

MIGRATING TO THE SOLARIS™ OPERATING SYSTEM

A Planning Guide for Moving from the HP-UX and Tru64
Operating Environments

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Chapter 1

Introduction

Why Migrate?

Capitalizing on new market segments, improving customer satisfaction, and establishing a strong foundation for future technology initiatives requires building a smarter data center that can respond to challenges on a variety of fronts. Availability is essential if service level agreements are to be met. Computing infrastructures must scale both horizontally and vertically. Security that protects businesses and identities during times of heightened global tensions is paramount. Complex IT infrastructures consisting of thousands of heterogeneous servers spread across the globe must be maintained. Handling all this while systems are being rendered obsolete is a challenge.

Today, organizations are realizing some resources are failing to keep pace and respond to these new business demands. For many, AlphaServer systems running the Tru64 operating environment and HP systems running HP-UX are now limited in capacity. Standard support contracts are expiring, and independent software vendor (ISV) support for some of these systems is waning. As IT organizations look for alternatives, migration to the Solaris® Operating System (Solaris OS) emerges as an obvious, and safe, choice. Indeed, HP-UX, Tru64, and the Solaris OS share a common UNIX history, making migration a straightforward task. Because these operating systems are descendents of the original AT&T UNIX, organizations can rest assured that they are more alike than they are different. While HP-UX, Tru64, and the Solaris OS have taken different paths over the years—and benefited from lessons learned by the Berkeley Software Distribution of UNIX (BSD), the Mach microkernel, and AT&T System V Release 4—their common heritage lays the foundation upon which advanced network computing thrives.

The Sun Enterprise Migration Solution

The Sun Enterprise Migration Solution offers a comprehensive, integrated package of life cycle services, developer migration programs, hardware, software, financial offerings, and partner skills to ease the transition to Sun systems. With the Sun Enterprise Migration Solution, Sun can provide a new, secure IT infrastructure that can accelerate development of new applications to help meet evolving business needs, while helping to maintain current business functionality and protect investments in business applications.

Based on the proven Architect, Implement, Manage (AIM) methodology and migration specific extension, the Sun Enterprise Migration Solution includes:

- *Enterprise Migration Justification Service*, helping organizations calculate the benefits of migration, constraints to address, partners with which to work, and more. This phase recommends an Enterprise Migration Workshop, a moderated exercise which ensures the project is scoped, and contradictions and ambiguities are identified and addressed.
- *Enterprise Migration Architecture Service, Application and Data*, helping organizations prepare for the actual migration project. This phase includes an application porting assessment, and provides a detailed migration plan that can be used throughout deployment and cutover to the new system.

- *Enterprise Migration Architecture Service, Infrastructure and Management*, establishing a detailed architecture and migration plan to move from current systems to the new architecture. It assesses key features of current platforms and operational processes and constraints, and factors in business objectives.
- *Enterprise Migration Implementation Service*, consisting of either a packaged solution from Sun or its partners, or a custom solution.

Scope

This guide provides an overview of the issues organizations may need to consider when migrating from the Tru64 or HP-UX environment to Sun systems running the Solaris Operating System (Solaris OS). This migration project planning guide provides an overview of the differences between the HP-UX, Tru64 and Solaris OS environments, and discusses migration project planning, and resources needed. It also describes some of the advanced features of the Solaris OS that are unique in the industry and may be unfamiliar to users. Whenever possible, pointers to more detailed information on how to perform a migration effort is provided throughout.

Chapter 2

Application Migration

Overview of the Application Porting Process

Porting involves moving a custom application, written in one or more programming languages, to another operating system. Figure 2-1 illustrates the primary steps associated with porting applications from Tru64 and HP-UX to the Solaris OS.

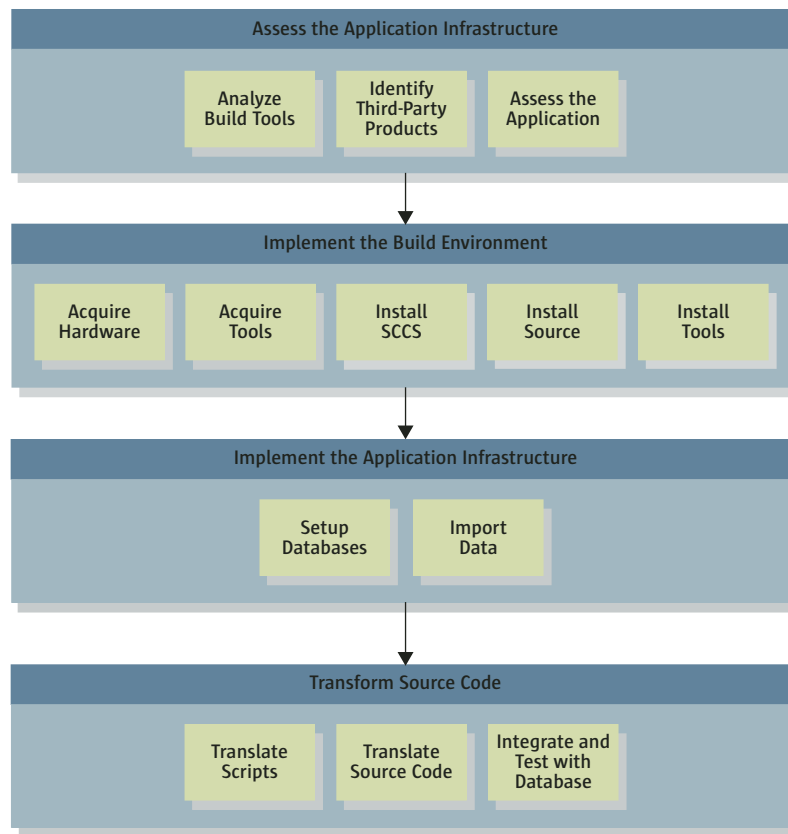


Figure 2-1. Porting an application from Tru64 or HP-UX to the Solaris OS involves several steps

Analyzing Build Tools

When migrating applications from Tru64 or HP-UX to the Solaris OS, several tools may need to be migrated, including compilers, the source code management system, a build environment, and potentially third-party products. Care must be taken to understand the semantics of the build options specified, ensuring tools on the Sun platform provide the expected functionality after the migration. For example, static linking, position-independent code, extended symbol information and other techniques may require new and different options in Sun tools.

Assessing the Application

Porting an application from Tru64 or HP-UX to the Solaris OS requires access to source code. With the source code available, two issues must be considered:

- *Understanding the composition of the code used by the application*
Many legacy applications are quite large, and can be comprised of millions of lines of code. Understanding the source tree layout and the file types can be a complex task.
- *Understanding which files within the source distribution are used to build the application*
Applications often evolve in response to business needs. Over time, some functionality may no longer be needed, and new functionality may be added. Developers should take care to ensure old, unused code in the source code tree is not ported.

Implementing the Build Environment

During migration planning, a Tru64 or HP-UX build log can help identify the tools and utilities used to create an application. Wherever possible, the same tools should be acquired and installed in the Solaris environment. In some cases, a different product with the same functionality, such as a compiler, may be acquired.

When installing the new build tools, placing them in similar locations can help minimize changes to sources files. Source files should be modified to use the new tools, utilities and libraries, and care should be taken to ensure the options used provide the intended functionality. If the original build environment is well designed, only a few key make file and setup scripts may need modification. A general approach to implementing the Solaris OS build environment includes:

- Understanding the key files that affect the whole build system, and porting those files first.
- Performing a global search for hardcoded values in make files, and changing them so they benefit from the new design, if applicable.
- Porting the disconnected hardcoded instances, if any remain.
- Releasing the new Solaris build environment for code porting work.

Integrating Databases

Many enterprises deploy databases to satisfy business intelligence requirements. Because these databases contain historical collections of summarized, enterprise-wide information that supports strategic decision making, it is imperative that they be migrated to a new environment with minimal disruption. Fortunately, the most popular database vendors support Tru64, HP-UX, and Solaris OS, ensuring the replacement environment is a near one-to-one mapping of component technology. Migrating and integrating databases involves several steps, including:

- Acquiring and installing appropriate products and licenses, including the database communication layer (database client and server libraries), the embedded SQL precompiler, the C compiler and linker, and the database engine.
- Acquiring and installing other third-party database reporting and management tools, taking care to reflect different environment variables and path names, and modifying any SQL statements.
- Modifying application source code to reflect any API changes introduced in the database technology.
- Creating the database objects to accept the data.
- Extracting the data from the AlphaServer system using vendor-supplied tools.
- Loading the data into the new database on the Sun system.
- Performing data translation, if needed.

Transforming Source Code

The migration planning and assessment phase may identify a number of application programming interfaces (APIs) in use which are incompatible with the Solaris OS. While in-line source code changes can be made, Sun recommends creating a compatibility library which implements the changes needed to resolve any incompatibilities. Modifications to the source code can then be limited to conditional compilation directives, ensuring backward compatibility.

Learn More

More detailed information on porting applications to the Solaris OS can be found in the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-3: The Porting Process*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf, as well as *Migrating to the Solaris Operating System—The Discipline of UNIX to UNIX Migrations*, located at <http://www.sun.com/blueprints/pubs.html>. Information on porting threaded applications from Tru64 to the Solaris OS can be found in *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-5: Porting Threaded Applications*.

Performing a Successful Application Port

Migration is the transition of an environment—including people, processes, and technologies—from one implementation to another. Porting, on the other hand, is the act of modifying or normalizing application source code so it can be recompiled and deployed on a new hardware platform that supports a different operating system. Sun's methodology for porting applications is depicted in Figure 2-2.

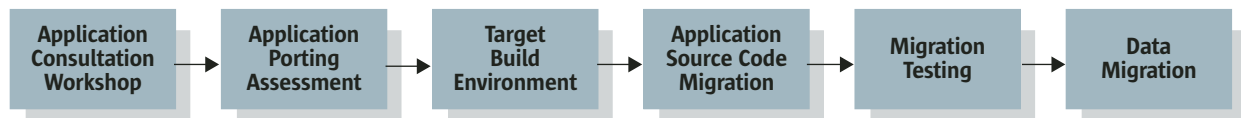


Figure 2-2. Sun's methodology for porting applications

- **Application Consultation Workshop**
The Application Consultation Workshop focuses on defining the project scope, reaching agreement on objectives, constraints, resources, roles, and responsibilities, and determining a level of effort (LoE) for the project.
- **Application Porting Assessment**
In the Application Porting Assessment phase a detailed analysis is conducted, including source code, build logs, shell scripts, and makefiles. The resulting report contains a description of the potential application migration from a level of portability perspective and includes several discussion areas, including an application architectural overview, build environment analysis, list of porting issues, and migration assumptions and clarifications. A table identifying tasks for the potential application migration implementation project is also provided that includes a level of effort estimate at the work unit level.

- Target Build Environment

During the Target Build Environment phase, Sun migrates the original build environment to the target Solaris Operating System. The original build process and methodology are reproduced as closely as possible, with appropriate changes made to account for differences between the original and target platforms. This step in the migration process includes designing and/or porting build scripts to automate the make/build configuration, porting makefiles and compiler options to conform to the target Solaris OS compilers, and installing third-party and other software as required by any application build dependencies identified. If needed, a Java Virtual Machine (JVM) is also installed.

- Application Source Code Migration

During Application Source Code Migration, all necessary changes to source code are implemented to ensure the application compiles and builds on the development machine and the target Solaris Operating System. This process includes potential source code and shell script changes; a clean compile and build of the source code per the build environment, using the original build logs as a reference; a check for embedded system commands in SQL code, and any needed porting; a check for embedded system commands or other system dependencies in scripts from other languages, such as Perl, and any needed porting; and a scan of application supporting files for system dependencies and porting.

- Migration Testing

The majority of problems encountered during functionality testing are related to the configuration of the runtime environment. Sun recommends implementing several testing techniques during the Migration Testing phase, including: unit testing, build process testing, non-regression testing, integration testing, stress testing, and performance testing.

- Data Migration

Data Migration is an important aspect of the porting process. First, it is important to decide on a data migration strategy. A cutover strategy entails moving data from one environment to the other and then running on the new systems. A parallel run strategy enables organizations to run on existing and new systems at the same time in order to gain confidence that the data migration is successful. After assessing the most appropriate data migration strategy, a plan is established and tested several times. Data migration processes, utilities, and test scripts are documented. Sun engineers recommend testing data migration on both the testing environment and the production environment before a cutover is performed. In some cases, automated data migration tools and testing scripts can be developed to make the data migration more productive and reliable.

Commercial Applications and Third-Party Products

All applications, whether running in the Tru64, HP-UX, or Solaris OS environment, depend on support from the operating system and its associated utilities to perform work. However, some applications assume the availability of third-party products which are integrated into the Tru64 and HP-UX environments. When migrating to the Solaris OS, this supporting software must be ported as well, as part of the application infrastructure. As a result, care should be taken during migration assessment to ensure required third-party software, or similar products, are available for the Solaris OS. In the unlikely event that needed third-party applications are not available for the Solaris OS, organizations can choose to make changes to the system to enable products that provide similar functionality to be used. Fortunately, most of the common, off-the-shelf applications used in Tru64 and HP-UX

environments are available for the Solaris OS. The most up-to-date information on applications available on Solaris 8 OS, Solaris 9 OS, and Solaris 10 OS can be found at:

- Solaris 10: <https://partneradvantage.sun.com/partners/10moves/solutions.html>
- Solaris 9: http://sdc.sun.com/solaris_list/s9supported_prod_alpha.html
- Solaris 8 OS: http://sdc.sun.com/solaris_list/s8supported_prod_alpha.html

In-House/Customer Applications

Even in its simplest form, migration must be approached with great care—even between similar systems such as Tru64, HP-UX, and the Solaris OS. As a result, organizations may need to consider how the existing environment and applications are affected by potential differences in several areas.

Data Alignment, Data Types, and Structures

The processor that runs in a computing system has a natural, or preferred, primary memory alignment for data objects. For example, the Solaris OS loads and stores a 64-bit (8-byte) pointer on 8-byte primary memory boundaries in order to take advantage of the underlying UltraSPARC processor. With a compound data type such as a C structure, which may contain a mix of differing data sizes, it is sometimes necessary to insert bytes for extra padding between data elements to satisfy processor data alignment rules. The use of padding may be specified by a compiler option, enabling padding to be permitted or disallowed as needed for space or performance optimization.

When porting an application from Tru64 or HP-UX to the Solaris OS, the differences in natural data alignment of basic data types typically is not an issue as the compiler and APIs handle data type alignment correctly. The use of overlaid data structures and casts (or equivalent) may require an understanding of the logic of the application, and possible code modification.

Read/Write Structures

Most applications read and write data to permanent storage media as a complete structure in binary form using standard C routines. These routines need the data size that is being read or written. Due to the different alignment and data type sizes on the Tru64, HP-UX and Solaris OS platforms, structure sizes vary. To ensure portability, the `sizeof ()` operator should be used to specify the number of bytes to read or write in these routines.

More information on implementation differences related to data types and alignment in Tru64, HP-UX and the Solaris OS can be found in the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-2: Porting Considerations*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Storage Order and Alignment

The order of data storage varies between platforms, and source code that expects a particular storage order is not portable. To maximize portability, source code should compare the individual fields of structure variables separately, rather than relying upon storage order.

Because data alignment and datatype sizes vary based on the platform, the alignment of structure field members also differs across platforms. This results in variable padding requirements that cause structures to change size. To maximize portability, the structure size should be accessed using the `sizeof ()` operator.

