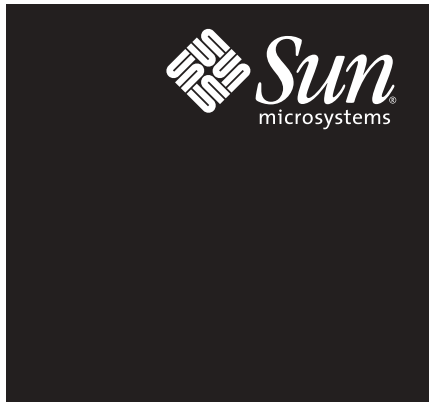
Sun™ OpenR$_X$ Framework

A Comprehensive Platform for Open Health Industry Solutions

A Technical White Paper

September 2003



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Chapter 1

Introduction

Over the past few decades, information technologies (IT) have transformed the healthcare industry. Evolutionary phases of network computing have introduced protocols and capabilities supporting new processes, business models, and medical advances. Most organizations have deployed best-of-breed solutions to meet departmental or facility business requirements. Today however, many organizations struggle with complex IT environments that offer varying levels of data integration, performance, scalability, and security.

As it becomes more critical to rapidly deploy scalable, highly available Web-based systems, healthcare organizations are faced with replacing legacy technologies or finding effective ways to securely connect them across the enterprise.

Sun Microsystems offers an end-to-end solution for the healthcare industry: the Sun™ OpenR_x Framework. It provides secure, open-platform technologies that organizations can integrate into existing environments to help provide anytime, anywhere, Web-based access to legacy systems. Additionally, the Sun OpenR_x Framework offers a robust and highly scalable platform for exciting new applications and improved interoperability with medical devices. Sun OpenR_x Framework components include what customers need to modify or build a robust, highly secure, cost-effective IT environment including software, hardware, development technologies, alliance partner solutions, and support for healthcare industry standards.

For more information about Services on Demand for the healthcare industry, visit http://www.sun.com/products-n-solutions/healthcare/collateral.html/

The Sun OpenR_x Framework includes traditional Internet-based functions—such as security, authentication, and directory—along with more advanced capabilities including virtualized storage, grid computing, remote diagnostics, and wireless technologies. Sun OpenR_x Framework components are platform-independent, integrateable, scalable, and Internet-ready, so organizations can leverage and extend existing IT resources, while reducing complexity and avoiding unneces-

sary costs. You can choose one or more components to help promote new levels of system openness and flexibility, boost interoperability between assets, improve performance levels, or build a robust foundation to support tomorrow's healthcare business challenges.

This white paper describes the Sun OpenR_x Framework—including related healthcare standards, Sun ONE software, Sun hardware, alliance solutions, and model architectures—and how it can leverage IT assets by making the network work for our customers.

Please e-mail any questions regarding the OpenR_x Framework to openrx@sun.com. For more information about Sun in healthcare, join the Healthcare Executive Boardroom. Get the details at http://www.sun.com/boardroom/healthcare.

Chapter 2

Sun OpenR$_X$ Framework Overview

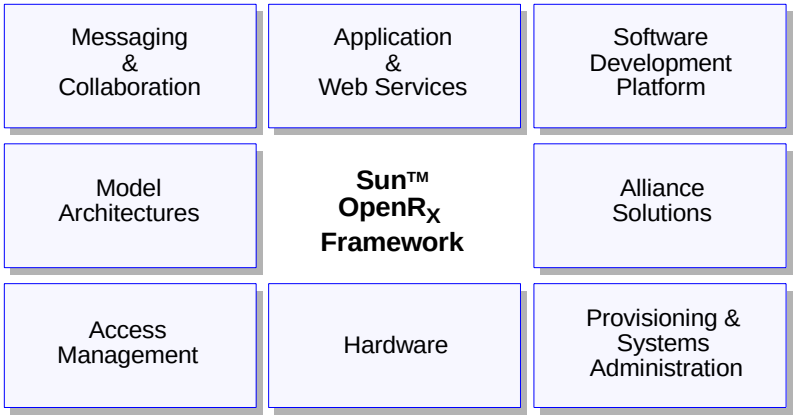
The Sun OpenR$_X$ Framework offers end-to-end, high-performance computing technologies designed to provide secure access to data anytime, anywhere. Healthcare organizations can deploy components into existing environments, and dramatically scale the technologies in the future to meet new opportunities and business challenges.

At a high level, the framework includes the following categories:

- Access management
- Web and application services
- Messaging and collaboration services
- Java™ technology-based development platform
- Provisioning and systems administration
- Hardware
- Alliance solutions
- Health industry model architectures

Each category includes open-standards-based technologies from Sun Microsystems and alliance partners, designed to meet the health industry's requirements for a highly secure network computing infrastructure. Individual components have been built using Java technologies, industry-standard Web service and interoperability technologies, and the Solaris™ Operating System (OS).

Figure 2-1: The Sun OpenR$_X$ Framework



Access Management

Access management addresses the need for positive and secure person identification within a healthcare enterprise and across multiple organizations. The Sun OpenR$_X$ Framework includes provisions for enterprise master person indexes, duplicate record checking, federated identification, biometric person identification, and secure user authentication and access. The Sun OpenR$_X$ Framework incorporates the following Sun alliance and Sun Open Net Environment (Sun ONE) access management applications:

- Sun™ Java System Directory Service
- Sun Java System Directory Proxy Service
- Sun Java System Identity Service
- Sun Java System Meta-Directory Service
- Initiate Identity Hub™ Enterprise Master Patient Index
- BiObex™, a biometric access package from AC Technology
- Trusted Solaris™ Operating System

Web and Application Services

Web and application services enable healthcare organizations to integrate IT assets and services across the network. The Sun OpenR$_X$ Framework supports portals and distributed Web-based services, as well as application-to-application integration using health industry messaging standards. Alliance partners and Sun offer products that enable open-platform, Web and application services including:

- Sun Java System Integration Service
- Sun Java System Application Service
- Sun Java System Portal Service
- Sun Java System Web Serving Service

Messaging and Collaboration Services

Messaging and collaboration services provide electronic communication—an increasingly mission-critical function. With its highly integrateable technologies and support for healthcare industry standards, the Sun OpenR$_X$ Framework can facilitate electronic data interchange, secure messaging, and calendaring within and across your organization.

