on ARIES options can be found in ARIES man page.

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Since ARIES is a shared library, options are passed through a resource configuration RC file which is named as .ariesrc for 32-bit ARIES and .aries64rc for 64-bit ARIES. The ARIES RC file can be placed in any of the locations as - system root directory, in which case options apply to all HP 9000 applications on the server. Application directory - in which case, the options will apply to all the executables in subdirectories of the application installation. User's home directory - in which case, the options will apply to HP 9000 applications invoked by the user. ARIES RC file format is application path followed by ARIES options. The application path can have wild-card characters '*' in directory and application name. For more details on ARIES options and ARIES RC file format, you should refer to ARIES man page or follow the URL mentioned here.

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On this slide and the next couple of slides, there are ARIES options mentioned and the ones which are mentioned in bold are the ones which users may find useful if at all required.

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As said earlier, these slides are for reference -

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- And complete details on ARIES options can be found in ARIES man page.

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The table shown on the left side of the slide is automatically generated by passing the option -help in ARIES resource configuration file. The table shows available ARIES options, their type, default values and option value ranges. Some of the ARIES options discussed in this section are available only with the latest ARIES patches for HP-UX 11i v2 and v3. For reference, patch IDs are provided here.

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This section provides information on ARIES latest releases and patches.

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ARIES product and man page patches for HP-UX 11i v2 and v3 for HP Integrity servers are mentioned in the two tables as show here. ARIES product patches are released twice in a calendar year during March and September months. You may use the patch IDs provided here to search for the latest patches at HP response center site - that is itrc.hp.com. Released ARIES patches can be downloaded from the HP response center site. The released ARIES patches are also released as part of HP-UX support media.

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In this section we will discuss the methods and mechanisms that we have used to ensure ARIES robustness and high reliability.

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ARIES has more than six years of field experience. Many customers have been using ARIES as quick and easy migration path for HP 9000 applications to be deployed on HP-UX 11i on HP Integrity servers. Due to confidentiality reasons, it is not possible to discuss the names of customers and applications here. Over the years, ARIES has been used to run following class of applications: database servers and clients, application servers, web servers and services, telecom applications, enterprise management applications, graphics applications, engineering applications and storage applications.

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ARIES robustness and correctness is verified using - Instruction set architecture emulation is verified using - random instruction set generator based on PA-RISC processor instruction testing tool. Environment emulation is verified using regression test suites of system shared libraries, a large number of targeted test cases for verification of rare conditions in ARIES systems run-time and application testing.

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This section covers details such as what is implied by ARIES binary compatibility support, what is the level of ARIES support, how to triage problems encountered under ARIES.

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ARIES binary compatibility and support document can be accessed from the URL mentioned. ARIES provides binary compatibility for all user space 32-bit and 64-bit HP 9000, HP-UX 10.20 (and higher) applications on HP-UX 11i v2 (and higher) on HP Integrity servers. ARIES is shipped free of charge as part of operating environment on all versions of HP-UX 11i running on HP Integrity servers. HP is committed to investment protection for its customers, application vendors and partners, and assures support and bug fixes to make sure that HP 9000 applications behave the same on HP Integrity servers as they did on HP 9000 servers. ARIES supports HP 9000 applications on Integrity servers that run correctly on the same HP-UX version on HP 9000 servers. It does not matter whether the application was built for the same or an older HP-UX version.

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Any issue encountered during application runtime using ARIES could be attributed to ARIES or the application environment. If the problem does not reproduce on an HP 9000 server, HP recommends contacting HP response center. Otherwise, contact the respective application vendor for resolution of the issue. Some useful references are provided for more information on ARIES and HP-UX binary compatibility.

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ARIES always runs the HP 9000 application in same HP-UX 11i model as running on the HP Integrity server. It does not matter for which HP-UX version the HP 9000 application was built on. As regards to security, ARIES is as secure as the HP 9000 application itself. To ensure secure emulation environment, ARIES runs in user space with user's credentials. ARIES is launched afresh for each invocation of HP 9000 application. If the emulated application is setuid or setgid, ARIES does not create or overwrite any temporary file in the file system.

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For applications deployed under ARIES on HP-UX 11i on HP Integrity servers, HP support is limited to ARIES product only. ARIES product support includes consultation for installation issues, resolution of ARIES issues resulting in application failures and addressing the performance concerns as the case may be. If required, user may be asked to demonstrate that the issue does not reproduce on an HP 9000 server. For installation of HP 9000 applications or patches on HP-UX servers, following option need to be passed to swinstall command, that



is -x allow_incompatible=true. To avail official HP support on ARIES, users must have HP-UX operating environment support. ARIES is shipped as part of HP-UX operating environment.