More information on storage order and alignment, and how it differs on Tru64, HP-UX and the Solaris OS, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-2: Porting Considerations*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Processor Endianness

Processors store multi-byte data objects, such as an 8-byte integer, in one of two ways. Architectures which store the most-significant byte of the data first are referred to as Big Endian (BE), while those that store the least-significant byte first are called Little Endian (LE). While the Tru64 operating system uses the Little Endian convention, and the HP-UX operating system uses the Big Endian convention, the Solaris OS supports both modes. Indeed, the Solaris OS is written to support Big Endian conventions, however it can support Little Endian mode as well, depending on the processor. For example, Solaris OS uses a Big Endian architecture on UltraSPARC-based systems, while Solaris x86 uses a Little Endian architecture.

When standard UNIX APIs are used to access data, the endianness of the platform is usually not an issue, as the layout of the data is abstracted by the APIs used to access it. Use of lower-level languages, legacy coding techniques, or operators such as *shifts*, logical or arithmetic *ands* and *ors*, with assumptions about the layout of a data element (and the consequential significance of the bits) may be an issue. The use of overlaid data structures and casts may require an understanding of the logic of the application, and possible code modification.

The endianness of the processor and operating system do not directly effect application performance or scalability, and the migration from Tru64 or HP-UX to Solaris OS should not pose undue migration risk due to operating system endianness. Lower level code, such as a device driver or other control software, may be sensitive to endianness. When faced with such challenges, developers can draw on many resources—sample device drivers, the Solaris Device Driver Interface and Driver Kernel Interface (DDI/DKI), derived types, and the help of Sun and ISV migration experts to assess and assist in the porting effort.

More information on processor endianness and its impact on source code migration can be found in the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-3: The Porting Process*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf, as well as the *Endianness in the Solaris Operating Environment* white paper located at <http://developers.sun.com/solaris/developer/support/driver/wps/endianness/files/c0101.html>. Information on developing or porting device drivers to the Solaris OS can be found in the *Writing Device Drivers* guide. A Device Driver Tutorial is also available for download at the Solaris 10 Developer Connection located at <http://docs.sun.com/app/docs/coll/45.20?q=device+driver&s=t> on the Sun Web site.

Compiler Considerations

Changes to source code may be required as a result of the semantic and syntactic differences in how Sun and HP implement the C and C++ languages. Both HP and Sun C compilers conform to the American National Standard for

Programming Language C, ANSI/ISO 9899-1990, and also support traditional K&R C (Kernighan and Ritchie, or pre-ANSI C). The ANSI C compilers on HP and Solaris OS are more similar than the K&R C implementations, and may provide a smoother transition.

Compiler Options

When porting applications from Tru64 or HP-UX to the Solaris OS, keep in mind that:

- Some options may have the same name but behave differently in the two environments
- Some options may have the same functionality but different names in the two environments

For a list of options and their behavior in both the HP and Sun environments, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 4-5: Language Differences Between HP-UX and the Solaris Operating System*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Language Differences—C

Some language differences exist between the HP and Sun C compilers. Some keywords in the HP environment, such as those relating to threading, do not exist in the Sun environment, as the Solaris OS automatically takes care of these issues. In addition, several data types are defined similarly in the two environments, but have different names. Library functions and macros may behave differently, or be called in a different manner, on the two systems. Environmental variables, which provide a way to make information about a program's environment available to programs, may not be defined in the same way on the two systems.

For a list of differences in keywords, data types, libraries, and environment variables on HP-UX and the Solaris OS, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 4-5: Language Differences Between HP-UX and the Solaris Operating System*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Transitioning to ISO C

Developers with applications written in the K&R style may wish to take advantage of features in the ISO C language on Sun systems. When transitioning to ISO C, keep in mind that:

- *Basic modes may be different.* The ISO C compiler allows both old-style and new-style C code. The compiler provides varying degrees of compliance to the ISO C standard when using some of the -X compatibility and conformance options.
- *Old-style and new-style functions are supported.* When writing a new program, use new-style function declarations (function prototypes) in headers, and new-style function declarations and definitions in other C source files for maximum portability. Existing applications can take advantage of ISO C function prototypes by simply recompiling the application, adding function prototypes to headers and source files, and changing all function declarations and definitions. These steps can be used singly or in combination, depending on the amount of code developers are willing to change. In many cases, old-style and new-style functions can be supported simultaneously.

- *Functions with varying arguments are supported.* ISO C encourages developers to use prototypes to specify the parameter types expected by a function. The syntax for prototypes includes a special ellipsis (...) terminator, and all declarations and the definition of a function should include it. A special set of macros, contained in the *stdarg.h* file, provides function access to these arguments.
- *Promotions may be handled differently.* Compilers on varying systems may adhere to different standards when it comes to handling unsigned values. Some compilers use an *unsigned preserving* rule which causes an unsigned type to be widened (if needed) to an unsigned type, as well as an unsigned type resulting from the mixtures of a unsigned and signed types. Other compilers, like the ISO C compiler, implement a *value preserving* rule in which the resulting type depends on the relative sizes of the operand types. When an unsigned character or unsigned short is widened, the resulting type is an integer, if an integer is large enough to represent all the values of the smaller type. Otherwise, the resulting type is an unsigned integer. The value preserving rule produces the least surprising arithmetic result for most expressions.
- *Tokenization and preprocessing may be implemented differently.* Previous generation C compilers performed tokenization and preprocessing differently from one another. The functions transform each source file from a characters into a sequence of tokens that are ready to parse. While all compilers included support for recognizing white space and comments, bundling characters into tokens, handling preprocessing directive lines, and performing macro replacements, their respective ordering was never guaranteed until ISO C.
- *Multibyte and wide characters are supported.* Internationalization efforts led to ISO C defining how multibyte and wide characters are handled. These capabilities are important when supporting Asian languages.
- *ISO C defines standard headers and reserved names.* ISO C includes library functions, macros, and header files. Many of these now have reserved names that should be avoided by application developers.
- *Expression grouping and evaluation may be handled differently.* Many C compilers, particularly those supporting K&R C style, are free to rearrange expressions involving adjacent operators that are mathematically commutative and associative, even in the presence of parentheses. However, ISO C compliant compilers do not perform such rearrangements.
- *Incomplete types are supported.* The ISO C compiler supports *incomplete types*—void, arrays of unspecified length, and structures and unions with unspecified content. Incomplete types can be defined by specifying the content in a subsequent declaration in the same scope for the same tag.
- *Compatible and composite types are supported.* ISO C compiler support *compatible types*, two declarations that refer to the same entity but are not identical. Compatible types are, in essence, close enough to the desired type. *Composite types* result when two compatible types are combined. While many K&R style C compilers support compatible and composite types, not all do so. Developers migrating applications from a K&R style compiler to an ISO C compiler may wish to take advantage of this functionality.
- *The lint utility can help the migration process.* The `lint` program can be used to check C source code for errors that may cause a compilation failure or unexpected runtime results. In many cases, the lint program warns developers about incorrect, error-prone, or non-standard code that the compiler may or may not flag. The lint program operates in two modes. The Basic (default) mode performs structure and flow analysis, constant propagations, constant expression evaluations, control and data flow analysis, data type usage analysis, and more. The Enhanced mode includes all of the processing performed in Basic mode, as well as detection of

unused directives, variables and procedures, usage of deallocated memory, usage of variables prior to initialization, deallocation of non-allocated memory, and more.

- *The `libfast.a` library can be used for performance tuning.* This library provides speed-tuned versions of standard C library functions. Because it is an optional library, it may use algorithms and data representations that may not be appropriate for the standard C library, even though they improve the performance of most applications. In general, the `libfast.a` library should be used if integer multiplication or division is important, or if memory allocation performance is important and the size of most commonly allocated blocks is close to a power of two. The `libfast.a` library can also be used if the performance of a block move or fill routine is important. However, the `libfast.a` library should not be used if the application is multithreaded or requires user mode, or if memory-mapped access to an I/O device that does not support 64-bit memory operations is required.

For detailed information on the issues related to transitioning to ISO C, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-4: Application Development Environment*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Migrating C++ Applications

The Sun C++ compiler, the Compaq C++ Version 6.2 for Tru64 UNIX, and the HP aC++ compiler all support the ANSI/ISO International Standard, reference designation number ISO/IEC 14882:1998. However, some changes in the definition of the C++ language prevent compilation of some older source code without minor changes. For example, some header file names have changed, and if used, source code must be modified to reflect these new file names.

The Sun C++ compiler provides two modes of operations: compatibility and standard mode. In compatibility mode, the compiler generates code that is fully binary compatible and mostly source compatible with earlier C++ 4 compilers. In standard mode, the compiler implements most of the C++ international standard, but may not be compatible with these earlier C++ compilers. When updated for compilation in standard mode, applications benefit from features that are not available in compatibility mode, including 64-bit support.

More information on migrating C++ applications to Sun systems can be found in the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-4: Application Development Environment*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf, as well as the *C++ User's Guide* located at <http://docs.sun.com/app/docs/doc/806-3572?q=compiler>.

Migrating to Fortran 95 from FORTRAN 77

The Sun Studio Fortran compiler is a Fortran 95 compiler that conforms to published Fortran language standards, and provides many extended features, including multiprocessor parallelization, sophisticated optimized code compilation, and mixed C/Fortran language support. While some HP-UX and Tru64 Fortran applications were created using Fortran 95 semantics and compilers, many legacy applications used FORTRAN 77. While Sun's Fortran 95 compiler accepts many FORTRAN 77 features directly, some may require compiling in FORTRAN 77 compatibility mode. To ensure continued portability, applications using non-standard FORTRAN 77 features should be migrated to standards-conforming Fortran 95. For detailed information on compatible FORTRAN 77 features, compilation options to use, a list of compatibility issues, and notes about linking Fortran 95 applications with FORTRAN 77

compiled routines, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-4: Application Development Environment*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

COBOL

Because not all COBOL compilers are available on all systems, be sure to keep the following in mind when migrating COBOL applications from Tru64 or HP-UX to the Solaris OS.

- Check COBOL syntax differences by compiling source code from the source machine on the target machine. Then resolve errors in the first few listings. Thereafter, repeating errors are due to different dialects of COBOL on both systems, which need to be fixed. An automated tool can be developed using a scripting language or tool (such as `sed`, `awk`, or `grep`) to perform most of these tasks.
- Locate and change operating system dependencies manually. One way to do this is to search for all `CALL` statements in the source code to find different routines that are called, and how many times they occur on an overall program basis. Changes then can be implemented.
- Translate job control language and data files to the target system.

Fortunately, the ACUCOBOL-GT developer suite is available on HP-UX and the Solaris OS, helping to ease the transition between systems. This development and runtime system includes a COBOL compiler along with a COBOL Virtual Machine, the Vision Indexed file system, a source-level interactive debugger, portable library routines, and support utilities for developing and deploying client-server and standalone applications. The COBOL Virtual Machine enables compiled COBOL applications to be moved between operating environments without modification or recompilation, facilitating application portability. Key features include:

- Interoperates with C and Java applications
- Provides access to leading RDBMSs, ODBC, ISAM, and EXTFH-compliant data
- Provides compatibility with other COBOL compilers, including HP COBOL II/XL, ICOBOL, RM/COBOL version 2 (ANSI 74), and RM/COBOL-85 (ANSI 85)

For more information on porting COBOL applications, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-4: Application Development Environment*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Development Tools

A variety of development tools are available on the Solaris OS, including many that are bundled with the operating system.

- *Modular Debugger*

The Modular Debugger (MDB) is an extensible utility for low-level debugging and editing of a live operating system, operating system crash dumps, user processes, user process core dumps, and object files. MDB provides a customizable environment for debugging these programs and scenarios, including a dynamic module facility that developers can use to implement their own debugging commands to perform program-specific analysis. Each MDB module can be used to examine the program in several different contexts, including live and post-

mortem. More information on the MDB utility can be found in the Solaris Modular Debugger Guide located at <http://docs.sun.com/db/doc/806-5194>. In addition, the MDB utility is available for download at <http://developers.sun.com/prodtech/solaris/driverdev/downloads/index.html>

- *Solaris Dynamic Tracing (DTrace) Facility*

The Solaris Dynamic Tracing (DTrace) facility is a dynamic tracing framework that provides top-to-bottom system observability for troubleshooting systemic problems in real time. Designed to quickly identify the root cause of system performance problems, Dtrace combines over a hundred thousand trace points with a powerful scripting language and a simple, interactive command-line interface. It works by safely and dynamically instrumenting the running operating system kernel and applications with over a hundred thousand trace points that are completely passive until enabled. These trace points can be enabled quickly for data collection, and then disabled again to minimize performance impacts on the system being examined. With this information, developers can rapidly identify performance bottlenecks, optimize resource utilization and performance, and quantify resource requirements. More information on DTrace technology can be found on the BigAdmin System Administration Portal at <http://www.sun.com/bigadmin/content/dtrace/>. In addition, a flash demo can be found at http://www.sun.com/software/media/flash/solaris_dtrace_web/index.html.

- *libumem*

The object-caching memory allocation library, `libumem`, is a standard shared library that provides fast, scalable memory allocation to user-level applications, including multithreaded applications. It provides access to the standard `malloc(3C)` family of functions, as well as the flexible `umem_malloc(3MALLOC)` functions, and powerful object-caching services described in `umem_cache_create(3MALLOC)`. Extensive debugging support, including detection of memory leaks, buffer overruns, multiple frees, use of uninitialized data, use of freed data, and many other common programming errors is also provided. More information on the `libumem` library can be found in the `libumem(3LIB)` man page. Information on using the `libumem` library to identify memory management flaws in applications can be found on the Sun Developer Network at http://developers.sun.com/solaris/articles/libumem_library.html

- *Development tools*

Solaris OS includes several development tools, include the `make()` utility, a source code control system (`scs`), and GNU tools.

Solaris OS Analyzer for C/C++ and COBOL Source Code

The Solaris OS Analyzer for C/C++ and COBOL Source Code is a Java technology-based application designed to help identify porting issues in C/C++ and COBOL source code files. This utility analyzes the difficulty of porting source files from other platforms to Solaris OS, which helps to estimate the total effort required for the port. The Solaris OS Analyzer for C/C++ and COBOL Source Code identifies potential problems during the porting effort by providing:

- Names of potential porting issues
- Sources with potential porting issues
- Solutions for resolving select porting issues

Use of the Solaris OS Analyzer for C/C++ and COBOL Source Code can save significant time and effort for developers working with large projects. For example, this tool can aid the porting effort by searching for HP-UX or Tru64-

specific APIs used in the target source files, and providing suggestions on how to port some of those APIs. More information on the Solaris OS Analyzer for C/C++ and COBOL Source Code can be found in the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 1-3: Solaris OS Analyzer for C/C++ and COBOL Source Code—Version 1.2.1 (formerly JScore)*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf. The tool is available for download on the Sun Web site at <https://partneradvantage.sun.com/partners/migration/tools.html>

Sun Studio

Sun Studio software contains C, C++, and Fortran compilers, which include advanced features for developing applications for the Solaris OS running on SPARC, x86 and x64 systems. These compilers utilize a common, optimizing, back-end code generator, and accept standard C, C++, and Fortran with extensions for 32-bit and 64-bit applications. Sun Studio provides:

- An integrated development environment built on the NetBeans™ open tools platform that is tuned for the needs of the C, C++, and Fortran developer and enables applications to be easily edited, compiled, debugged, and tuned
- Multithreading development tools for developing and tuning multithreaded/multiprocessing applications
- A visual graphical user interface (GUI) builder to quickly develop graphical user interfaces in the C, C++, and Java programming languages
- Libraries, including floating-point arithmetic, file space management, LAPACK version 3.0, BLAS, Fast Fourier Transform (FFT) routines, convolution and correlation routines, and much more
- Performance analysis tools, enabling program performance assessment, problem identification, and errant source code location
- Java technology support, enabling traditional languages, such as C, C++, and Fortran, to be integrated with the Java language
- Compatibility with Sun Performance Library software, providing maximum performance for matrix algebra and signal processing

More information on Sun Studio, including features and compatibility between K&R and ISO C can be found in:

- *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-4: Applications Development Environment*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf
- *Sun Studio Compilers and Tools*, located at <http://developers.sun.com/prodtech/cc/>

DProfile

Integrated in Sun Studio 11, DProfile is a system performance tool that helps developers optimize code and administrators tune systems. A complement to the Solaris Dynamic Tracing Facility, DProfile provides in-depth, drill-down diagnostics and identifies inhibitors to maximum scalability. It provides complete observability of data motion in Sun's computing systems. By spanning both hardware and software, DProfile provides users with unprecedented insight into the flow of data through the system. With DProfile, performance bottlenecks can be

identified rapidly, leading to faster resolution of system-level hot spots. More information on DProfile can be found at <http://www.sun.com/software/products/studio/> on the Sun website.