Specifically, the Sun OpenR_X Framework encompasses the following standards and products:

- HL7 Messaging
- Electronic Data Interchange (EDI) X.12N transactions
- National Council for Prescription Drug Programs (NCPDP) standards
- Standardized medical terminology and code sets including LOINC, SNOMED, ICD, CPT, UMLS, and DSM
- Digital Imaging and Communications in Medicine (DICOM) standard
- Sun Java System Messaging Service
- Sun Java System Calendar Service
- Sun Java System Instant Messaging Service

Java Technology-based Development Platform

The Java technology platform offers an integrated environment for designing, building, and testing open standards-based healthcare solutions including desktops, servers, mobile computing devices, and industry-specific applications. In fact, Java technologies offer several tools designed for healthcare industry developers, including:

- Java 2 Platform, Standard Edition (J2SE™)
- Java 2 Platform, Enterprise Edition (J2EE™)
- Java 2D™ two-dimensional application programming interface (API)
- Java 3D™ three-dimensional API
- Java Massachusetts General Hospital Utility Multi-programming System (MUMPS) Toolkit (jMT)
- Java 2 Platform, Micro Edition (J2ME™)
- Jini™ Network Technology
- Java Card™ API
- JXTA
- Sun Java Studio
- Radio frequency automatic identification (RFID)

Provisioning and Systems Administration

Provisioning and systems administration technologies help to make the most of a customer's IT investments and third-party resources. The Sun OpenR_X Framework provisioning components allow systems and network administrators to allocate network resources where they are needed most, instead of having processes run on a dedicated device. They can also leverage resources though open-platform computing grids and redundant configurations. Systems administration technologies facilitate new levels of data availability and reliability through features such as configurable archiving policies, shared file access, multi-platform integration, and storage scalability up to 252 terabytes.

Developed to help reduce the cost and complexity of the overall healthcare computing environment, the Sun OpenR_X Framework encompasses the following components:

- N1 Provisioning Server
- Sun™ ONE Grid Engine
- Sun Infrastructure Solution for Enterprise Continuity
- Sun StorEdge™ Utilization Suite
- Sun StorEdge™ Performance Suite

Hardware

The Sun OpenR_X Framework supports heterogeneous hardware components across the enterprise. This document highlights the following devices:

- Sun Ray™ thin clients with smart card reader and hot desking capabilities (the ability to resume a session context using any network-connected Sun Ray device)
- Sun Fire™ V880Z visualization server with the Sun XVR-4000 graphics accelerator
- Sun Fire Blade Platform with a 16 slot Intelligent Shelf
- Sun™ Crypto Accelerator board for high performance secure socket layer (SSL) and IPsec transactions
- Sun StorEdge™ systems

Sun servers offer binary compatibility along with the Solaris or Trusted Solaris OS. Additionally, Sun's range of x86 hardware has been certified as compatible with Red Hat Enterprise Linux, and certifications for SuSE Linux are forthcoming.

For more information about the Solaris, Trusted Solaris, and Red Hat Enterprise Linux operating systems, visit http://wwws.sun.com/software/product_categories/operating_systems.html/

Alliance Solutions

Sun Microsystems is collaborating with its partner community to help offer affordable, end-to-end solutions designed for small- to large-scale healthcare organizations. Currently, there are over 100 integrateable, open-platform technology alliance partner solutions designed to enhance information exchange, streamline processes, improve security, or boost system availability.

Health Industry Model Architectures

To illustrate the robust flexibility of the Sun OpenR_X Framework, this white paper offers a high-level discussion of how components can be employed to build the following health industry model architectures:

- *Community health information infrastructure* that supports a comprehensive patient record securely shared by authorized healthcare organizations
- *Disease and bio-surveillance grid* that helps agencies rapidly detect and respond to infectious disease or bio-terror events
- *Java Health Card* that contains patient and user system access rights, and can be used in hot desking environments
- *Outcomes and research data warehouse* that stores and analyzes key patient, health insurance, and provider data collected by heterogeneous systems
- *Medical imaging grid* that enables remote diagnostic interpretation and archiving of medical images
- *Patient health network* that supports emerging wireless, wearable medical devices, and implantable silicon-based medication delivery systems
- *Real-time healthcare enterprise* that electronically links healthcare organizations to facilitate business process integration and help improve the revenue cycle
- *Smart medical supply network* that enables supply chain products to electronically communicate with drug or device manufacturers and distributors using RFID technologies
- *ePrescriber network* that electronically connects physicians at the point of care with pharmacists and pharmacy benefit management companies

Chapter 3

Access Management

Today's Web-based computing models and services have brought about new access management requirements. Administrators need supporting technologies that can streamline patient registration and admitting processes without jeopardizing security. End-users desire user-friendly systems that offer features such as single sign-on. Patients and clients want to be assured that their data is protected from unauthorized access. Additionally, governments have instituted healthcare privacy and security regulations that need to be addressed.

The Sun OpenR$_X$ Framework includes robust, open-standard access management components, including:

- Sun Java System Directory Service
- Sun Java System Directory Proxy Service
- Sun Java System Identity Service
- Sun Java System Meta-Directory Service
- Initiate Identity Hub Enterprise Master Patient Index
- BiObex, a biometric access package from AC Technology
- Trusted Solaris Operating System

Sun Java System Directory Service

The Sun Java System Directory Service software provides a central repository for storing and managing patient, care-giver, administrator and user identity profiles, access privileges, and application and network resource information. The software helps improve the security and protection of

global information assets by enforcing appropriate access management policies across all communities, applications, and services.

Sun Java System Directory Proxy Service

The Sun Java System Directory Proxy Service software offers secure firewall-like services for the healthcare enterprise. Designed to accommodate large numbers of healthcare users, the Sun Java System Directory Proxy Service works with the Sun Java System Directory Service to help protect against attacks and promote around-the-clock availability. As a lightweight directory access protocol (LDAP) gateway, the Sun Java System Directory Proxy Service automatically routes requests from healthcare clients to the appropriate directory server through a referral mechanism.