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The discussion on ARIES support cannot be complete without covering the details about how to triage the application failures in ARIES mode and self help tips. Application failures under ARIES can happen for a variety of reasons. Check for the application error and diagnostic logs. All ARIES messages can be identified if beginning with a pattern of the form [HP ARIES32 or 64]. Check for missing shared libraries or ones with wrong file permissions - this can happen if the application installation was copied over from the HP 9000 server to the HP Integrity server. Check for latest patch levels on shared libraries. Trace the application using HP-UX system call tracer, or use HP GDB to debug the application. If no valid reason for application failure can be established, HP will provide diagnostic ARIES for collecting the ARIES trace logs for triaging of the failure.

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ARIES web page at www.hp.com/go/aries provides frequently asked questions and a separate section on ARIES troubleshooting. If the multi-threaded application fails under ARIES with the error no. (errno) set to EAGAIN you need to increase the ARIES specific kernel tunable parameter pa_maxssiz_32bit value. And also increase the ARIES option -heap_ssz value in ARIES resource configuration file. This is not an ARIES issue and it's more to do with the environment configuration. Some applications like Oracle client require install time re-linking. This requires setting up the right environment. You should install the patches mentioned here and modify the \$PATH environment variable appropriately.

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Using HP-UX tools for triaging of performance issues for applications that are deployed in ARIES mode. For triaging of performance issues, tools like caliper and glance can be used. The output of these tools provided pertains mostly to ARIES and not for the emulated application. All information about kernel behavior like system call usage pattern will be valid while the application is running in ARIES emulation mode.

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In this section, we briefly cover some of the customer experiences about using ARIES.

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Due to confidentiality reasons, customer and application names are not provided on these slides. The positive customer experiences highlight the value in using ARIES for migration of HP 9000 applications on HP-UX 11i on HP Integrity servers.

[NEXT SLIDE]

In this section, we briefly cover officially supported applications under ARIES on HP-UX 11i on HP Integrity servers.

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Starting with August 30, 2007, Oracle officially supports Oracle database client application version 10g R2 using ARIES on HP Integrity's servers. For more details, refer to mentioned document ID on Oracle Metalink site.

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During early 2005, HP released Open View Operations for Unix (OVOU) version 8.1 and Network Node



Manager (NNM) Advanced Edition 7.5 under ARIES for HP 11i on Integrity servers. Note that both the software mentioned here are available natively on HP-UX 11i on HP Integrity servers now.

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BSP, Incorporated, Japan, supports its applications A-Auto on HP-UX 11i on HP Integrity servers. A-AUTO application is enterprise job management and scheduler software. You may refer to the mentioned URL for more details.

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Recently, Lyon Highways Monitoring Center migrated from Tru64 Alpha to HP-UX 11i on HP Integrity servers. CORALY is a traffic management system by operators of roads in the Lyon region in France. In this migration effort, ARIES was used to run an application there that interfaces remotely with CORALY environment. You may follow the URLs provided here to get more details about the case study and a video.

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In this section, we'll briefly cover some of the HP products that are run in ARIES mode on HP Integrity servers.

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As discussed in the previous section, Open View Operations for Unix 8.1 and Network Node Manager Advanced Edition 7.5 were released in ARIES mode for HP-UX 11i on HP Integrity servers. Several of non-core secondary agents for OVOU were released under ARIES. Both OVOU and NNM Advanced Edition are now available native on HP-UX 11i on HP Integrity servers. Several factors led to release of Open View Operations and Network Node Manager in ARIES mode - the main reason was a successful deployment pilot at a customer site.

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Some of the other products that are run using ARIES are WDB GUI, which is the HP debugger using GDB. System Administration Manager - SAM, Common Desktop Environment - CDE and Xmotif, Softbench development environment, and many system commands.

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Having come to the end of this session on HP ARIES, we would like to provide pointers to further resources.

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You may use the mentioned pointers here to access more information on ARIES, HP-UX binary compatibility and software transition kit. ARIES man page on HP-UX 11i on HP Integrity server is a good source of information about ARIES and contains an advanced level discussion of many topics covered in this presentation.

[NEXT SLIDE]

Bye, and have a nice day.

For more information:

www.hp.com/go/knowledgeondemand