Sun Java Studio

Sun Java Studio is an integrated development environment (IDE) for the Java platform that facilitates the creation of Java technology-based components, Web-tier applications, and Web services. Sun Java Studio provides:

- Fast and optimal Web application construction and deployment
- Dynamic creation of enterprise-strength Web applications through an interactive and intuitive graphical environment
- A formal Model entity and View framework (MVC type II), offering developers a common interface for using any enterprise resource and reusing common presentation logic
- Well-defined events with a Controller architecture that provides both centralized and distributed implementations
- Out-of-the-box page components and dynamic third-party component discovery within the visual environment
- Integrated Unit Testing with JUnit and improved ClearCase and CVS Support
- Dynamic STRUTS import capabilities

More information on Sun Java Studio Standard and Enterprise Editions can be found at <http://www.sun.com/software/sundev/jde/index.xml> and <http://www.sun.com/software/products/jsenterprise/index.xml>

Application Programming Interface (API)

Tru64, HP-UX and the Solaris OS are UNIX systems that follow the POSIX standard and provide a well-defined system call interface to access kernel facilities. While most of the calls are identical on these systems, there are some differences. In some cases, functions with the same name may take different parameters, or behave differently, depending on the platform. Also, some calls are available only on HP-UX or Tru64, or only on the Solaris OS. Detailed information on API differences can be found in *Chapter 4-10: API Call Differences* of the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers* located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf. This chapter details differences in differences in system calls in the following areas:

- File system calls
- Process-related call
- Shared memory calls
- Multithreading calls
- Interprocess communication calls

Shell Scripts

The UNIX environment has a long history of multiple tools or utilities working together to accomplish a larger task. IT staff, administrators, and programmers alike often use *scripts* to automate development, administration and reporting. Scripts provide an easy way to automate application compilation, create tools to administer an application, analyze or modify data, and to provide functional support for an application. Note that scripts do not

just do the work themselves—they can leverage programs and utilities that exist elsewhere in the operating environment to perform various administrative tasks. While there are great similarities between the Tru64, HP-UX, and Solaris OS scripting environments, it is important to be aware of possible differences. Some possible issues include:

- Command not available
- Command is in a different location
- Command uses an option, or flag, which does not exist in the Solaris OS version
- Command uses an option, or flag, which provides different functionality in the Solaris OS version
- Command output is different and/or redirected to a different location

Many of these issues can be found through the use of Sun tools and utilities designed to assist in migration. For example, Sun's `scriptran` tool reports issues caused by differences between existing Tru64 and HP-UX scripts and Solaris OS scripts. `scriptran` reports many issues which may then be corrected before the script is used in the Solaris OS. More information on the `scriptran` utility can be found at http://developers.sun.com/prodtech/solaris/downloads/lincat/lincat_3.html

Tools to Help the Porting Process

Several tools are available for download at <https://partneradvantage.sun.com/partners/migration/tools.html> to help automate the porting of Tru64 and HP-UX applications to the Solaris OS. These tools include:

- *Appcert*, helps identify potential binary compatibility issues when porting applications to the Solaris OS
- *Oldworld and Newworld utilities*, aid in moving system configuration from HP-UX to the Solaris OS
- *Scriptran utility*, scans shell scripts and reports identified compatibility issues
- *Solaris Migration Tool for HP-UX and Tru64*, provides emulation libraries, tools for scanning source code, and clickable reports on changes required to port source code
- *Solaris OS Analyzer for C/C++ and COBOL Source Code*, analyzes issues in porting C/C++ source files
- *Solaris OS Implementation for HP-UX API*, a free downloadable library which provides a Solaris OS implementation of a subset of server-based HP applications

Chapter 3

Data Migration

Data migration is the movement of application data—which may be in the form of a database or sets of files on a file system or other storage medium—from a system using one operating environment to another. One of the most important aspects of system migration, data migration may range from the trivial, such as restoring a backup from tape, to complex sequences involving multi-step network data transfers and data transformation. When migrating from the Tru64 or HP-UX environments to the Solaris OS, it is important to understand whether and how file systems and data are potentially affected, and to determine how best to move data from one platform to another.

File System Types

The Tru64 and HP-UX operating environments provides users with a rich suite of file systems. Solaris OS supports many of these, enabling users to simply mount existing file systems rather than migrate them. In particular, the Solaris OS supports the Advanced File System (AdvFS) widely used on Tru64, as well as PC-FS, providing the ability to integrate with Microsoft Windows-based systems with ease. Table 3-1 list many common file systems and details their availability on HP-UX, Tru64, and the Solaris OS.

Table 3-1. File systems supported on HP-UX, Tru64, and the Solaris OS

File System	Description	HP-UX Support	Tru64 Support	Solaris OS Support
CacheFS	Used to improve the performance of remote file systems or slow devices, such as CD-ROM drives. When a file system is cached, data read from the remote file system or CD-ROM is stored in a cache on the local system.	•	—	•
CDFS	CD-ROM file system.	•	•	•
FDFS	Provides explicit names for opening files using file descriptors.	•	•	•
FFM	File-on-File Mounting System. Used to mount one directory on top of another directory	—	•	—
FIFOFS	First-in, first out file system. Provides named pipe files that give processes common access to data.	•	•	•
HSFS	High Sierra File System, ISO 9660, the first CD-ROM file system	•	—	•
LOFS	Loopback File System. Allows the creation of a new virtual file system so that files can be accessed using an alternative path name.	•	—	•
MNTFS	Provides read-only access to the table of mounted file systems for the local system.	•	—	•
NAMEFS	Used primarily by the STREAMS facility for dynamic mounting of file descriptors on top of files.	•	—	•

Table 3-1. File systems supported on HP-UX, Tru64, and the Solaris OS

NFS	Network file system.	•	•	•
PCFS	PC file system. Allows read and write access to data and programs on DOS formatted disks that are written for DOS-based personal computers.	•	•	•
PROCFS	Resides in memory and contains a list of active processes, by process number, in the /proc directory	•	•	•
SPECFS	Provides access to character special devices and block devices	•	•	•
SWAPFS	Used by the kernel for swapping	•	•	•
TMPFS	Uses local memory for file system reads and writes, which is typically faster than a UFS file system	•	•	•
Tru64 AdvFS	Tru64 Advanced File System	•	•	•
Tru64 CFS	Tru64 Cluster File System	—	•	—
Tru64 MFS	Tru64 Memory File System	—	•	—
UDF	Universal Disk Format file system. An industry standard format for storing information on optical media technology, such as DVD media.	•	•	•
UFS	UNIX file system	—	•	•

File System Size

The maximum file size supported by the file system, and thus the operating system, can limit the maximum file size supported by a computer configuration. When the maximum file system size is reached workarounds, such as splitting a file or database into multiple parts or distributing it across multiple machines, are often required. Such solutions increase management complexity by requiring more IT resources, and their associated costs. The Tru64 Advanced File System (AdvFS) scales to a maximum of 16 TB. The standard HP-UX file system scales to 1 TB. The Solaris OS, combined with the Sun™ SAM-FS file system and QFS, scales to 252 TB. As a result, organizations migrating from HP-UX or Tru64 to the Solaris OS should not experience file system size issues.

Data Transformation

Data transformation is the process of converting data from one format to another, and is an important component of any migration effort if data is to be readable on the target system. Data transformation may involve file systems, file content, application, and database content.

Encoded Data Transformations

Encoded data transformations are necessary when data is stored in a different or incompatible file format than the receiving system anticipates. Fortunately, Tru64, HP-UX, and the Solaris OS both use ASCII to store textual data, as well as a standard text file format. As a result, issues stemming from the use of other character sets, such as

EBCDIC, and differences in text file formatting, such as the use of control-linefeed (CR/LF) versus carriage return (CR) characters to delimit lines in a file, are avoided. Furthermore, IT staff can take advantage of their training and knowledge in UNIX tools and conventions to quickly and easily migrate Tru64 text files and data to Sun systems.

Application Data Transformation

Tru64, HP-UX, and the Solaris OS provide many common applications and utilities for managing data. For example, the tape archive utility (`tar`) uses a similar data format and provides many common options in both environments. As a result, IT staff already familiar with the `tar` utility in the Tru64 or HP-UX environment will be immediately productive on the Solaris OS. This commonality is true for many other applications and utilities, and can yield significant benefits both during and after the data migration. For those applications which differ between Tru64, HP-UX, and the Solaris OS, most provide a utility to convert standard data interchange formats, such as comma separated values or tab delimited files, into their format.

Database Transformation

Many organizations use large databases to provide needed performance, and many of these are available for Tru64, HP-UX, and the Solaris OS. Organizations may have an older version of a database running in the Tru64 or HP-UX environment, and licenses may or may not be available for those versions on the Solaris OS. Enterprises should be prepared to purchase a current version of the database software. It is important to note that changes to the infrastructure may be needed to support the new database and its configuration, however existing data should be immediately accessible.

While there are many similarities between a database running on Tru64 or HP-UX and one running on the Solaris OS, simply moving a database from one to the other likely requires some data transformation. In the case of the same database vendor in both environments, this may be as simple as exporting the database running on Tru64 or HP-UX to a standardized file format, followed by an import into a new database on the Solaris OS. When the migration also involves a change in database vendors, more extensive data transformations may be required. Because database transformations are usually such a large part of the overall migration, many specialized utilities have been created to address them. These programs, called Extract, Transform, and Load (ETL) utilities, take a wide array of formats and convert them into Structured Query Language (SQL) for relational database management systems (RDBMS). Most RDBMSs provide a basic set of utilities to convert SQL or standard interchange formats into their data storage format. Furthermore, Sun experts can aid the database transformation process, resulting in a lower cost migration that is quick and efficient.

Data Transfer Media

The speed of the network connecting the HP and Sun systems, the quantity of data to be transferred, the amount of conversion required, and the amount of downtime acceptable must all be considered when determining the optimal data transfer medium. Since virtually all UNIX systems support TCP/IP and Ethernet standards, the network is the preferred method for data transfer from Tru64 or HP-UX to the Solaris OS. However, in the event it is inappropriate to use a network, such as wide area network (WAN) transfers over a slow link, other techniques (such as physical transfer of storage media) may have to be implemented.

Chapter 4

Operating System Considerations

Organizations migrating from Tru64 or HP-UX to the Solaris OS can take comfort in the fact that the two operating environments share a common heritage—and consequently enjoy more similarities than differences. All are 64-bit versions of UNIX, with common application programming interfaces (APIs), languages, protocols and data models. Because Tru64, HP-UX, and the Solaris OS have common underlying architectural and design philosophies, developers and administrators can leverage their expertise across the migration. However, migration is never a trivial issue, even between similar systems such as Tru64, HP-UX, and the Solaris OS. As a result, organizations may need to consider how the existing environment and applications are affected by potential differences in several areas.

Directory Structure

Tru64, HP-UX and the Solaris OS use different directory layouts, as well as the standard defines related to them. For a detailed listing of the Solaris OS hierarchy, including a description of each directory, see the *Migration Resource Guide—For Project Managers, Technical Architects, and Developers, Chapter 6-2: Porting Considerations*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf

Device Naming Conventions

Tru64, HP-UX, and the Solaris OS use device names as a means to give users and applications controlled access to devices and critical system resources such as disk drives, network adaptors, memory and I/O channels. Controlled access to such resources is key to a high performance, reliable, secure enterprise data center. Protecting business information, whether on-line or archived, requires that the same security level which is applied to on-line files and databases also be applied to archive devices such as tape drives or removable media. Doing so ensures only users and applications with proper authorization are allowed to access backups and other important archived data.

Tru64, HP-UX, and the Solaris OS place all device resources into a highly secure file name hierarchy used for files and directories, bringing the full power of the security system to device access and control—in a uniform manner across all devices. By treating device access just like file access, existing, proven Solaris OS security models are automatically applied, closing potentially devastating back-door security flaws that can render data vulnerable to unauthorized users or applications.

While the actual directory placement and naming of devices varies when migrating from Tru64 and HP-UX to the Solaris OS, the device security and control semantics—involving operating system calls such as `open()`, `ioctl()`, and `close()`—are the same. The result is that porting an application that interacts with device control software, such as a device driver, from Tru64 and HP-UX to the Solaris OS is straightforward. Developers only need to change the file system hierarchy location and device name in the source code and recompile in the Solaris environment. Program control logic need not be modified. IT staff familiar with Tru64 and HP-UX device naming conventions retain their existing UNIX and architectural knowledge across the migration, eliminating the need for administrative re-training.

More information on devices and device naming conventions in the Solaris OS can be found in the *Solaris System Administration Guide: Devices and File Systems* located at <http://docs.sun.com/app/docs/doc/819-2723?q=device+naming+convention>

Support for Unique Hardware

In order to support unique, proprietary hardware, and to take advantage of special features, the Tru64 and HP-UX operating systems may require special additions or modifications, such as a new device driver or other software module. Ordinarily, such customized software needs special attention when migrating from one operating system to another. Fortunately, Tru64, HP-UX, and the Solaris OS provide a similar device driver model and architecture, easing the porting issues when such specialized, custom software is needed. As a result, the migration effort can leverage existing device expertise to provide a lower cost, more efficient transition with less risk. Sun provides several products, technologies, and services that facilitate the migration of specialized hardware:

- *Device Driver Interface and Driver Kernel Interface (DDI/DKI)*

For years, Solaris OS has included the Device Driver Interface and Driver Kernel Interface (DDI/DKI), enabling the development of device drivers that operate with full source-level compatibility across multiple platforms and instruction sets architectures, including x86 and UltraSPARC (Figure 4-1). Host bus dependencies must be removed from the device driver in order to produce multiple platform, multiple instruction set architecture portability. Sun's mature DDI/DKI provides operating system resources, configuration properties, device mapping, and low-level I/O access to device drivers. Use of the DDI/DKI provides an abstraction layer, helping to isolate the device driver from hardware, as well as offering portability, cleaner control logic, and a consistent interface across similar devices. Device drivers maintain their portability by adhering to a standard suite of interfaces rather than directly accessing the system resource or I/O device, and the issue of working with 32- and 64-bit data is greatly simplified. More information on the Solaris DDI/DKI can be found in the development resources listed at the end of this document.