For more information about Sun Java System software solutions, visit http://wwws.sun.com/software/

Sun Java System Identity Service

The Sun Java System Identity Service software is a standards-based product designed to help healthcare organizations manage secure access to Web and non-Web-based applications both on the intranet and extranet. As healthcare organizations require more financial, organizational, and competitive agility to compete in the marketplace, the Sun Java System Identity Service provides mission-critical functionality such as:

- Scalable access management services that help secure the delivery of clinical and administrative information
- Improved user experience through single sign-on
- A federated identity framework that creates collaborative opportunities through enhanced affinity relationships between community physicians, patients, and business partners

Federated identification across a regional and national network of government agencies and commercial healthcare organizations is achieved through the Identity Server's support for the Liberty Alliance Identity and SAML Web services security standards.

Sun Java System Meta-Directory Service

The Sun Java System Meta-Directory Service consolidates and integrates patient, care-giver, administrator, and user identity information—spread throughout the healthcare enterprise—into a single profile. The software can help consolidate and aggregate identity information from disparate sources like departmental systems, clinical data repositories, enterprise master person index, human resources applications, financial systems, network operating systems, messaging systems, and telephone databases. The Sun Java System Meta-Directory Service also helps improve the quality of administrative and clinical information within diverse applications through bi-directional synchronization: when changes are made to an identity in one application, other applications across the healthcare network are automatically updated.

Enterprise Master Patient Index

For more information about Initiate Identity Hub technology, visit http://www.initiatesystems.com/

Initiate Systems Inc.'s Initiate Identity Hub is the underlying technology for accurate identification and linking of identities to patient or customer records. Formerly Madison Information Technologies, Initaite Systems has developed technology designed to help consolidate fragmented customer identities into a linkage set that forms a 360 degree view of the customer. Designed to work in Web-based or legacy system environments, the Initiate Identity Hub software supports both business-line and enterprise requirements for managing customer identities. The software employs a probabilistic algorithm that can scan hundreds of millions of records to identify potential duplicates, and establish automatic linkages based on configurable threshold parameters.

Biometric Identification

For more information about biometric identification solutions supported by the Sun OpenR$_x$ Framework, see Appendix A.

Sun alliance partner AC Technology offers BiObex: a highly portable and extensible turnkey biometric access package that uses fingerprints to provide an extremely reliable layer of access security. After signing on, the user places a randomly selected finger on a scanner. A successful match between the scanned finger and fingerprints stored in the database or LDAP-compliant directory server allows access. The system is also capable of augmenting existing Java Card technology access to thin-client architectures by providing an additional layer of security to the username and password. The BiObex System is comprised of an enrollment/authentication software bundle, as well as a fingerprint and capture device.

Sun alliance partner Cross Match Technologies offers the highly durable, Verifier E fingerprint scanning device. The device includes a larger platen to capture high quality, FBI-standard prints. An intelligent Smart Scanner assesses prints by counting minutia ridges to help achieve accurate fingerprint verification.

Trusted Solaris Operating System

For more information about the Trusted Solaris OS, visit http://wwws.sun.com/software/solaris/trustedsolaris/index.html/

Achieving high-levels of system security in the healthcare industry is a critical business and regulatory requirement. Considerable cost, damage, or loss can be caused by hostile or unauthorized access and use of medical information. To control external access, firewalls and other access management methods are often used as gatekeepers. The Trusted Solaris OS offers extensive internal protection against intruders and system misuse by helping enable administrators to:

- *Limit access to system data and resources*
  Controls may be set on all potential interactions with programs, file access, and utilities on a user-by-user basis.
- *Eliminate super user*
  Dividing super-user functions into multiple roles makes penetration far more difficult.
- *Obtain an independent evaluation*
  An independent third party evaluates the operating system to validate that its security functions are working correctly.
- *Prevent eavesdropping in the window environment*
  In conventional UNIX® environments, an intruding program can capture keystrokes typed in other windows. Trusted Solaris software provides a *trusted* path that protects entered data. This is particularly important for passwords, which may also be protected by requiring password changes or generating random passwords.
- *Augment security auditing*
  Actions that may affect security or sensitive files can be monitored. To detect suspicious actions, administrators may generate reports of usage by user, file, data, and time.

- *Prevent spoofing programs*
  Trojan horses, such as programs used to intercept passwords or other sensitive data, are prevented by a graphical user interface and protocol. A trusted graphic displayed in a reserved area provides continuous, visible feedback of session integrity.
- *Protect local devices against unauthorized users*
  Authorized users may control access to local devices.

In many cases, misuse by authorized users is the main source of security violations. Trusted Solaris software helps stop violations by driving a security policy that controls the access and handling of information—including system administration, operation, and monitoring tools.

Chapter 4

Application and Web Services

Web-based computing can support new levels of data sharing, employee efficiency, and collaboration between healthcare organizations. By leveraging the power of the Internet, companies can seamlessly connect remote locations, more quickly configure new clinics, bring computing technologies to the bedside, expedite old processes, leverage third-party information resources, and allow for remote diagnostic procedures.

Sun and its alliance partners have designed robust application and Web service technologies using secure, open-platform Java technologies, the Solaris OS, and Web service protocols such as Simple Object Access Protocol (SOAP), XML, Electronic Data Interchange (EDI), Web Services Description Language (WSDL), and Universal Description, Discovery and Integration (UDDI).

The following Sun OpenR_X Framework components are designed to support a *Services on Demand* environment, where businesses can provide secure, anytime, anywhere access to enterprise technologies:

- Sun Java System Integration Service
- Sun Java System Application Service
- Sun Java System Portal Service
- Sun Java System Web Serving Service
- Sun iForce℠ Program

Sun Java System Integration Service

The Sun Java System Integration Service is available in two editions: Enterprise Application Integration (EAI) and Business to Business (B2B). The Sun Java System Integration Service EAI supports enterprises that need to integrate packaged, custom, legacy, and new Java technology applica-

tions. The Sun Java System Integration Service integrates heterogeneous Web services through SOAP messaging, which can export a service definition via WSDL, UDDI, or other SOAP clients. Companies can benefit from the automation of business processes across distributed information systems with increased productivity and efficiency.

Sun Java System Integration Service B2B Edition software allows companies to exchange business documents securely and reliably over the Internet with a variety of protocols and data types, including EDI and XML. With the Sun Java System Integration Service B2B Edition, enterprises can communicate with trading partners of any size, of any level of technological sophistication, and using any type of business documents.

For more information about how technologies like SOAP, WSDL, UDDI are used to develop Web services, visit http://www.sun.com/bigadmin/content/developer/howtos/overview_soap.html/

Sun Java System Application Service

The Sun Java System Application Service delivers solid, end-to-end, high performance across a broad spectrum of requirements and usage scenarios. The Sun Java System Application Service provides the foundation for delivering enterprise-class application and Web services by offering a unique new modular architecture based on some of the industry's most proven, standards-compliant components. Additionally, the Sun Java System Application Service integrates with the powerful, open-standard Java technology development environment, so developers can rapidly develop new Internet-ready services.

Sun Java System Portal Service

The Sun Java System Portal Service is an application that manages identity, end user access, and policy information in conjunction with portal access. For instance, the Sun Java System Portal Service provides single sign-on and system access capabilities, as well as services like personalization, aggregation, security, integration, mobile access, and search. Unique capabilities that facilitate secure remote access to internal portals and applications round out a complete portal platform for deploying robust patient-to-physician, physician-to-healthcare organization, and organization-to-organization portals.

For more information about Sun Java System software solutions, visit http://wwws.sun.com/software/

Sun Java System Web Serving Service

The Sun Java System Web Serving Service delivers content to end users at high trust and service levels. Web content, generated from a variety of technologies including Active Server Pages (ASP) and Java technologies, is protected using security standards and resilient authentication and access management options. The Sun Java System Web Serving Service helps maximize uptime through its unique and powerful multithreaded, multiprocessing architecture.

iForce Program

The iForce™ Program is an integration, configuration, and testing support service available to healthcare organizations at no cost. Through the program, world-class engineers from Sun Microsystems collaborate with IT staff from the healthcare organizations to proactively address each customer's unique configuration, scalability, reliability, security, and integration testing issues.

For more information about the Sun iForce program, visit http://www.sun.com/executives/iforce/

Chapter 5

Messaging and Collaboration Services

Healthcare organizations collect and exchange huge volumes of information. Up to date information and the ability to share it is critical in large and small provider and payor organizations. However, exchanging information becomes difficult if applications don't use common medical terminology, code sets, transaction protocols, or application messaging.

The Sun OpenR_X Framework components are designed to facilitate new levels of data integration, transaction processing, customer service levels, and employee communication. The technologies support many of the industry's most popular standards while also promoting security, mobile access, and scalability. The Sun OpenR_X Framework includes:

- Support for Health Level Seven (HL7), X.12 electronic data interchange (EDI), National Council for Prescription Drug Programs (NCPDP), ACR/NEMA Digital Imaging and Communications in Medicine (DICOM), and numerous medical terminology and code set standards
- Sun Java System Messaging Service
- Sun Java System Calendar Service
- Sun Java System Instant Messaging Service

Healthcare Industry Standards

As computing technologies evolved, disparate technologies emerged to serve localized business and departmental requirements. The plethora of heterogeneous best-of-breed solutions today often impedes the integration of data, processes, and collaboration. To help integrate existing systems into a distributed computing model, the Sun OpenR$_x$ Framework supports several key industry standards.

Health Level 7 Application Messaging

HL7 is an ANSI Standards Developing Organization addressing the interoperability requirements of the healthcare industry. The organization focuses on boosting the effectiveness of clinical and administrative data exchange between healthcare applications. For instance, HL7 provides:

- Standards for the exchange, management, and integration of clinical and administrative data that support patient care
- Standards for the management, delivery, and evaluation of healthcare services
- Messaging specifications supporting clinical and administrative data exchange

ASC Electronic Data Interchange X.12N Transaction Mapping

EDI is the electronic transfer of information using a standard format. Prior to the implementation of HIPAA-mandated X.12N EDI transactions, there were about 400 formats for electronic health claims being used in the United States. The lack of standardization made it difficult and expensive to develop and maintain software—while also minimizing the ability of healthcare providers and health plans to achieve efficiency and savings.

EDI allows entities within the healthcare system to exchange medical, billing, and other information—as well as process transactions quickly and cost effectively—so that organizations can enjoy:

- Substantial reduction in handling and processing time compared to paper
- The elimination of risk surrounding lost paper documents
- The elimination of inefficiencies related to paper handling
- Significant reductions in paper-based administrative burdens and operating costs
- Improved overall data quality compared to paper-based records

National Council for Prescription Drug Programs

The NCPDP standards are designed to facilitate data interchange across the pharmacy services sector of the healthcare industry. The NCPDP address transaction standards for the following three areas:

- Telecommunications
- SCRIPT
- Manufacturer rebates

ACR/NEMA Digital Imaging and Communications in Medicine Standard

The DICOM Standard facilitates the interoperability of medical imaging equipment by specifying standards for network communication, media communication, and command syntax and semantics. Specifically, the DICOM standard addresses digital medical image file format, medical directory structures, and communications protocols.

Medical Terminology and Code Sets

Today, no single healthcare terminology standard exists that meets the needs of healthcare information users. Some of the most common terminology and code sets include LOINC, SNOMED, ICD, CPT, UMLS, and DSM. Each vocabulary has been designed for different purposes by different healthcare constituencies.

There is a vast array of healthcare information available to providers as well as people seeking answers to medical questions. Consumer-oriented health Web sites, electronic medical record systems, and clinical bibliographic databases offer unprecedented access to medical knowledge. However, the accurate and efficient retrieval of desired information remains a challenge for everyone, including consumers trying to find information about a family illness, physicians pursuing a difficult diagnosis, or researchers exploring a clinical protocol.