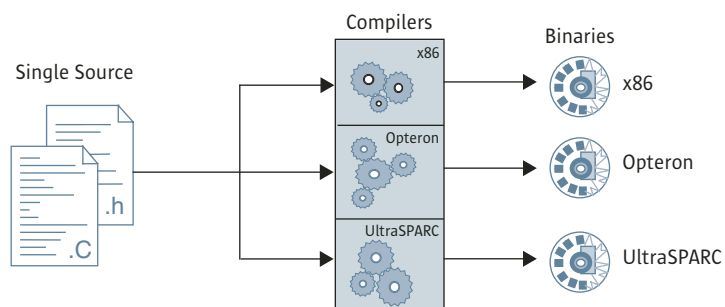


Figure 4-1. Sun's DDK/DDI enables a single set of driver source to be compiled for multiple platforms

- *Sample device drivers, documentation and tools*

Sun provides sample device drivers, documentation, installation instructions, operating instructions and downloadable tools that support device driver development efforts for all Solaris platforms. These tools can be found in the Source for Developers section located at <http://developers.sun.com> on Sun's Web site.

- *Sun expertise and services*

Sun offers a comprehensive, integrated package of life cycle services, developer migration programs, and partner skills to ease the transition to Sun systems. Sun experts can help organizations analyze, rehost or migrate existing software onto Sun systems. Migration consultation and assessment, as well as porting services are available. These services, combined with Sun's commitment to a long term roadmap of technology enhancements and support, help enterprises maintain current functionality and protect software investments by rehosting them to the Solaris operating system.

- *Open standards*

Open standards help ensure operability across heterogeneous platforms, systems, and environments, and give organizations the flexibility to incorporate additional capabilities as they are needed. Because AlphaServer, HP, and Sun systems are based on open hardware standards, such as the Peripheral Component Interconnect (PCI) bus, migrating compliant devices to Sun systems is straightforward.

64-Bit Data Models

With the price of memory continuing to tumble, organizations are reaping the performance advantages of keeping more application data in main memory rather than on disk. Although few require an entire 64-bit address space, the impact of more than 32 bits of address space benefits a wide variety of commercial and high-performance computing applications. For example, databases, Web caches, simulation and modeling software run more effectively in the much larger primary address space of a 64-bit architecture. These benefits include:

- A greater proportion of a database can live in primary memory
- Larger CAD/CAE models and simulations can live in primary memory
- Larger scientific computing problems can fit in primary memory
- Web caches can hold more data in primary memory and reduce access latency
- The wider data paths of a 64-bit processor offer improved computational performance

Tru64, HP-UX, and the Solaris OS provide 64-bit computing using the LP64 data model, in which longs and pointers are 64 bits in length. With the same 64-bit data model, application modifications are minimized when migrating from Tru64 and HP-UX to the Solaris OS. Both operating system kernels provide the larger data paths and primary address space 64-bit applications demand. As a result, applications which rely on these features are well positioned to take advantage of the scalability, manageability, and reliability provided by Sun systems.

Not all applications are well suited to a 64-bit model. If the application does not require a large primary address space or wider data path, migrating the application to the 64-bit model may not be warranted. In such situations, Solaris OS provides support for applications written using a 32-bit computing model, enabling a smooth transition yet providing access to 64-bit computing and other features should the need arise.

It is important to note that many size issues can be mitigated when migrating between data models by using *derived types*, a mechanism for specifying the size of an attribute or its intended use. The use of derived types—which are safe for both 32- and 64-bit environments—increases program clarity and portability, helping to mitigate differences in the hardware environment.

More information on using derived types in the Solaris OS can be found in the *Solaris 64-bit Developer's Guide* located at <http://docs.sun.com/app/docs/doc/806-0477?q=derived+types>, as well as *Chapter 6-4: Application Development Environment of the Migration Resource Guide* located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

Threading Models

To maximize performance, applications can be architected to execute many tasks simultaneously. To make this possible, the operating system provides support for concurrent processing, such as multiple threads, shared memory, and asynchronous I/O. At the application level, the Solaris OS user-level threads library provides a mechanism for exploiting multitasking. Using user-level threads, applications can be decomposed into subtasks to take advantage of multiple processors.

Solaris OS supports both POSIX and Solaris threads at three levels:

- The kernel uses one thread to handle each system call and interrupt, allowing multiple CPUs to accelerate kernel tasks.
- The user code to kernel interface uses multiple light weight processes (LWPs) — software representations of processors — allowing a single user process to have multiple outstanding system calls and be scheduled onto multiple CPUs.
- A user mode thread library allows very lightweight thread switching and large numbers of threads, using LWPs as virtual processors to run the threads.

Solaris OS allows an application to control how many threads and LWPs it needs to maximize performance and minimize kernel overhead. One application might have multiple threads all using the same LWP, the method most existing thread libraries use on conventional uniprocessor UNIX implementations, executing only one thread at a time. Another application might use multiple threads and multiple LWPs because it needs to have several outstanding system calls, or because it needs to execute on multiple CPUs simultaneously.

Threads are the primary interface for application parallelism. Multithreaded application programs can be written without regard to the number of CPUs configured on the target machine — the thread library detects whether there are insufficient LWPs to run the program efficiently, and can automatically start more LWPs as needed.

Based on the POSIX Standard

Solaris OS continues to create, track, and provide support for evolving industry standards. The POSIX P1003.4a Pthreads standard is incorporated at the user library level, allowing Solaris OS to quickly respond to evolving standards. The Solaris OS thread interface is a superset of the POSIX 1003.4a standard, and has been adopted by UNIX International as the standard thread interface for the multiprocessor extensions to UNIX System V Release 4.

Solaris OS, with POSIX thread libraries and support for the Tru64 POSIX thread extensions, offers a low-risk migration from Tru64 or HP-UX to the Solaris OS. Since all three operating systems support POSIX, applications do not require extensive modifications or rewrites, enabling them to be quickly and easily moved from the Tru64 or HP-UX threading model to the Solaris OS threading model.

The *Migration Resource Guide—For Project Managers, Technical Architects, and Developers* available at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf contains information on the differences in threading models between the different platforms:

- *Chapter 4-2 Architectural Issues of Migration from HP-UX to the Solaris Operating System* discusses POSIX threads in both the HP-UX and the Solaris OS
- *Chapter 4-10 API Call Differences* itemizes the differences in system calls between HP-UX and the Solaris OS
- *Chapter 4-11 Implementation of Threads on Solaris* discusses the differences in the threads implementation in the Solaris OS versus POSIX
- *Chapter 4-14 Multithreading APIs* provides code samples that illustrate methods for implementing equivalents of HP-UX multithreading API calls on the Solaris OS
- *Chapter 6-2 Porting Considerations* lists the POSIX standards supported on Tru64 and the Solaris OS
- *Chapter 6-5 Porting Threaded Applications* reviews the issues related to porting threaded applications from Tru64 to the Solaris OS

Internationalization

The Solaris internationalization architecture provides a flexible, pluggable method of handling input methods, character set encodings, codeset conversion, and other basic aspects of language services. Applications can be deployed in multiple language environments without knowing how input methods work or which codeset converter needs to be enabled, simply by following standard APIs. Language attributes can be customized, and converter tables can be changed as needed. In particular, the Solaris OS includes:

- *Full Unicode 3.1 support*
The Solaris OS includes full Unicode 3.1 support, as defined in Unicode and ISO/IEC 10646, for selected locales. Extensive support for over 39 languages and 162 locales is provided, including complex text layout environments needed to support Thai and Hindi, and bidirectional layout environments for languages such as Arabic and Hebrew. Additional information can be found in *Unicode Support in the Solaris Operating Environment* located at <http://docs.sun.com/app/docs/doc/806-5584?q=unicode>.
- *Localization functions and environment variables*
Tru64, HP-UX, and the Solaris OS all include the concept of *locales*, explicit models and definitions of native-language environments. The notion of a locale is explicitly defined and included in the library definitions of the ANSI C language standard. Because the HP and Sun compilers support this standard, and provide a consistent set of localization functions and environment variables, migrating applications from Tru64 or HP-UX to the Solaris OS should be straightforward.
- *Codeset independence*
Many areas around the globe, such as those utilizing PC-Kanji in Japan, Big5 in Taiwan, and GBK in the People's Republic of China, rely on non-Extended UNIX Code (non-EUC) codeset support. To address these concerns, yet maintain maximum application portability, the Solaris OS provides a Codeset Independence (CSI) framework that enables both EUC and non-EUC codeset support. The CSI framework aims to remove dependencies on specific codesets or encoding methods from Solaris libraries and commands. Codeset independence enables application and platform software developers to keep source code independent of encoding such as UTF-8, and also provides

the ability to adopt new encoding without having to modify the source code. While Tru64, HP-UX, and the Solaris OS all support EUC and non-EUC codesets, implementations may differ, and applications may or may not need porting to the Solaris CSI framework to support internationalization efforts.

- *Internationalization APIs*

The Solaris OS provides APIs for multibyte (file code) and wide character (process code) that can help keep track of maintaining proper character boundaries when using multibyte characters. These APIs include messaging functions, code conversion, regular expressions, the wide character class, locale queries, character classification and transliteration, character collation, monetary and date and time formatting, and more.

- *Porting utilities*

The Solaris OS includes porting utilities focused on internationalization. The `genmsg` utility can be used with the `catgets()` family of functions to create internationalized source message catalogs. It examines source program files for calls to functions in `catgets` and builds a source message catalog from the information it finds. The `geniconvtbl` utility enables user-defined and user-customizable codeset conversions with a standard system utility and interface like `iconv(1)` and `iconv(3C)`, enhancing the ability of applications to deal with incompatible data types, particularly data generated from proprietary or legacy applications. Modification to existing Solaris codeset conversions is also supported.

More information on internationalization support in the Solaris OS can be found in *Chapter 6-6:*

Internationalization of the Migration Resource Guide—For Project Managers, Technical Architects, and Developers, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf.

This chapter provides detailed information on Unicode support, locales supported, localization functions and environment variables, codeset independence, a list of CSI-enabled functions and libraries, internationalization APIs provided, and how to use the porting utilities available in the Solaris OS.

Memory Scalability

The maximum size of main memory directly effects the ability of a system to grow and handle more applications, users, and network requests. While the Tru64 operating system supports 256 GB of main memory, and HP systems running HP-UX support up to 1 TB GB of main memory, the Solaris OS supports a larger memory size. While the largest Sun system currently supports up to 576 GB of main memory, the Solaris OS supports 2^{64} bytes of memory. As a result, memory size should not be an issue when migrating from Tru64 or HP-UX to the Solaris OS.

Additionally, the number of threads available for use is closely related to the amount of memory configured into the system. As a result, the large memory capacity of Sun servers gives developers the flexibility to use as many threads as are needed, thereby increasing application performance.

System Tuning

Once migration from Tru64 or HP-UX to the Solaris OS is complete, attention can turn to system tuning. A key consideration in system tuning is that setting various system variables is often the least effective thing that can be done to improve performance. Changing the behavior of the application is generally the most effective tuning aid available. Adding more physical memory and balancing disk I/O patterns are also useful. In some cases, changing system variables may have a substantial effect on system performance.

- The `/etc/system` settings on Tru64 or HP-UX might not be applicable in the Solaris OS. Carefully consider the values in the `/etc/system` file with respect to the Solaris OS, and make sure system behavior is understood before attempting to apply changes to the system variables.
- It may be necessary to set system parameters relating to physical memory (`physmem`), stack size (`lwp_default_stksize`), and kernel page memory (`segkpsize`).
- The `sysdef ()` and `kstats ()` tools are available on the Solaris OS to examine the system configuration. The `sysdef ()` command provides the values of System V IPC settings, STREAMS tunables, process resource limits, and more. `kstats` are data structures maintained by various kernel subsystems and drivers, and provide a mechanism for exporting data from the kernel to user programs without requiring that the program read kernel memory or have root privilege.
- Issues related to System V tuning, such as message queues, semaphores, shared memory, process sizing tunables, and paging, are different on POSIX compliant systems like the Solaris OS. See *Chapter 6-7 System Tuning Information of the Migration Resource Guide—For Project Managers, Technical Architects, and Developers*, located at https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf for details on differences between the environments.

Integration of Key Infrastructure Software

Many enterprise computing environments utilize a variety of products from a number of vendors to deliver infrastructure services such as directory, email, calendar, identity, and portal services. This can result in a host of potential problems, including high acquisition costs, unnecessary deployment delays, compatibility and interoperability issues, unpredictable schedules, expensive licensing agreements, complicated version control and release schedules, and more.

Sun has taken a radical new approach to software infrastructure to help reduce costs throughout the IT project life cycle from acquisition, through deployment, and on to operation and maintenance. The Sun Java Enterprise System offers a single, comprehensive software system containing all of the critical enterprise infrastructure components every business needs to build applications and services. The software system is a set of open infrastructure network services delivered as a complete, modular system of pre-integrated components that share a common set of technology components, a consistent architecture, and a cohesive user experience. Table 4-1 describes the key infrastructure software products that are integrated into the Solaris OS.

More information on the Sun Java Enterprise System can be found in the *Sun™ Infrastructure Solution for Tru64 Migration—Assessing the Move to Sun Systems* technical white paper located at http://www.sun.com/solutions/documents/white-papers/tru64_tech_wp.pdf?facet=-1, as well as <http://www.sun.com/software/javaenterprisesystem/> on the Sun website.

Table 4-1. The Solaris OS includes a set of modular infrastructure software components

Communication and Collaboration Services	
Sun Java System Calendar Server	Facilitates team collaboration by enabling users to manage and coordinate appointments, events, tasks, and resources.
Sun Java System Instant Messaging	Provides a standards-based, real-time communication and collaboration application, and delivers presence information and extended, real-time messaging capabilities, including instant messaging, conferences, alerts, news, polls, and file transfers.
Sun Java System Messaging Server	Provides a high performance, secure messaging platform that can scale to millions of users. Extensive security features help ensure the integrity of communications through user authentication, session encryption, and appropriate content filtering to help prevent spam and viruses.
Identity Management Services	
Sun Java System Access Manager	Enables secure access to Web applications through open, standards-based authentication and policy-based authorization with a single, unified framework, single sign-on support, and federation across trusted networks.
Sun Java System Directory Server, Enterprise Edition	Provides a central repository for storing and managing identity profiles, access privileges, and application and network resource information.
Sun Java System Identity Manager	Delivers a complete user provisioning and meta-directory solution that enhances enterprise security.
Portal Services	
Sun Java System Portal Mobile Access	Provides mobile access to applications, content, and services through support for many of devices, mark-up languages, protocols, and standards.
Sun Java System Portal Server	Delivers identity-based content, easy-to-use services, and ability to add content and services to portal pages with simple-to-use developer tools accessing Web services or data repositories via a content management system, workflow management, and enterprise integration.
Sun Java System Portal Server, Secure Remote Access	Delivers secure Internet or extranet access to internal portals and Intranet applications through any Java technology-enabled browser. It provides key portal services, including aggregation, presentation, security, personalization, integration, community, policy, access management, and single-sign-on.
Web and Application Services	
Sun Java System Application Server	Provides a J2EE compatible platform for developing and delivering server-side Java applications and Web services.
Sun Java System Message Queue, Enterprise Edition	Provides a standards-based business integration enterprise message server.
Sun Java System Service Registry	Provides the ability to register, discover, and manage services.
Sun Java System Web Proxy Server	Provides network traffic management capabilities, a secure gateway for content distribution, and acts as a control point for Internet traffic.
Sun Java System Web Server	Provides a secure, reliable, easy-to-use Web server, and a single deployment platform for Web services, JavaServer Pages (JSP) and Java Servlet technologies, Microsoft Active Server Pages, PHP, and CGI.