The Sun OpenR_X Framework messaging and collaboration solutions help provide medical terminology services that mediate the differences between clinical and administrative systems.

Open-platform Software Solutions

The Sun OpenR_X Framework offers secure, highly scalable messaging and collaboration services that can help streamline information systems across the enterprise.

Sun Java System Messaging Service

The Sun Java System Messaging Service is a highly scalable software product that helps provide a centralized location for the exchange of electronic messages between millions of patients, physicians, administrative staff, and business associates. The Sun Java System Messaging Service also offers value-added differentiated services such as outsourcing, wireless, and unified messaging services.

For more information about The Radicati Group study, visit http://www.sun.com/software/insidesun/050503_insidetrack.html/

According to a March 2003 study from The Radicati Group, an independent market research firm, Sun Java System Messaging Service delivers a 2:1 total cost of ownership advantage over IBM and Microsoft.

Sun Java System Calendar Service

For more information about Sun Java System solutions, visit http://wwws.sun.com/software/index.html/

The Web-based Sun Java System Calendar Service helps healthcare users manage their schedules, share resources, and schedule events or appointments. The server is customizable, and accessible anytime, anywhere, from any Web-enabled device. Customers in both enterprise and service provider markets use the Sun Java System Calendar Service in conjunction with the Sun Java System Messaging Service to offer comprehensive communications, facilitate collaboration, and streamline operations.

Sun Java System Instant Messaging Service

The Sun Java System Instant Messaging Service supports secure, real-time communication between healthcare constituents across departments and organizations. The Sun Java System Instant Messaging Service incorporates presence awareness capabilities such as chat, conferences, alerts, news, polls, and file transfers to create a rich collaborative environment. Sun Java System Instant Messaging Service ensures the integrity of communications through its multiple authentication mechanisms and SSL connections. Integration with the Sun Java System Portal Service and Sun Java System Identity Service incorporate additional security features, access policy, user management, and secure remote access.

Chapter 6

Software Development

Healthcare developers can use Java technologies and the Solaris OS to create innovative, distributed, real-time services designed to facilitate:

- Interoperability between different systems and communities
- Platform independence so peers can communicate despite the language, system, and network
- Ubiquity so that every device has a digital heartbeat
- High performance, scalable Web-based services
- Secure, mobile access
- Rapid time to market

The Sun OpenRx Framework includes end-to-end Java technology-enabled tools for healthcare developers, including:

- Java 2 Platform, Standard Edition (J2SE)
- Java 2 Platform, Enterprise Edition (J2EE)
- Java 2D two-dimensional application programming interface (API)
- Java 3D API
- Java Massachusetts General Hospital Utility Multi-programming System (MUMPS) Toolkit (jMT)
- Java 2 Platform, Micro Edition (J2ME)
- Jini Network Technology
- Java Card API
- JXTA
- Sun Java Studio
- Java Community Process

Java 2 Platform, Standard Edition

The Java 2 Platform, Standard Edition (J2SE) is at the core of Java technology. From client to server and desktop to supercomputer, enterprises can use Java technology to develop more robust, scalable healthcare applications with less effort and in less time.

For more information about Java technologies, visit http://java.sun.com/

J2SE helps developers leverage existing systems without changing their underlying platforms by offering support for industry standards technologies such as XML, DOM, SSL, Kerberos, LDAP, and CORBA to ensure operability across heterogeneous platforms, systems, and environments. J2SE also supports very large memory configurations and ultra-fast I/O, allowing for entirely new classes of applications to be developed.

Java GSS-API with Kerberos support, Java Secure Socket Extension (JSSE), Java Cryptography Extension (JCE), and other security enhancements allow developers to implement the highest levels of security in their Java code. Combined with Solaris OS security features, Java software provides the ideal secure platform for developing *Services on Demand*.

Java 2 Platform, Enterprise Edition

The Java 2 Platform, Enterprise Edition (J2EE) extends the capabilities of J2SE by adding full support for enterprise application integration capabilities, such as Enterprise JavaBeans™ components, Java™ Servlet API, JavaServer Pages™ and XML technology. J2ME is a highly optimized Java runtime environment designed to address small memory footprint consumer devices ranging from smart cards and pagers, to cell phones, set-top boxes, and other devices.

Java 2D Application Environment

The Java 2D API is a comprehensive set of classes for advanced 2D graphics and medical imaging. Included in J2SE, the Java 2D API provides a rich set of display-oriented imaging operators and extensive support for image composition, alpha channel images, and accurate color space definition and conversion. Applications developed using the Java 2D API are Internet-ready and can run on heterogeneous platforms and systems.

Java 3D Application Environment

The Java 3D API, an optional package in J2SE, supports the creation of three-dimensional medical graphics applications and Internet-based 3D applets. Developers can use the API's high-level constructs to create and manipulate 3D geometry, efficiently defining and rendering very large virtual worlds. Moreover, in line with the Java platform's *write once, run anywhere* vision, applications written using the Java 3D API can run on a wide range of platforms and systems, and are adapted for Internet use.

The Java 3D API incorporates a high-level, scene-graph model that helps developers focus on objects and scene composition. This speeds application development, because programmers do not need to design specific geometric shapes, write rendering code for the scene display, manage attribute states, or tune and scale the application's scene graph to the underlying hardware. Additionally, the Java 3D API maximizes performance by providing three rendering modes: Immediate, Retained, and Compiled-retained.

Java MUMPS Toolkit (jMT)

By employing a standard Java technology-based interface with functions that are syntactically equivalent to native MUMPS database functions, the jMT provides access to MUMPS-enabled databases. Thus developers can use jMT to easily leverage the plethora of Java-based tools and technologies (like security services, directory services, and Web services) to build applications that

interact with MUMPS environments—without making code or data changes to the existing system.

While there are tools currently available that bring Java to the MUMPS environment, the jMT is primarily focused on bringing MUMPS databases capabilities—including multidimensional sparse arrays, multi-level locking, and automatic subscript collation— to the Java technology platform.