Chapter 5

Platform Infrastructure

When migrating from one platform to another, it is important to choose a server and operating system combination, and storage devices, that can handle business demands now and in the future. By replacing HP systems with Sun servers, and Tru64 or HP-UX with the Solaris OS, enterprises not only solve their immediate needs, they can also improve operational efficiency by consolidating and standardizing onto fewer systems and affecting better resource utilization

Servers

Server scalability is a critical factor when determining how to make the most cost-effective use of computing resources, gracefully handle peak workloads, and grow the computing environment as business needs dictate. Indeed, the careful sizing of a server is essential if the computing environment is to operate at peak efficiency. It is imperative, therefore, that organizations carefully analyze the roles systems play, and usage loads and patterns, and that they ensure sufficient capacity exists for both short and long term growth. Failure to do so places the effectiveness of the computing environment in jeopardy.

Organizations migrating from HP systems to Sun servers can select from a wide range of systems. Table 5-1 can be used to qualify the class of Sun servers to replace HP systems¹. For a comprehensive analysis and sizing of systems, organizations can call on Sun architects to analyze performance, availability, and scalability requirements and help ensure the right platform is selected for the job at hand. Configurations can be simulated in Sun Solution Ready Centers, providing the ability to build and test proof-of-concept demonstrations and run pilot programs, validate architectures, and accelerate the deployment of high quality IT infrastructure solutions.

Table 5-1. A general guide to replacing HP systems with Sun servers

	HP Server	Sun Fire™ Server
Entry Level Servers	1 CPU AlphaServer 4100 (1x300 MHz) AlphaServer 4100 (1x600 MHz) Compaq AlphaServer DS10 (1x616 MHz) Compaq AlphaServer DS20 (1x500 MHz) Compaq AlphaServer DS20E (1x833 MHz) Compaq AlphaServer ES40 (1x500 MHz) Compaq AlphaServer ES45 (1x1000 MHz) HP AlphaServer DS15 (1x1000 MHz) HP AlphaServer DS25 (1x1000 MHz) HP AlphaServer ES45 (1x1250 MHz) HP AlphaServer ES47 (1x1000 MHz)	Sun Fire™ V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz) Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade™ 1500 (1x1062 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade 1500 (2x1062 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade 1500 (1x1062 MHz) Sun Fire V490 (1x1050 MHz) or Sun Blade 1500 (1x1062 MHz) Sun Fire™ V490 (1x1050 MHz, Dual Core) or Sun Fire V240 (2x1280 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade 1500 (1x1062 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade™ 2500 (1x1280 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V240 (2x1280 MHz) Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V240 (2x1280 MHz)

1. Sizing guidelines based on system configurations available as of November, 2005.

		HP Server	Sun Fire Server
Entry Level Servers	1 CPU	HP 9000 rp5470 (1x650 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire™ V250 (2x1280 MHz)
		HP 9000 rp5470 (1x750 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V250 (2x1280 MHz)
		HP Integrity Server rx1600 (1x1000 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core)
		HP Integrity Server rx2600 (1x1500 MHz)	Sun Fire V490 (1x1350 MHz, Dual Core)
	2 CPUs	AlphaServer 4100 (2x300 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz)
		AlphaServer 4100 (2x600 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz)
		Compaq AlphaServer DS20 (2x500 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade 1500 (1x1062 MHz)
		Compaq AlphaServer DS20E (2x833 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Blade 1500 (2x1280 MHz)
		Compaq AlphaServer ES40 (2x500 MHz)	Sun Fire V490 (1x1050 MHz) or Sun Blade 1500 (1x1062 MHz)
		Compaq AlphaServer ES45 (2x1000 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire™ V880 (2x1050 MHz) or Sun Fire™ V40z (1x2600 MHz)
		HP AlphaServer DS25 (2x1000 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V880 (2x1050 MHz) or Sun Fire™ V20z (1x2600 MHz)
		HP AlphaServer ES45 (2x1250 MHz)	Sun Fire V490 (2x1050 MHz, Dual Core) or Sun Fire™ V440 (2x1600 MHz) or Sun Fire™ X4100 (1x2800 MHz)
4 CPUs	HP 9000 rp5470 (2x650 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V250 (2x1280 MHz)	
	HP 9000 rp5470 (2x750 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V250 (2x1280 MHz)	
	HP Integrity Server rx1600 (2x1000 MHz)	Sun Fire V490 (2x1050 MHz, Dual Core)	
	AlphaServer 4100 (4x300 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz)	
	AlphaServer 4100 (4x600 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz)	
	Compaq AlphaServer ES40 (4x667 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Netra™ 20 (2x1200 MHz) or Sun Fire V40z (1x2600 MHz)	
	Compaq AlphaServer ES45 (4x1000 MHz)	Sun Fire V490 (2x1050 MHz, Dual Core) or Sun Fire V480 (4x1200 MHz) or Sun Fire V880 (4x1050 MHz) or Sun Fire™ X2100 (1x2200 MHz)	
	HP AlphaServer ES45 (4x1250 MHz)	Sun Fire V490 (4x1050 MHz, Dual Core) or Sun Fire V440 (4x1600 MHz) or Sun Fire X4100 (2x2800 MHz)	
Mid Range Servers	8 CPU	HP 9000 rp5470 (4x650 MHz)	Sun Fire V490 (1x1050 MHz, Dual Core) or Sun Fire V250 (2x1280 MHz)
		HP 9000 rp5470 (4x750 MHz)	Sun Fire V490 (1x1050 MHz) or Sun Fire V250 (2x1280 MHz) or Sun Fire V20z (1x2400 MHz)
		HP Integrity Server rx4640 (4x1300 MHz)	Sun Fire V490 (4x1050 MHz, Dual Core) or Sun Fire V490 (4x1.5 GHz, Dual Core)
	HP Integrity Server rx4630 (4x1500 MHz)	Sun Fire V490 (4x1350 MHz, Dual Core) or Sun Fire V490 (4x1.5 GHz, Dual Core)	
	8 CPU	AlphaServer 8400 (8x300 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz)
		AlphaServer 8400 (8x612 MHz)	Sun Fire™ V2900 (2x1050 MHz) or Sun Fire V2900 (1x1500 MHz)
Compaq AlphaServer GS80 (8x1001 MHz)		Sun Fire V890 (4x1200 MHz, Dual Core) or Sun Fire V490 (4x1050 MHz, Dual Core) or Sun Fire V40z (4x2400 MHz)	
8 CPU	HP AlphaServer ES80 (8x1150 MHz)	Sun Fire V890 (8x1200 MHz, Dual Core) or Sun Fire™ E4900 (8x1200 MHz, Dual Core) or Sun Fire V490 (4x1.5 GHz, Dual Core)	
	HP AlphaServer GS80 (8x1224 MHz)	Sun Fire V890 (4x1200 MHz, Dual Core) or Sun Fire™ 4800 (8x1200 MHz) or Sun Fire V40z (4x2600 MHz)	

		HP Server	Sun Fire Server
Mid Range Servers	8 CPU	HP 9000 rp7410 (8x750 MHz) HP 9000 rp7420 (8x1000 MHz) HP Integrity rx7620 (8x1500 MHz)	Sun Fire V490 (2x1050 MHz, Dual Core) or Sun Fire V880 (4x1050 MHz) or Sun Fire 4800 (4x1200 MHz) or Sun Fire V40z (2x2600 MHz) Sun Fire E4900 (8x1050 MHz) or Sun Fire™ 6800 (12x1050 MHz) Sun Fire™ V890 (8x1200 MHz)
	12 CPUs	AlphaServer 8400 (12x300 MHz) AlphaServer 8400 (12x350 MHz) AlphaServer 8400 (12x440 MHz) AlphaServer 8400 (12x612 MHz)	Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz) Sun Fire V490 (1x1200 MHz) or Sun Fire V490 (1x1500 MHz) Sun Fire V2900 (2x1050 MHz) or Sun Fire V2900 (1x1500 MHz) Sun Fire V2900 (2x1050 MHz) or Sun Fire V2900 (1x1500 MHz)
	14 CPUs	AlphaServer 8400 (14x440 MHz)	Sun Fire V490 (2x1050 MHz) or Sun Fire V490 (1x1500 MHz)
	High End Servers	16 CPU	Compaq AlphaServer GS160 (16x731 MHz) Compaq AlphaServer GS160 (16x1001 MHz) HP AlphaServer GS160 (16x1224 MHz) HP AlphaServer GS1280 (16x1300 MHz) HP 9000 Superdome (16x552 MHz) HP 9000 Superdome (16x750 MHz) HP Integrity rx8620 (16x1600 MHz) HP Integrity Superdome (16x1500 MHz)
	32 CPUs	Compaq AlphaServer GS320 (32x1001 MHz) HP AlphaServer GS320 (32x1224 MHz) HP 9000 AlphaServer GS1280 (32x1300 MHz) HP 9000 Superdome (32x1000 MHz) HP Integrity Superdome (32x1500 MHz)	Sun Fire E6900 (24x1050 MHz, Dual Core) or Sun Fire 12K (24x1200 MHz) or Sun Fire V890 (8x1.5 GHz, Dual Core) Sun Fire 12K (32x1200 MHz) or Sun Fire V890 (8x1.5 GHz, Dual Core) or Sun Fire E6900 (24x1.5 GHz, Dual Core) Sun Fire™ 25K (28x1200 MHz) Sun Fire E12K (36x1200 MHz) or Sun Fire™ 20K (24x1200 MHz) or Sun Fire E6900 (24x1.5 GHz, Dual Core) Sun Fire 20K (32x1200 MHz) or Sun Fire E6900 (24x1.5 GHz, Dual Core)
	64 CPUs	HP AlphaServer GS1280 (64x1300 MHz) HP 9000 Superdome (64x552 MHz) HP Integrity Superdome (64x1500 MHz)	Sun Fire™ 25K (64x1200 MHz, Dual Core) or Sun Fire E20K (36x1.5 GHz, Dual Core) Sun Fire E6900 (24x1050 MHz, Dual Core) or Sun Fire 12K (24x1200 MHz) or Sun Fire V890 (8x1.5 GHz, Dual Core) Sun Fire 25K (62x1200 MHz)
Clusters	2 node	AlphaServer 8400 (24x612 MHz)	Sun Fire E2900 (6x1050 MHz) or Sun Fire E2900 (4x1500 MHz)
	4 node	AlphaServer 8400 (32x612 MHz)	Sun Fire E2900 (6x1050 MHz) or Sun Fire E2900 (4x1500 MHz)
	8 node	AlphaServer 8400 (64x612 MHz)	Sun Fire E2900 (10x1050 MHz) or Sun Fire E2900 (6x1500 MHz)
	12 node	AlphaServer 8400 (96x612 MHz)	Sun Fire E4900 (12x1050 MHz) or Sun Fire E4900 (8x1500 MHz)

Storage Devices

Planning is critical to any migration effort, and nowhere is that more important than when dealing with storage systems and the valuable data they contain. It isn't uncommon for IT managers to discover migrated data was not converted to the correct format for use with a new application, or a new capability could have been implemented but had not been planned. As a result, any migration effort from Tru64 or HP-UX to the Solaris OS should consider the following factors:

Storage Capacity

It is essential to consider more than just active data when determining storage capacity requirements. Needs that may be overlooked include: new users and applications supported in the new environment, mirrored volumes for business continuity functions, backup data, archived volumes, multitiered storage for data life cycle management, shared volumes for clustered environments, and more. All data storage requirements must be included in the planning.

Current Storage Hardware

Organizations running Tru64 or HP-UX may be able to retain existing HP StorageWorks or EMC Symmetrix drives and install them on the target Sun server and storage platform. While this approach may appear to be cost-effective and to help simplify the migration process, it may not be the case. Due to the different file systems and data formats used on the Solaris OS, it is unlikely the data can be left on the drives. Typically, data must be moved onto intermediate storage, converted to the proper format, and then moved back to the drives once they are installed on the Sun system. Other factors to consider include conflicts with the new system's firmware, the increasing maintenance costs of aging hardware, the difficulty integrating and supporting third-party storage on new servers, and the need to implement a new storage topology.

Storage Connectivity Topology

Migration to a new storage system provides an excellent opportunity to consider deploying a new storage architecture. Installing a Storage Area Network (SAN) or Network Attached Storage (NAS), for example, rather than Direct Attached Storage (DAS), might enable other clients and applications to fully utilize resources that were previously unavailable. Storage devices, including disk drives, array subsystems, and tapes, may be directly attached via hardware adapters to an HP system. When considering such direct attached storage, the migration plan must identify which hardware is compatible with the new Sun environment. Because Sun supports open standards, most hardware devices are supported in the Solaris OS, enabling storage devices that support those standards to be migrated to Sun systems.

Other devices, such as network attached storage (NAS) or those located in storage area networks (SANs), typically connect through standard network hardware interfaces supported by Tru64, HP-UX, and the Solaris OS and tend to require minimal effort to move to the Solaris OS. Deploying a SAN helps achieve high levels of availability, performance, and resource utilization efficiency. The Sun StorEdge Open SAN Architecture is a comprehensive SAN solution that integrates storage management software, host bus adaptors (HBAs), intelligent switches, storage arrays, and backup devices. It provides an extensive, heterogeneous, shared SAN file system resulting in better utilization of storage devices, simplified storage management, and lower TCO. For a current list of storage devices

supported on the Solaris OS, see the *Hardware Compatibility List for the Solaris OS*, located at <http://www.sun.com/bigadmin/hcl>

Storage Management Policies

The storage migration process provides an opportunity to review existing data management policies. For the most part, policies used in the Tru64 or HP-UX environment should be migrated to the Sun environment. In addition, new policies can be developed to address emerging regulatory issues such as those necessary to comply with Sarbanes-Oxley, HIPAA, 21 CFR Part II, SEC, and NASD regulatory requirements. These corporate policies impact operational functions such as backup/archiving, time of retention, redundancy, accessibility, tape pool size, security, and more.

Supporting Software

Due to the focus that is usually placed on migrating major business applications, data management tools are often neglected. In general, currently used tools either in the form of third-party products or custom, in-house scripts must be integrated into the Sun environment.

People

The organization of the data center staff including relationships and reporting structures should be evaluated to ensure the most efficient utilization of scarce resources. The skill sets required for each task should be determined and the appropriate people identified and trained or acquired (for example, from Sun Client Solutions) to ensure each task can be successfully accomplished.

Guidelines for Storage Migration

The following guidelines may prove helpful when migrating storage systems from Tru64 or HP-UX to the Solaris OS:

- *Define the scope*
Tightly defining and carefully controlling the scope of a storage migration effort helps reduce the likelihood of “scope creep”. The data to be migrated must be identified stipulating its size, location, and volatility, and data that does not to be transferred should be eliminated from the project.
- *Determine risks and contingencies*
Storage migrations often involve a number of interdependencies and instigate change in the environment. As a result, it is important to specify the time available for the migration effort, as well as the ramifications of going beyond the allotted time. Be sure to establish the risk of losing or corrupting data and determine how to recover from it should it occur. A risk management strategy including risk identification, estimation, and evaluation, along with a mitigation and contingency plan, should be developed.
- *Perform a total cost of ownership analysis*
A storage total cost of ownership (TCO) analysis identifies opportunities for cost reduction while maintaining or increasing service levels. While all aspects of the storage system life cycle must be analyzed, including acquisition, deployment, operation, support, and retirement, simplification of operations and reduction of infrastructure complexity are key factors to be considered. When migrating from Tru64 or HP-UX to the Solaris OS, take advantage of Sun storage TCO evaluations. The Storage TCO Review is a no-charge, first level analysis of

the storage infrastructure. Executive interview results are processed through a unique modeling tool producing a report on approximate TCO with comparisons to industry norms and suggested approaches for improvement. A more detailed Storage TCO Discovery assessment is available that identifies how efficiently storage assets are being used and where capacity is available. A modeling tool is used to provide business, financial, and process recommendations, as well as recommended architectural approaches. Finally, the Storage TCO Full Study is a customized analysis using comprehensive data processed through a master modeling tool. The results include models of future changes as well as “what if” alternatives.

- *Perform a full assessment*

Performing a full assessment of the storage migration effort helps ensure all assumptions are correct, and that all requirements and dependencies for the architecture are documented. Assessment efforts should include evaluation of all existing data to determine which is currently in active use, which is duplicated and can be eliminated, which is stale and is no longer needed, and which can be archived. The assessment should investigate each element of the storage environment so that all changes needed to rehost on the new storage platform are determined including: hard disk drives (HDDs), host bus adapters (HBAs), backup devices (tape, optical), connectivity topology (networks), storage and data management tools (utilities, applications), processes, facilities, and policies.

- *Design and prototype the solution*

When migrating from Tru64 or HP-UX to the Solaris OS, be sure to design a new storage solution that takes into account all data storage requirements. Construct a scaled-down version of the solution providing a proof-of-concept for the initial design. This prototype can be used to test the data transfer methodology as well as the accuracy and efficiency of any required data conversion, without impacting currently running systems.

- *Port storage and data management software*

In the event commercial off-the-shelf (COTS) data management software is not intended to be used, or the specific application desired is not available on the Solaris OS, port essential data management software.

- *Backup all data before beginning the storage migration process*

Before beginning the data transfer operation, backup all active data. Ensure backed up data can be accessed during the transfer to safeguard against unlikely data loss during the process. This can be accomplished by installing a compatible backup device and backup software on the Sun system, or restoring archived data to the HP system and then migrating it to the Sun system as part of the overall data migration.

- *Take advantage of Sun services related to storage system and data migration*

Sun offers several programs to help make the transition from Tru64 and HP-UX to the Solaris OS as smooth as possible. The Data Migration Service focuses on assessing the environment and scoping requirements for the new system, and then centers on documenting a detailed data migration plan. Sun experts can also provide Sun StorEdge Data Replication Services that explore and document data replication goals, assess continuity and business process requirements, and make recommendations based on the existing environment. More information on available Sun services can be found at <http://www.sun.com/servicessolutions/> and <http://www.sun.com/service/datareplication/index.html>.

More information issues and strategies for storage and data migration can be found in *Migrating to a Sun StorEdge Solution—An Effective Process for Migrating from AlphaServer/Tru64 to Solaris Operating System Based Storage Systems* available at http://www.sun.com/service/storage/storage_migration.pdf

Clustering Technology

Organizations running the Tru64 or HP-UX environment may also be using TruCluster or HP ServiceGuard clustering software. Because TruCluster and HP ServiceGuard are only available on their respective operating systems, data centers transitioning from Tru64 or HP-UX to the Solaris OS must select a replacement clustering technology. The Sun™ Cluster software provides similar functionality to TruCluster and HP Serviceguard. Integrated with the Solaris OS, the Sun Cluster software supports load balancing, automatic fault detection and failover, helping to keep mission-critical applications and services available when needed. The cluster software continuously monitors the health of cluster members and prevents a failing node from participating in the cluster to protect against data corruption. The cluster also monitors services and fails over to a designated standby node, restarting applications after hardware or software problems occur. Sun Cluster software also allows multiple nodes in a cluster to handle growing numbers of simultaneous users. With Sun Cluster software, administrators can add or remove nodes from a cluster, and mix and match servers to meet specific needs.

Key components of the Sun Cluster software include:

- *High availability framework*, software which detects node failures quickly and creates a new server for framework resources on another node in the cluster. The framework includes a *Cluster Membership Monitor*, a distributed set of agents which exchange messages over the cluster interconnect to enforce a consistent membership view, drive synchronized reconfiguration, handle cluster partitioning, and help maintain full connectivity among all cluster members.
- *Global devices, files and networking*, enabling all global devices, files, and network interfaces to be seen as local resources. With these facilities, users have virtually seamless storage and network scalability, as well as improved resource availability and simplified administration.
- *Cluster-aware applications*, third-party applications, such as Oracle RAC, which have direct knowledge of the Sun Cluster environment through close relationships between Sun and third-party vendors.
- *Failover agents*, providing failover for application agents and services.
- *Scalable agents*, enabling application instances to run on multiple cluster nodes simultaneously.
- *SunPlex™ Agent Builder tool and related libraries*, enabling developers to create simple or sophisticated agents that enable custom applications to be made cluster-aware.

Agents

The Tru64, HP Serviceguard, and Sun Cluster environments support two kinds of agents. *Failover agents* provide failover for application agents and services. When a failure occurs, a running application is either restarted on the same node, or migrated to another node in the cluster without user intervention, depending on application configuration. To accomplish this task, failover services migrate and reconfigure services between cluster nodes. The Sun Cluster software provides a framework and API to build failover agents. Sun Cluster provides a large collection of fully tested and supported application agents, including Oracle Server, Apache Web Server, Apache

Proxy Server, Sybase, SAP, DNS, NFS, Sun Java System Directory Server, Sun Java System Web Server, Sun StorEdge Net Backup, Broadvision, and more. See <http://www.sun.com/software/cluster/ds/ds-cluster31/index.xml> for more information about available agents.

Scalable agents enable application instances to run on multiple cluster nodes simultaneously. Files containing application and network resources (shared addresses) on which the scalable agents depend are used to house the critical information needed to migrate services from one cluster node to another. All nodes hosting a scalable agent use the same shared address to host the service. Service requests enter the cluster through a single global interface and are distributed to cluster nodes based on a load balancing policy. Should the node hosting the global interface fail, the global interface fails over to another node. Some of the scalable agents available in the Sun Cluster environment include: Apache Web Server, Apache Proxy Server, Sun Java System Web Server, SAP, Oracle 9i Real Application Cluster and Oracle Parallel Server.

See <http://www.sun.com/software/cluster/ds/ds-cluster31/index.xml> for the most up-to-date list of agents available for the Sun Cluster environment. Custom agents can be ported to the Sun Cluster environment by using the SunPlex™ Agent Builder. More information on this tool can be found in the *Sun Cluster Data Services Developer's Guide for Solaris OS: Chapter 9, Sun Plex Agent Builder*, available at <http://docs.sun.com/app/docs/doc/819-0581/6n30f91ua?a=view>

Migrating an Application from TruCluster or HP Serviceguard to Sun Cluster

The TruCluster, HP Serviceguard, and Sun Cluster environments all provide a way for applications to determine whether they are operating properly, as well as giving administrators the ability to specify the actions to be taken if problems are detected. While different in implementation, these frameworks all provide the ability to use an existing agent, or develop a customized agent that can be used to monitor the health of the clustered application. Sun Cluster provides a large collection of tested and supported application agents. These agents provide the functionality needed by most applications in use today. For organizations needing an agent for a custom-built application, Sun also provides the SunPlex Agent Builder. This graphical wizard helps administrators to build custom agents quickly and efficiently. See the *Sun Cluster Developer Guide* located at <http://docs.sun.com/app/docs?q=api&p=doc%2F819-0581> for detailed information on Sun Cluster agent development.

Migrating Clustered Data

Migrating data is a key concern when moving from one platform to another. Organizations invested in non-Sun storage infrastructure can use it in Sun Cluster environments. The Sun Cluster Open Storage Program provides an expanded choice of supported third-party storage arrays that work in Sun Cluster environments. In fact, Sun works with other storage system vendors to self-certify their arrays for Sun Cluster software. More information on the Sun Cluster Open Storage Program can be found at <http://www.sun.com/software/cluster/osp/>.

Monitoring and Administering Clusters—SunPlex™ Manager

In a traditional datacenter environment, management overhead increases proportionally to the number of servers employed—as the number of servers increases, so does management complexity. With SunPlex systems, organizations can be assured that overall manageability improves as clusters grow. Indeed, with the right level of abstraction, a clustered system is as easy to manage as a single server. SunPlex Manager is a browser-based tool for administering SunPlex systems. The SunPlex™ Manager software enables administrators to perform system

management and monitoring, software installation, and system configuration. Key features of the SunPlex Manager software include:

- Built-in security and authorization mechanisms
- Secure Sockets Layer (SSL) support
- Role Based Access Control (RBAC)
- Pluggable Authentication Module (PAM)
- NAFO group administration facilities
- Quorum devices, transports, device and resource group administration
- Sophisticated error checking and auto-detection of private interconnects
- Context-sensitive on-line help
- SunPlex Agent Builder for automated creation and packaging of resource types

Cluster Configurations

By migrating to the Sun Cluster software, businesses continue to have a scalable and flexible solution that is equally suited to a small local cluster or larger extended clusters which may be a part of the enterprise disaster recovery strategy. Sun Cluster technology supports:

- *Local Clusters.* Businesses or applications use proactive strategies, including highly available clusters, when shorter recovery time objective (RTO) and higher recovery point objective (RPO) are of concern. A *cluster* is a collection of loosely-coupled computing nodes that provide a single view of application services, including databases, Web, and file services. A cluster implemented using Sun Cluster software offers restart, failover, and scalable services, capacity for modular growth, and a low entry price point compared to fault tolerant systems. *Local clustering* provides a solid level of continuous service availability in the event of application, operating system, or hardware failure within a single data center. In addition, Sun Cluster software enables planned downtime of individual servers within a cluster. While a single room cluster provides service-level high availability, it does not provide site-level disaster tolerance against even a minor disaster such as a fire or flood.
- *Campus Clusters.* The next level of availability extends a cluster to another room or across a campus. *Campus Clusters* enable cluster components, such as nodes and shared storage, to be located at distances up to 40 kilometers. In the event of a localized disaster, such as a flood, fire, or building power outage, surviving nodes can support the service for a failed node. This solution offers some site-level tolerance, subject to quorum. However, the short distance limits survivability of the cluster and its services for larger disasters like earthquakes or grid power outages. More information on Campus Clusters in the Sun environment can be found in *Campus Clustering in the Sun Cluster Software—Concepts*, available at <http://docs.sun.com/app/docs/doc/816-3380/6m9lqcda0?a=view>
- *Metro Clusters.* For greater availability across an increased distance, cluster nodes can be separated by up to 400 kilometers using Sun Cluster software and dense wave division multiplexing (DWDM) technology to provide application service continuity in the event of a catastrophic failure. However, this is a single cluster solution supported across a limited distance that can still be affected by a single disaster. For instance, if a financial services firm runs a metro cluster from New York City to Boston, both sites could be affected during a large scale power grid failure like the one experienced across the northeast region of the United States in 2003. Finally,

because the storage systems are shared across the cluster, disk performance is constrained by the speed of the connecting links.

- *Geographic Clusters.* The Sun™ Cluster Geographic Edition software is a layered extension of standard Sun Cluster software. The Sun Cluster Geographic Edition software employs multiple clusters of systems separated by long distances, a duplicated application configuration, and redundant storage infrastructure to replicate data between these clusters. This capability enables enterprises to adequately separate two cluster sites to help ensure that both sites are not afflicted by the same disaster. Because the data is replicated between clusters, application services can be migrated to a geographically separated secondary cluster in the event of a disaster or for planned maintenance. The Sun Cluster Geographic Edition software builds on the same hierarchical concepts as Sun Cluster software and provides a suite of tools to manage and configure geographically separated clusters and migrate services between sites. More information on Geographic Clusters in the Sun Environment can be found in the *Sun Cluster Geographic Edition Software Collection* documentation available at <http://docs.sun.com/app/docs/coll/1191.1>

Networking

Addressing the network infrastructure during a Tru64 or HP-UX migration to the Solaris OS lies in correctly sizing the network environment. Since AlphaServer, Tru64, Sun servers, and Solaris OS all support open standards, addressing the network infrastructure during a Tru64 to Solaris OS migration lies in correctly sizing the network environment. As a result, organizations should consider the following:

- The data center networking facilities which will host the new system should be reviewed, ensuring sufficient capacity to handle additional network load today and well as future growth.
- All aspects of the networking environment should be evaluated, including data center cabling, network adapters, switches, routers, and the size and number of intranet and Internet connections.
- With increased hardware capability, the network management software should also be properly sized, based upon the new hardware and networking software demands.

Solaris OS supports a variety of technologies and products that can be used to build or extend a high performance network infrastructure:

- *Network hardware innovations.* Solaris OS extends the open TCP/IP networking protocol to work with the latest network hardware innovations, including FDDI, Fast Ethernet, Gigabit Ethernet, ISDN, and ATM.
- *Sun Gigabit Ethernet adapters.* Organizations can replace multiple 100 MB/second interfaces with a single Sun Gigabit Ethernet adapter—a card that delivers ten times the bandwidth of Fast Ethernet and supports both full- and half-duplex modes—in congested servers, reducing administrative complexity and cost.
- *Solaris IP Multipathing.* Organizations can configure a server to have multiple network ports connects to the same subnet. Solaris IP Multipathing (IPMP) software provides resilience from network adapter failure by detecting the failure or repair of a network adapter and switching the network address to and from the alternative adapter. Moreover, when more than one network adapter is functional, Solaris IPMP increases data throughput by spreading outbound packets across adapters.

- *Persistent session connections.* The Sun Java System Application Server supports connectors for several applications, such as Tuxedo and PeopleSoft, that provide bind duration management, dynamic bind escalation, and state and session management.
- *Best-of-breed network management tools.* Solaris OS supports a variety of tools, such as the Sun StorEdge Traffic Manager software, for easy LAN monitoring and control with dynamic path failover and load balancing.

Chapter 6

Administration and Management

While migration from Tru64 or HP-UX to the Solaris OS requires hardware and software changes, perhaps the greatest difference among the systems relates to system administration and management. All systems provide tools for configuring and maintaining systems. However, the Solaris OS includes several important and innovative technologies—many of them built right into the operating system—that can help organizations build smarter enterprises.

Solaris™ Containers Technology

As organizations look for ways to reduce costs and better manage end user service levels, attention is turning to how the computing infrastructure is utilized. Today, application services are frequently comprised of components that are distributed across multiple servers, and managing a vast number of servers and application instances is growing expensive. In addition, systems are often designed with extra capacity to handle occasional peak loads that occur during periods of high demand. This extra system capacity remains unused during normal operation. By allowing other applications to borrow this unused capacity a more cost-effective solution can be realized. During periods of high demand resources can be dynamically reallocated to important applications. Sharing resources in this way leads to higher resource utilization, reduces capital and system management costs by reducing the total number of systems required.

For the consolidation of applications onto fewer systems to be effective, applications must be able to be managed independently. This requires the ability to control resource utilization, isolate faults, and manage security between multiple applications on the same server. In other words, it requires the establishment of virtual server boundaries within the server. *Server virtualization* is a technique that allows large servers to be flexibly partitioned into independent execution environments that provide total isolation within the same server. Solaris™ Containers technology—Sun's operating system virtualization technique—consists of several technologies that work together to foster improved resource management and virtualize the environment. With Solaris Containers, organizations can determine how to allocate resources among applications and services, and ensure they are isolated from one another. Isolating applications is made possible by a Solaris Container technology called Solaris™ Zones that provides separate environments on a given machine that isolate applications from one another. Each application receives a dedicated namespace in which to run, and cannot see, monitor, or affect applications running in another zone.