Included in the jMT is a 100 percent Java technology-based, ANSI 1995-compliant MUMPS interpreter that exposes MUMPS legacy transactions and data to more modern Web-service architectures. The ability to execute MUMPS code locally allows for the transitioning of some or all existing MUMPS code to the Java technology platform, at a pace suitable to the customer's business.

Java 2 Platform, Micro Edition

J2ME is the Java platform for consumer and embedded devices such as medical devices, mobile phones, PDAs, TV set-top boxes, in-vehicle telematics systems, and a broad range of embedded devices. The J2ME platform delivers the power and benefits of Java technology tailored for consumer and embedded devices including a flexible user interface, robust security model, broad range of built-in network protocols, and support for networked and disconnected applications. With J2ME, applications are written once for a wide range of devices, are downloaded dynamically, and leverage each device's native capabilities.

Jini Network Technology

Jini network technology is an open architecture that allows healthcare developers to create network-centric services—implemented in hardware or software—that can scale from the medical device to the enterprise information system. Jini technology can be used to build adaptive networks that are scalable, evolvable, and flexible as typically required in dynamic computing environments.

Jini technology facilitates mobility by allowing Java executables and data to be extended over the network via a Java object. Additionally, the technology boosts fault tolerance through self-healing and self-configuration, helping to reduce total cost of ownership.

Java Card Application Environment

The Java Card specifications enable Java technologies to run on smart cards and other devices with limited memory. The Java Card platform is licensed on an OEM-basis to manufacturers, which already represents more than 90 percent of the worldwide smart card manufacturing capacity. Across virtually all industries, the Java Card standard has the largest market penetration, and is employed by organizations like the Taiwan Health Ministry and U.S. Department of Defense. Java Cards' popularity can be attributed to features such as:

- Interoperability with any Java Card technology-based smart card, independent of card vendor and underlying hardware
- Inherent security provided by the Java technologies runtime environment
- Multiple applications co-exist securely on a single Java Card
- The ability to install new applications after a card has been issued
- Support for object-oriented programming processes and off-the-shelf Java technology development tools
- Compatibility with international standards for smart cards such as ISO7816 and EMV
- Recognition by major industry-specific standards such as Global Platform and ETSI

Project JXTA Technology

JXTA technology is a set of open protocols that allow any connected device on the network—including medical devices, cell phones, wireless PDAs, PCs, and servers—to communicate and collaborate in a peer-to-peer manner. JXTA peers create a virtual network where peers can interact, and access resources directly and securely—even when some peers and resources are behind firewalls or NATs, or are on different network transports.

Sun Java Studio

Sun Java Studio is an integrated development environment (IDE) for Java technology. Based on the modular, open source NetBeans Tools Platform, Sun Java Studio is ideal for building and deploying Web services across multiple hardware and software platforms, including Windows, Windows NT, Linux, and the Solaris operating environments. Sun Java Studio is also scalable, offering plug-in modules for fast adoption of new technologies from Sun, Sun's partners, and the community.

Auto-ID Technologies

Automatic Identification (Auto-ID) is a broad term for technologies that help devices identify objects. The aim of most Auto-ID systems is to increase efficiency, reduce data entry errors, and free up staff to perform more critical functions. The technologies that fall under the Auto-ID umbrella include bar codes, smart cards, sensor technologies, voice recognition, some biometric technologies such as retinal scans, optical character recognition, and radio frequency automatic identification (RFID).

The standards for Auto-ID technology are being defined and driven through the Auto-ID Center™: a unique partnership between over 87 global companies and three of the world's research universities (Massachusetts Institute of Technology in the US, University of Cambridge in the UK, and University of Adelaide in Australia). Sun Microsystems became an early sponsor of the Auto-ID Center in June 2000 and presently chairs the center's Technology Board and Software Action Group.

RFID Technology

RFID is a generic term for technologies that use radio waves to automatically identify individual items. There are several methods of identifying objects by use of RFID. The most common is to store a serial number that identifies a product, and perhaps other information, on a microchip that is attached to an embedded antenna. (The chip and the antenna together are called an RFID transponder or an RFID tag.) The antenna enables the chip to transmit the identification information to a reader. It converts the radio waves from the RFID tag into a form that can then be passed on to computer applications.

Java Community Process

The Java Community Process (JCP) is an open organization of international Java developers and licensees whose charter is to develop and revise Java technology specifications, reference implementations, and technology compatibility kits. Both Java technology and the JCP were originally created by Sun Microsystems, however, the JCP has evolved from the informal process that Sun used beginning in 1995, to a formalized process overseen by representatives from many organizations across the Java community.

Chapter 7

Provisioning and Systems Administration

Through mergers, acquisitions, and the historic proliferation of localized departmental systems, many healthcare organizations now find themselves with disparate computing platforms. The Sun OpenR$_X$ Framework components can help utilize systems and services in new ways, helping to provide:

- Reduced system cost and complexity
- Enhanced system performance
- Resources where you need them, when you need them
- Flexibility and scalability to meet tomorrow's challenges
- High availability levels

The Sun OpenR$_X$ Framework provisioning and systems administration components include:

- N1 Provisioning Server
- Sun ONE Grid Engine
- Sun Infrastructure Solution for Enterprise Continuity
- Sun StorEdge Utilization Suite software
- Sun StorEdge Performance Suite software

N1 Provisioning Server

The N1 Provisioning Server is the core component of the Sun N1 architecture. A radical new computing paradigm, the N1 architecture treats the network as the computer. A system is no longer just a *box*, a computer, a storage system, a network router, or some other resource used by only one department, building, or location. Instead, N1 makes the data center work like a single system. Once isolated resources become a pool of virtual resources, available to be re-allocated in minutes and used in more flexible ways.