Detailed information on the role of Solaris Containers technology, and guidelines for how to use it to consolidate systems and better manage applications can be found in the following Sun BluePrints™ articles and training:

- *Creating Self-Balancing Solutions with Solaris Containers*, located at <http://www.sun.com/blueprints/0605/819-2888.pdf>
- *Solaris Containers—What They Are and How to Use Them*, located at <http://www.sun.com/blueprints/0505/819-2679.pdf>
- *Slicing and Dicing Servers: A Guide to Virtualization and Containment Technologies*, located at <http://www.sun.com/blueprints/1005/819-3734.pdf>

- *Web Consolidation on the Sun Fire T1000 using Solaris Containers*, located at <http://www.sun.com/blueprints/1205/819-5149.pdf>
- *Solaris 10 Containers Course*, a Web-based, live virtual class that discusses Solaris Zones features, concepts, and configuration, as well as resource pools and how to use the `zonecfg` command. Information about this course can be found at <http://www.sun.com/training/catalog/courses/VC-SA-226-S10.xml>

Predictive Self-Healing

New in the Solaris 10 Operating System, Predictive Self-Healing technology enables Sun systems to accurately predict component failures and mitigate many serious problems before they actually occur. It is designed to maximize the availability of the system and application services by automatically diagnosing, isolating, and recovering from faults. This helps to not only reduce hardware failures but also to reduce the impact of application failures, leading to increased system and application availability.

Predictive Self-Healing technology consists of two components: the Solaris™ Fault Manager and Solaris™ Service Manager. The Solaris Fault Manager receives data relating to hardware and software errors and automatically diagnoses the underlying problem. Once diagnosed, the Solaris Fault Manager automatically responds by offlining faulty components. The Solaris Service Manager makes services, rather than processes, into first-class citizens, permitting automatic self-healing. Base Solaris services have service descriptions which include full dependency information for start, stop, and restart; applications can easily be converted to run under Solaris Service Manager.

More information on Predictive Self-Healing technology can be found in *Predictive Self-Healing in the Solaris 10 Operating System* located at http://www.sun.com/software/whitepapers/solaris10/self_healing.pdf. In addition, a *Solaris 10 Predictive Self-Healing Course* is available. This Web-based, live virtual class discusses fault and system management features found in the Solaris 10 OS, including changes to the fault management architecture and the service management facility. Information about this course can be found at <http://www.sun.com/training/catalog/courses/VC-SA-227-S10.xml>

Resource Management

While many system management tools provide the means to monitor the use of system resources, they typically lack the means to control them. Indeed, to exert optimum control over system resources, resource management needs to be tightly integrated with the operating environment. Understanding this, Sun assembled the best elements of its resource management technologies and has incorporated them directly into the Solaris OS. These resource management facilities enable resources to be allocated among individual tasks and users in a structured, policy-driven fashion. System resources—such as CPU time, processes, virtual memory, connect time, and logins—can be proactively allocated, controlled, and monitored on a fine-grained basis, resulting in more predictable service levels. These capabilities include:

- *Resource containment*, enabling administrators to establish resource boundaries and create isolated computing environments through the use of resource pools
- *Workload classification*, enabling administrators to identify application services based on business rules through the use of projects

- *Resource accounting*, enabling access to detailed usage information through integration with Solaris extended accounting and statistical tools
- *Resource controls*, enabling administrators to set resource limits for projects, tasks and processes
- *Differentiated services*, enabling fine-grained CPU resource control among projects based on business priority using the Fair Share Scheduler software

For more information on resource management in the Solaris OS, see the Solaris 9 Resource Manager white paper located at <http://www.sun.com/software/whitepapers/solaris9/srm.pdf>. For information on these resource management facilities can be used in combination with other Sun technologies, like Solaris Containers, see Solaris Containers—What They Are and How to Use Them, located at <http://www.sun.com/blueprints/0505/819-2679.pdf>

Sun™ Management Center

Sun™ Management Center software offers a single point of management for all Sun systems and the Solaris OS. It provides a platform upon which enterprises can base administrative and management operations, helping make the systems and the services they provide highly available. A powerful and flexible tool for managing networks, Sun Management Center software enables system administrators to easily perform remote system configuration, monitor performance, and detect and isolate hardware and software faults all through an intuitive graphical or command-line interface.

Sun Management Center software can also be used as the interface to manage dynamic reconfiguration within Sun servers, including domain creation, dynamic board attach, and dynamic detach. To support legacy networks and heterogeneous environments, Sun Management Center software is tightly integrated with major enterprise management frameworks like CA Unicenter TNG, HP Open-View, IBM Tivoli, and software monitoring tools such as BMC PATROL and Halcyon. More information on Sun Management Center software can be found at <http://www.sun.com/software/products/sunmanagementcenter/index.xml>

Solaris™ Live Upgrade

Solaris™ Live Upgrade software enables the operating system to continue to run while upgrades, patch installations, or routine maintenance operations are being performed. Integration with Web Start Flash technology enables system administrators to install a complete pre-tested, pre-configured system image rapidly on a new inactive boot environment while the production boot environment is fully operational. In the event of a failure, administrators can fallback to a previous environment with a simple reboot if necessary.

Storage and Data Management Tools

Several tools are available on the Solaris OS to manage storage systems and data:

- *Sun StorEdge™ Traffic Manager*, part of the Sun StorEdge™ SAN Foundation software, combines easy LAN monitoring and control with dynamic data path failover and load balancing to help further improve the overall availability and performance of business applications, while helping to reduce storage management administrative costs.

- *Solaris™ Volume Manager*, a disk and storage management solution that helps companies address their storage management, administration, availability, and performance needs. A component of Solaris OS, Solaris Volume Manager helps provide high data availability and reliability through support for various RAID levels, software partitioning and hot spares, enhanced system and I/O performance, system monitoring, and simplified large system and disk administration.
- *Sun StorEdge™ Enterprise Backup software*, an integral component of Sun's data continuance solutions, delivers centralized data protection and management across heterogeneous environments. Features such as snapshot management, advanced indexing, high speed parallelism, automated media management, LAN-free and serverless backup, cluster awareness, comprehensive NDMP (Network Data Management Protocol) support, and dynamic tape drive sharing enable organizations to fully protect storage assets and minimize downtime. For hands-free data protection, the software's Autochanger and Silo Modules support an extensive variety of Sun StorEdge tape and robotic devices. In addition, a DiskBackup Option enables data to be backed up to disk, staged from disk, and automatically moved to tape or cloned from disk to tape or disk—all with single-step recovery. Combined with Sun StorEdge Enterprise Backup software and the Sun StorEdge Availability Suite software's point-in-time copy capability software, organizations achieve an even higher level of impact-free data protection.
- *Sun StorEdge™ Availability Suite software* delivers a key component of Sun's data continuance offering, providing robust and comprehensive solutions designed to help solve problems associated with protecting data and applications.
- *Sun StorEdge™ Instant Image software*, allows creation and management of instant snapshot copies of data. The availability of online data is increased by taking snapshots of live data, which can be used for backups, as well as decision support, contingency planning, application development and testing, and revision control, all without affecting the performance of the applications containing the data. The Sun StorEdge Instant Image software is aware of the Sun Cluster software, and works independently of the underlying data availability hardware and software.
- *Sun StorEdge™ SDNR software*, allows data to be mirrored to multiple remote secondary sites for disaster recovery, data protection, and storage migration. The software supports both synchronous and asynchronous data replication, providing the flexibility to address a variety of application requirements.
- *Veritas NetBackup DataCenter software* and *Veritas NetBackup BusinessServer software* are high-performance backup and recovery applications providing reliable, highly available, and scalable data protection for business-critical environments—from data centers to global enterprises. These tools provide extensive robotics-device and media support, automated management with wizard-driven installation, parallel backup and restore, configuration and management, and checkpoint restart to streamline backup failure recovery operations.

Solaris OS Administration Training

Understanding how best to administer and manage new systems and environments is an important element of a migration project. Sun offers several educational services related to Solaris OS administration and management that are targeted at administrators migrating systems to the Solaris OS, including:

- *Solaris OS Administration for Experienced HP-UX and Tru64 Administrators*, focusing on core system administration tasks in the Solaris OS and identifying corresponding HP-UX or Tru64 operating system elements. More information on this course can be found at <http://www.sun.com/training/catalog/courses/STS-277.xml>

- *Solaris System Administration for Experienced UNIX Administrators*, provides experienced UNIX administrators with information about core Solaris concepts, and focuses on practical experience implementing Solaris OS features through lab exercises. More information on this course can be found at <http://www.sun.com/training/catalog/courses/STS-276-S10.xml>
- *Solaris 10: Ten Moves Ahead of the Competition*, a free, Web-based course providing an overview of the key features, high-level value proposition, and introductory technical information that illustrates the advantages of the Solaris 10 OS. More information on this course can be found at <http://www.sun.com/training/catalog/courses/WS-245.xml>

A detailed list of Solaris OS educational services can be found in Appendix C.

Chapter 7

Security in the Solaris OS

The advent of open, networked computing has led to the need for mechanisms for securing and protecting information on the network. The Solaris OS provides a sophisticated network-wide security system that controls the way users access files, protect system databases, and use system resources. From integrated security services and applications, to enhanced encryption algorithms, to an enterprise firewall for network protection, the Solaris OS sets a high standard for operating system security by addressing security needs at every layer. Extended security features are also available, including authentication, data integrity, data privacy, and single sign-on capabilities so that tampering, snooping, and eavesdropping do not compromise data or associated transactions.

More information on security features of the Solaris OS can be found in *Solaris 10 Operating System — Unparalleled Security to Enable and Protect Business* located at <http://www.sun.com/software/whitepapers/solaris10/s10security.pdf>

System Hardening

The Solaris OS is substantially easier to harden and minimize, helping to reduce the risk that a system or application will be compromised. Reduce Networking metacluster configurations can be installed—with fewer software packages, no active networking, a minimum number of running services, and enhanced security. Such configurations not only reduce networking metacluster install time, they also provide a secured building block for customized deployments. In addition, the Solaris OS provides strong default file permissions, including file integrity checking, and delivers digital signatures on essentially all applications in the system. With these tools, system administrators can verify the integrity of any file on the system.

Process Rights Management

In traditional UNIX-based operating systems, applications and users often need administrative access to perform tasks. However, in most implementations there is one level of higher privilege: the root super-user. Any user or application given root access has the ability to make major changes to the operating system—and is typically the target of hacking attempts. The Solaris OS offers unique User Rights Management (also known as Role-Based Access Control) and Process Rights Management. These technologies reduce security risk by granting users and applications only the minimum capabilities needed to perform tasks. Indeed, system administrators can grant—or deny—any of over 50 discrete privileges to any process on the system. Using fine-grained control of process rights, organizations can create more stable and secure systems. With Process Rights Management, organizations can:

- Increase security through the realization of effective security policies on the system managed at the kernel level
- Improve system stability by minimizing hostile or inadvertent actions that could bring the system down
- Maximize data integrity by controlling access to data in a fine-grained manner
- Ensure compliance with regulatory requirements to implement the principle of least privilege throughout the enterprise

Unlike other operating systems and third-party solutions, no application changes are required to take advantage of these security enhancements. Consider a Web server application. All UNIX-based Web server software requires root

access to serve applications on port 80, the Web TCP/IP port commonly used. Using Process Rights Management, a Web server application running on the Solaris OS can be granted just the privileges to bind to a low-numbered port (port 80) without giving it any additional administrative access. Should the Web server software be attacked, the hacker cannot escalate privileges, launch additional attacks, or gain further access to the system.

More information on Process Rights Management can be found at <http://www.sun.com/software/solaris/ds/security.jsp#2>, as well as http://www.sun.com/bigadmin/xperts/sessions/16_prm/ on the BigAdmin System Administration Portal.

Solaris Cryptographic Framework

The Solaris OS includes the Solaris Cryptographic Framework, a high performance framework that helps developers add data encryption to applications and support encrypted transactions over the Internet. Based on the PKCS#11, OpenSSL, and NSS standards, the Solaris Cryptographic Framework provides cryptographic services to users and applications through commands, a user-level programming interface, a kernel programming interface, and user-level and kernel-level frameworks. The Solaris Cryptographic Framework provides these cryptographic services to applications and kernel modules in a seamless manner to users, and brings direct cryptographic services, like encryption and decryption for files, to users.

The user-level framework is responsible for providing cryptographic services to consumer applications and end user commands. The kernel-level framework provides cryptographic services to kernel modules and device drivers. Both frameworks give developers and users access to software-optimized cryptographic algorithms. The programming interfaces are front-ends to each of the frameworks. A library or a kernel module that provides cryptographic services can be plugged into one of the frameworks by the system administrator, making cryptographic services available to applications or kernel modules. This flexibility allows system administrators to plug in different cryptographic algorithm implementations or hardware accelerated cryptographic providers.

With the Solaris Cryptographic Framework developers can:

- Increase performance and scaling through transparent access to hardware cryptographic acceleration, without the need to modify applications
- Reduce development time through use of the de facto PKCS#11 standard
- Improve simplicity and manageability by using a single extensible framework that supports multiple encryption methods
- Gain automatic access to cryptographic algorithms and hardware acceleration by writing applications to the PKCS#11 or OpenSSL libraries

More information on the Solaris Cryptographic Framework can be found at http://www.sun.com/bigadmin/features/articles/crypt_framework.html on the BigAdmin System Administration Portal.

Trusted Solaris™ Operating System

Organizations needing even higher levels of security can take advantage of the Trusted Solaris™ operating system, a hardened version of the Solaris OS that helps solve the increasing problems associated with securing information from both internal and external threats. It provides a platform for deploying high security desktops, database

servers, firewalls, and communication gateways, as well as any application where access to sensitive information or networks must be strictly controlled. Key features of the Trusted Solaris OS include:

- Configurable security functionality
- Trusted roles
- Multi-level file system for user classification and segregation
- Privilege and authorization mechanisms
- Label-based access control
- Mandatory/discretionary access control
- Profile mechanisms
- Role-based administration
- Trusted networking
- Scalable security

More information on Trusted Solaris can be found at <http://www.sun.com/software/solaris/trustedsolaris/index.xml>

Appendix A

High Level Comparison of HP and Sun Platform Features

Feature	AlphaServer/Tru64	HP Integrity/HP-UX	HP9000/HP-UX	Sun/Solaris OS
Processor Support	• Alpha	• PA-RISC, Itanium	• PA-RISC	• SPARC, AMD Opteron, x86, x64
Availability				
Memory, CPU error detection	• Yes	• Event Monitoring Svc	• Event Monitoring Svc	• Predictive Self-Healing
Fault Prediction	• Yes	• No	• No	• Predictive Self-Healing
Service Configuration Change Identification	• Unknown	• No	• No	• Solaris Service Manager
Dynamic Reconfiguration	• Yes (CPU Only)	• Yes	• Yes	• Yes
Consolidation				
Hardware Partitioning	•	• nPartitions	• nPartitions	• Dynamic System Domains
Virtualization		• vPars	• vPars	• Solaris Containers
Integrated Software				
Middleware	• Yes (Some)	• Yes (Some)	• Yes (Some)	• Sun Java Enterprise System
Resource Management	• No			• Solaris Resource Manager
System Management	• SysMan	• HP OpenView	• HP OpenView	• Sun Management Center • HP OpenView
Performance Analysis				
Real-Time Analysis	• No	• No	• No	• DTrace
Dynamic Kernel Instrumentation	• No	• No	• No	
Security				
LDAP Directory Included	• No (Third-Party)	• Netscape v6.2	• Netscape v6.2	• Sun Java Enterprise System Directory Server 5.2
Kerberos v5	• Yes	• Yes	• Yes	• Yes
Cryptographic Framework	• Yes (CDSA)	• Yes (CDSA)	• Yes (CDSA)	• Yes (Solaris C. F.)
Smart Card Support	• No (Third-Party)	• Yes	• Yes	• Yes
Pluggable Authentication Module	• Yes	• Yes	• Yes	• Yes
Host-Based Firewall Protection	• Yes	• Yes (IP Filter)	• Yes (IP Filter)	• Yes (IP Filter)
IPSec/IKE	• Yes	• Yes	• Yes	• Yes
Process Rights Management (Least Privilege)	• Unknown	• No	• No	• Yes

Appendix B

Differences Between Sun Cluster, TruCluster, and HP Serviceguard

		TruCluster	HP Serviceguard	Sun Cluster
Nodes		<ul style="list-style-type: none"> AlphaServer 8 	<ul style="list-style-type: none"> Itanium, PA-RISC 8 	<ul style="list-style-type: none"> SPARC, AMD Opteron 16
Clusters	Campus Cluster	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> Unknown 	<ul style="list-style-type: none"> Yes (40 KM)
	Stretched Cluster	<ul style="list-style-type: none"> Unknown 	<ul style="list-style-type: none"> Unknown 	<ul style="list-style-type: none"> Yes (400 KM)
Operating System		<ul style="list-style-type: none"> Tru64 	<ul style="list-style-type: none"> HP-UX, Red Hat Linux 	<ul style="list-style-type: none"> Solaris OS 8, 9, 10
Cluster Interconnect		<ul style="list-style-type: none"> Memory Channel Gigabit Ethernet Ethernet 	<ul style="list-style-type: none"> Ethernet HypterFabric Infiniband (Future) 	<ul style="list-style-type: none"> Sun Cluster Interconnect (SCI) Gigabit Ethernet Ethernet Infiniband
Disk Storage	Shared Root Disk	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> No 	<ul style="list-style-type: none"> No
	Single System Image	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> Yes with additional products 	<ul style="list-style-type: none"> No
	Disk Storage	<ul style="list-style-type: none"> Compaq 	<ul style="list-style-type: none"> HP, EMC, IBM 	<ul style="list-style-type: none"> Sun, EMC, NetApp, IBM, HP
Data	Volume Manager	<ul style="list-style-type: none"> Logical Storage Manager SanWorks Enterprise Vol Mgr 	<ul style="list-style-type: none"> Veritas Volume Manager Logical Volume Manager 	<ul style="list-style-type: none"> Solaris Volume Manager Veritas Volume Manager
	Cluster Volume Manager	<ul style="list-style-type: none"> Logical Storage Manager 	<ul style="list-style-type: none"> Veritas Volume Manager Logical Volume Manager 	<ul style="list-style-type: none"> Sun SVM Veritas CVM
	File System	<ul style="list-style-type: none"> AdvFS 	<ul style="list-style-type: none"> VxFS, JFS 	<ul style="list-style-type: none"> UFS, VxFS, QFS
	Cluster File System	<ul style="list-style-type: none"> AdvFS 	<ul style="list-style-type: none"> VxFS, JFS 	<ul style="list-style-type: none"> UFS (non-RAC), QFS (RAC)
	Data Multipathing		<ul style="list-style-type: none"> HP Securepath Veritas DMP 	<ul style="list-style-type: none"> Sun StorEdge Traffic Manager EMC PowerPath HDLM
	Snapshot Technology	<ul style="list-style-type: none"> SanWorks DRM Technology 		<ul style="list-style-type: none"> Sun StorEdge™ Network Data Replicator Instant Image technology
	Backup	—		<ul style="list-style-type: none"> Veritas NetBackup Sun StorEdge Net Backup
Availability	Vertically Scalable Application	<ul style="list-style-type: none"> Managed by failover agents Simple failover 		<ul style="list-style-type: none"> Managed by failover agents More granular fault monitoring
	Horizontally Scalable Application	<ul style="list-style-type: none"> Cluster aliasing CAA Memory channel 		<ul style="list-style-type: none"> Scalable agents Consistent service levels Ease of operation
	Global Name Space	<ul style="list-style-type: none"> Yes 	<ul style="list-style-type: none"> No 	<ul style="list-style-type: none"> Yes
	Data	<ul style="list-style-type: none"> TruCluster File Service 		<ul style="list-style-type: none"> Global File Service
	Network	<ul style="list-style-type: none"> Cluster aliasing 		<ul style="list-style-type: none"> Global Network Service
Integration		<ul style="list-style-type: none"> SysMan Station 		<ul style="list-style-type: none"> SunPlex Manager

Network	Network Multipathing	• Cluster Alias	• Auto Port Aggregation	• IPMP
	Network Load Distribution	• Yes	• Additional network hardware	• Yes (Global File Service) • Hardware load balancer
Agent Development		• CAA • No GUI • Shell scripts		• SunPlex Agent Builder • Simple two-step process • Horizontal agents • Scalable agents • Shell scripts or C programs
Agents (Partial List)		• HA Oracle, NFS, SAP • Parallel databases		• HA Oracle, NFS, DNS, Sybase • Oracle Parallel Server (OPS) • iPlanet, SAP, Broadvision • Apache Web Server • Apache Proxy Server • Sun Java System Directory Server, Oracle Server • Sun Java System Web Server • Sun StorEdge NetBackup • Oracle 9i 10g Real Application Cluster (RAC)
Security		• Single security domain	• HP Security Patch Check Tool	• JASS security

Appendix C

Solaris Educational Services and Service Plans

Solaris Educational Services

Educational training is an important element of a migration project. Sun offers a complete life cycle of learning solutions, including team and individual training options, as well as consulting to help maximize system availability, and simplify management and operations. This integrated portfolio of educational services can help migration project team members assess their IT knowledge and skill level and identify gaps, build knowledge and skill competency, and certify individuals to ensure career development.

General	Web Site URL
All Solaris 10 Training and Certification At A Glance	http://www.sun.com/training/catalog/operating_systems/s10_glance.xml
Solaris 10: Ten Moves Ahead of the Competition	http://www.sun.com/training/catalog/courses/WS-245.xml
UNIX Essentials Featuring the Solaris 10 Operating System	http://www.sun.com/training/catalog/courses/SA-100-S10.xml
Administration	Web Site URL
Intermediate System Administration for the Solaris 10 Operating System (SPARC Platform)	http://www.sun.com/training/catalog/courses/PK-SA-200-S10.xml
Intermediate System Administration for the Solaris 10 Operating System (x64/X86 Platform)	http://www.sun.com/training/catalog/courses/PK-SA-201-S10.xml
Advanced System Administration for the Solaris 10 Operating System (x64/x86 Platform)	http://www.sun.com/training/catalog/courses/CDS-203-S10.xml
Solaris 10 New Features for Experienced Solaris System Administrators	http://www.sun.com/training/catalog/courses/SA-225-S10.xml
Features and Technologies	Web Site URL
Dynamic Performance Tuning and Troubleshooting with DTrace (3 Days)	http://www.sun.com/training/catalog/courses/SA-327-S10.xml
Solaris 10 Containers (1 Day)	http://www.sun.com/training/catalog/courses/VC-SA-226-S10.xml
Solaris 10 Predictive Self-Healing (1 Day)	http://www.sun.com/training/catalog/courses/VC-SA-227-S10.xml
Solaris 10 Security (1 Day)	http://www.sun.com/training/catalog/courses/VC-SA-228-S10.xml
DTrace Facility (3 Days)	http://www.sun.com/training/catalog/courses/VC-SA-327-S10.xml
Migration	Web Site URL
Solaris System Administration for Experienced UNIX Administrators	http://www.sun.com/training/catalog/courses/STS-276-S10.xml
Solaris Operating System Administration for Experienced HP-UX and Tru64 Administrators	http://www.sun.com/training/catalog/courses/STS-277.xml
Solaris Volume Manager Administration	http://www.sun.com/training/catalog/courses/ES-222.xml

Security Courseware	http://www.sun.com/training/catalog/operating_systems/security_admin.html
Training for HP Migration Solution	http://www.sun.com/training/team/solutions_hp.html
Everything Data Center	http://www.sun.com/training/team/datacenter/index.html

Service Plans

An important element of any migration project includes on-going support and life cycle of the operating environment. Sun delivers Solaris Service Plans to provide technical and interoperability support, Solaris OS updates, remote update services through the Sun Update Connection, access to Solaris system administration resources including Knowledge Bases, support bulletins, and Educational Services.

Sun offers three Solaris Service Plans that address a wide variety of requirements:

- *Solaris Basic Service plan*, providing immediate Web access to updates, upgrades, and patches
- *Solaris Standard Service plan*, providing all services in the Solaris Basic Service Plan plus weekday technical support with four hour response
- *Solaris Premium Service plan*, providing 24 hour by 7 day full technical support, and live call transfer response

More information on Solaris Service Plans can be found at <http://www.sun.com/service/solaris10/>.

Appendix D

References

Books, Papers, and Guides

	Title	Web Site URL or ISBN
Administration and Management	Sun Management Center — Managing the Integrated Enterprise	http://www.sun.com/software/products/sunmanagementcenter/whitepapers/SunMC-MIE-final.pdf
Clustering	Designing Enterprise Solutions with Sun Cluster 3.0	ISBN 0-13-008458-1
	Developing Agents for Applications Running on Sun Cluster Software	http://www.sun.com/software/whitepapers/wp-clusterapi/Cluster3.0API_final-wp.pdf
Migration	Migration Resource Guide — For Project Managers, Technical Architects, and Developers	https://partneradvantage.sun.com/partners/migration/pdf/mgr_resource_guide_0204.pdf
	Migrating to a Sun StorEdge Solution — An Effective Process for Migrating from AlphaServer/Tru64 to Solaris Operating System Based Storage Systems	http://www.sun.com/service/storage/storage_migration.pdf
	Sun Infrastructure Solution for Tru64 Migration — Assessing the Move to Sun Systems	http://www.sun.com/solutions/documents/whitepapers/tru64_tech_wp.pdf?facet=-1
	Sun Infrastructure Solution for Tru64 Migration — Helping Organizations Move to an Industry-Leading Platform to Affect Greater Data Center Utilization	http://www.sun.com/datacenter/migration/tru64/Tru64Migration_ExecWP_Final.pdf
Resource Management	Solaris 9 Resource Manager	http://www.sun.com/software/solaris/whitepapers.html
	Solaris Containers — How Advances in Server Virtualization Will Simplify Service Manageability	http://www.sun.com/software/whitepapers/wp-svccont/wp-svccont.pdf
Solaris Operating System	Solaris Operating System and Linux Solutions from Sun — Offering Value, Choice and Innovation	http://www.sun.com/software/solaris/whitepapers.html
	Endianness in the Solaris Operating Environment	http://developers.sun.com/solaris/developer/support/driver/wps/endianness/files/c0101.html
Storage	An Information Lifecycle Management Maturity Model	http://www.sun.com/storage/white-papers/ilm_maturity_model.pdf
	Improving Backup and Recovery Strategies	http://www.sun.com/storage/white-papers/improving_backup_recovery.pdf
	Storage Consolidation	http://www.sun.com/storage/white-papers/cost_risk_complexity.pdf

Migration Tools and Web Sites

Title	Web Site URL
HP-UX to Solaris Migration Migration Tools	http://www.sun.com/datacenter/migration/hpux/ https://partneradvantage.sun.com/partners/migration/tools.html
Oldworld and Newworld Utilities	http://developers.sun.com/prodtech/solaris/downloads/lincat/lincat_4.html
Roadmap to Sun Developer Documentation	http://developers.sun.com/solaris/articles/sun_dev_docs.html
scriptran Utility	http://developers.sun.com/prodtech/solaris/downloads/lincat/lincat_3.html
Solaris Migration Tool for HP-UX and HP-Tru64	http://javashoplmsun.com/ECOM/docs/Welcome.jsp?StoreId=8&PartDetailId=Tru_2_Solaris-1.0-G-F&TransactionId=try
Solaris OS Analyzer for C/C++ Source Code	https://partneradvantage.sun.com/partners/migration/tools.html
Solaris OS Implementation for HP-UX API	https://partneradvantage.sun.com/partners/migration/tools.html
Tru_to_Solaris OS Migration Tool for C/C++ Source Code	http://developers.sun.com/prodtech/solaris/downloads/tru_to_solaris/index.html

Sun BluePrints™ Articles and Books

Title	Web Site URL
A New Open Resource Management Architecture in the Sun HPC ClusterTools Environment	http://www.sun.com/blueprints/1102/817-0861.pdf
Creating Self-Balancing Solutions with Solaris Containers	http://www.sun.com/blueprints/0605/819-2888.pdf
Migrating to the Solaris Operating System — The Discipline of UNIX-to-UNIX Migrations	ISBN 0-13-1506308
Protecting Investments Through Technology Advancements	http://www.sun.com/blueprints/1005/819-3931.pdf
Service Provisioning with Resource Management	http://www.sun.com/blueprints/1104/817-7525.pdf
Slicing and Dicing Servers: A Guide to Virtualization and Containment Technologies	http://www.sun.com/blueprints/1005/819-3734.pdf
Solaris Containers—What They Are and How to Use Them	http://www.sun.com/blueprints/0505/819-2679.pdf
Sun Cluster 3.0 Series: Guide to Installation — Part 1	http://www.sun.com/blueprints/0403/817-2015.pdf
Sun Cluster 3.0 Series: Guide to Installation — Part 2	http://www.sun.com/blueprints/0503/817-2016.pdf
Understanding the Benefits of Implementing Oracle RAC on Sun Cluster Software	http://www.sun.com/blueprints/0105/819-1466.pdf
Using Solaris Resource Manager with Run Ray	http://www.sun.com/blueprints/0604/817-6617.pdf
Web Consolidation on the Sun Fire T1000 using Solaris Containers	http://www.sun.com/blueprints/1205/819-5149.pdf

Training Courses

Title	Web Site URL
Designing Storage Area Networks	http://www.sun.com/training/catalog/courses/NWS-4940.xml
Disk Subsystems Fundamentals	http://www.sun.com/training/catalog/courses/ES-215.xml
Installing and Configuring Storage Area Networks	http://www.sun.com/training/catalog/courses/ES-490.xml
SAN Concepts Connectivity—Implementation	http://www.sun.com/training/catalog/courses/STK-1666.xml
Sun Cluster 3.0 Software Overview	http://www.sun.com/training/catalog/courses/WE-3330.xml
Sun Cluster 3.1 Administration	http://www.sun.com/training/catalog/courses/ES-338.xml
Sun Cluster 3.1 Advanced Administration	http://www.sun.com/training/catalog/courses/ES-438.xml
Sun Cluster Geographic Edition 3.1 Software Administration	http://www.sun.com/training/catalog/courses/ES-361.xml
Sun Training Product Index	http://www.sun.com/training/catalog/courses/

Web Sites of Interest

	Web Site URL	Description
Hardware	http://www.sun.com/servers	Sun Servers
Clustering	http://www.sun.com/software/cluster/ds/ds-cluster31/index.xml	Sun Cluster
	http://www.sun.com/software/cluster/osp/	Sun Cluster Open Storage Program
Software	http://www.sun.com/solaris	Solaris Operating System
	http://www.sun.com/software/javasystem	Sun Software
	http://www.sun.com/suntone	SunTone Service Excellence
	http://www.sun.com/software/products/studio/	Sun Studio
Storage	http://www.sun.com/storage	Sun Storage
Security	http://www.sun.com/security	Security
	http://www.sun.com/software/solaris/ds/security.jsp#2	Process Rights Management
Services	http://www.sun.com/service	Sun Services
	http://www.sun.com/service/sunps/platform/migration.html	Integration Services
	http://www.sun.com/service/datacenter/applicationmigration.html	Application Migration Services
	http://www.sun.com/service/datareplication/index.html	Sun StorEdge Data Replication Services
Migration	http://www.sun.com/datacenter/migration/tru64	Tru64 to Sun Migration
	http://www.sun.com/datacenter/migration/hpux/	HP-UX to Solaris Migration
	http://www.sun.com/datacenter/migration/hpux_x86/	Making the Move from HP to Sun's Newest x64 Servers
	http://www.sun.com/datacenter/migration/	Sun Migration Programs
Partners	http://www.sun.com/partners	Sun Partners

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