For more information about the N1 architecture, visit http://wwws.sun.com/software/solutions/n1/index.html/

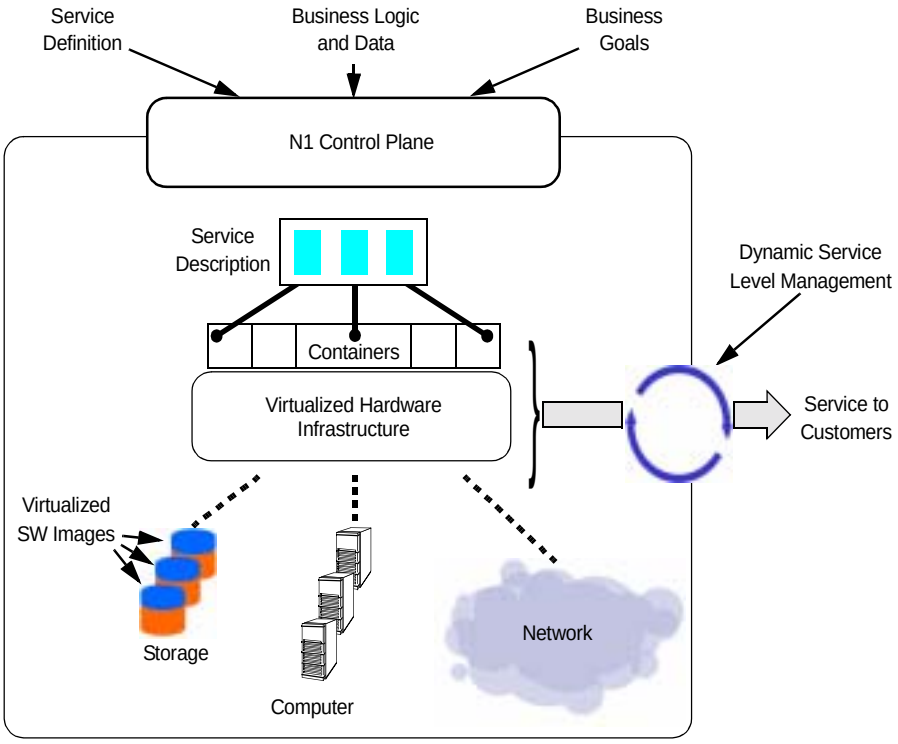


Figure 7-1: N1 Provisioning Server
N1 can use several key abstractions to support an environment designed to meet service-level objectives. IT architects use the N1 control plane to translate service definitions and business goals into a service description. The business logic is housed in containers, such as an application server or an operating system. Containers are hosted on hardware containers such as servers, Dynamic System Domains, and server appliances. The virtualized hardware infrastructure specifies a pool of computing resources connected through networks, including computing platforms, Dynamic System Domains, network infrastructure elements, and storage systems. Virtualized software images include business logic and container code, and can be off-the-shelf or customized software that supports business objectives.

The N1 Provisioning Server manages which network components support which services. Re-allocating resources as needed to support flexing system demands, the N1 Provisioning Server creates a virtual pool of business services and then maps services to resources as required, automatically. Services are no longer restricted to run on a single system. Instead, services are allocated to the appropriate hardware device so that system resource utilization and efficiency is boosted, not wasted.

Using a graphical user interface (GUI), administrators specify performance objectives for network services. The N1 Provisioning Server uses the performance objectives to monitor the health and availability of each application. If a service requires more computing power, the N1 Provisioning Server reallocates computing resources. If there is an outage, the N1 Provisioning Server maps the services to available resources.

For more information about the N1 Provisioning Server, visit http://wwws.sun.com/software/products/provisioning_server/

Through its efficient management of existing and future compute resources, the N1 Provisioning Server can help:

- Reduce costs and complexity
- Improve utilization rates
- Increase the efficiency of resources
- Improve management and administration efficiency
- Promote agility in meeting changing business requirements
- Protect IT investments by incorporating existing hardware and software

Virtualization Through the N1 Control Plane

A key function provided by the N1 architecture is virtualization: breaking down the boundaries between resources so they can be pooled and used by any number of services. The N1 Control Plane, a component of the N1 Provisioning Server, allows for the virtualization of hardware resources. Similar to a computer system bus that holds processors, memory cards, or networking cards, the N1 control plane stores information about the architecture's compute, storage, and network resources so that services can be readily mapped to available resources.

Sun ONE Grid Engine Software

For more information about Sun ONE Grid Engine software, visit http://wwws.sun.com/software/gridware/sge.html/

Sun ONE Grid Engine software is Sun's solution for managing cluster grids. A cluster grid consists of multiple systems—including distributed workstations, servers, and centralized resources in a data center environment—interconnected through a network. Typically owned and used by a single project or department, cluster grids support high-throughput and high-performance functions such as those performed by medical imaging and clinical research applications.

Sun ONE Grid Engine software is designed to provide:

- Transparent resource access
- Distributed resource management
- High system utilization
- Increased computing throughput

A unique feature of Sun ONE Grid Engine software is its ability to quickly provide computer resources where they are needed most in the cluster. For example, the software helps clinical researchers access high-performance computing resources that can process hundreds of billions of arithmetic operations per second—speeds that outperform some of the most powerful supercomputers just a few years ago.

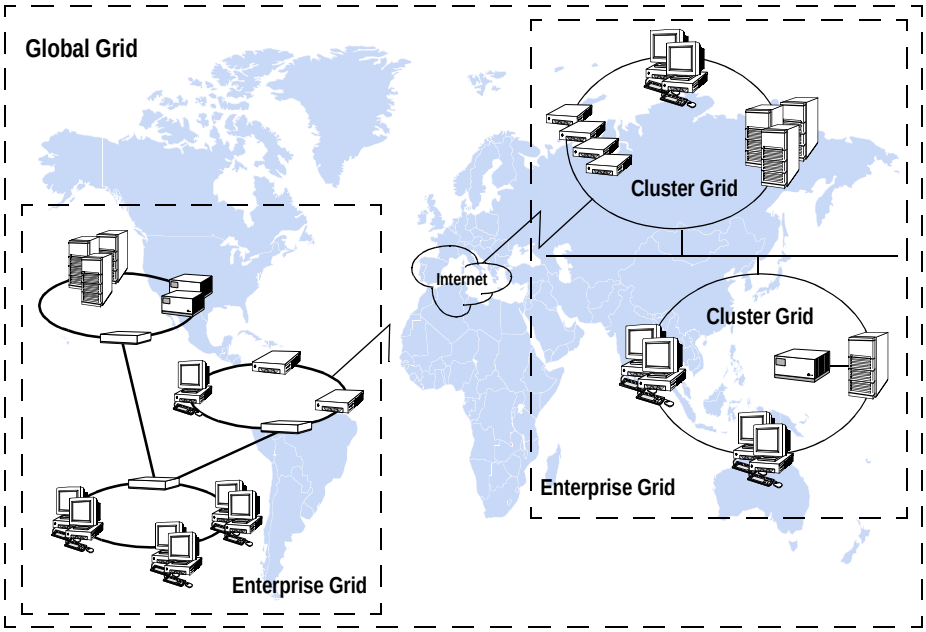


Figure 7-2: Sun One Grid Engine Software
Sun One Grid Engine software addresses the needs of cluster, enterprise, and global grids. Cluster grids consist of multiple systems interconnected through a network. Enterprise grids include more than one cluster grid, interconnected to support multiple projects or departments. Global grids are a collection of enterprise grids that have agreed on global usage policies and protocols, but not necessarily the same implementation.

The Sun Infrastructure Solution for Enterprise Continuity

Sun and Nortel Networks have collaborated to develop the Sun Infrastructure Solution for Enterprise Continuity. An availability product based on redundant systems, Sun Infrastructure for Enterprise Continuity is designed to keep mission-critical applications running no matter what happens—at distances up to 200 kilometers apart.

The Sun Infrastructure Solution for Enterprise Continuity physically links multiple data centers to create a single, highly available data center. Multiple sites act as one geographically dispersed storage area network (SAN), and the SunPlex™ cluster acts as one unified application cluster. In the event of a system failure, a secondary system at another site automatically takes over within minutes.

For more information about the Sun Infrastructure Solution for Enterprise Continuity, visit http://www.sun.com/solutions/infrastructure/3_0.html/

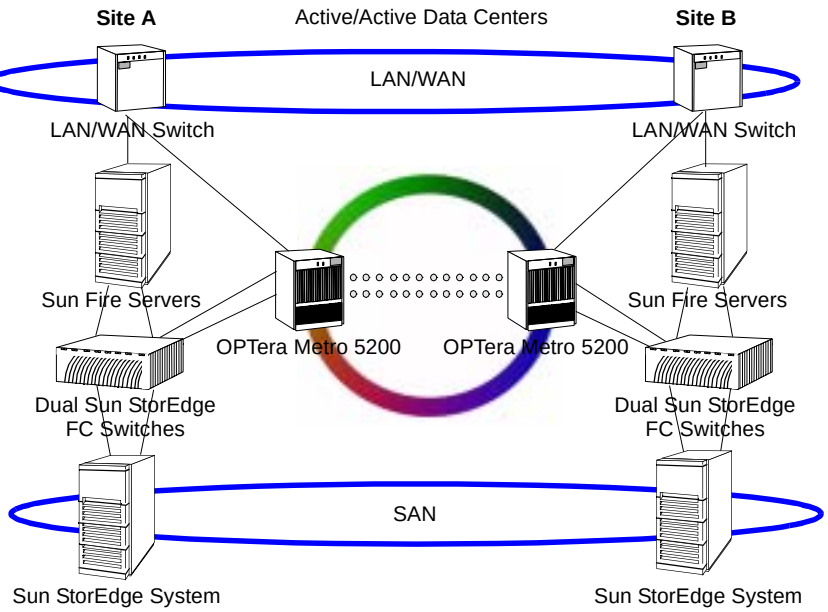


Figure 7-3: Sun Infrastructure Solution for Enterprise Continuity

Organizations can employ the Sun Infrastructure Solution for Enterprise Continuity to help protect against localized disasters, boost productivity, reduce the need for additional IT investments in replication hardware and software, and cut costs by housing secondary data centers in less costly real estate markets.

The key components of the Sun Infrastructure Solution for Enterprise Continuity include:

- *Nortel Network OPTera Metro 5200*
  A Dense Wavelength Division Multiplexing (DWDM) multi-service platform that supports the precise high-speed interaction necessary between clustered servers at geographically disparate sites.
- *Sun Open SAN Environment*
  A total SAN solution that integrates storage resources, host bus adaptors (HBAs), interconnect, and backup devices to help provide high-availability access to mission-critical data, expedited backup and recovery procedures, resource consolidation, and centralized system management.
- *Sun™ Java System Cluster Service Runtime Environment and SunPlex System Technology*
  Delivering high-availability application services to the data center, the Sun Java System Cluster Service Runtime Environment extends the Solaris operating system to seamlessly support applications on heterogeneous machines, in a tightly-coupled clustering model. SunPlex systems feature redundant paths between systems, disk subsystems, and external networks. Thus no single point of failure—hardware, software, or network—can bring a SunPlex system down.

Sun StorEdge Utilization Suite SAM-FS Software

The Sun StorEdge Utilization Suite incorporates Sun StorEdge Archival Manager File System (SAM-FS), which combines outstanding archiving and back-up methodologies with a robust file system to offer superior data management performance, scalability, and reliability. The software replaces traditional backups to improve storage resource utilization and promote more cost-effective data management. By efficiently utilizing valuable archives—such as digital images, clinical data, or research information—both small and large enterprises can help reduce operational expenses, and gain a competitive edge by having reliable, high-performance data access.

For more information about Sun StorEdge Performance Suite software, visit http://www.sun.com/storage/software/utilization/Sun StorEdge Archival Manager File System (SAM-FS), combines outstanding archiving and back-up methodologies with a robust file system to offer superior data management performance, scalability, and reliability. The software replaces traditional backups to improve storage resource utilization and promote more cost-effective data management. By efficiently utilizing valuable archives—such as digital images, clinical data, or research information—both small and large enterprises can help reduce operational expenses, and gain a competitive edge by having reliable, high-performance data access.

Sun StorEdge SAM-FS software is an advanced storage management product that combines unmatched performance, an easy-to-use graphical user interface (GUI), and advanced functionality for medium to high-end storage configurations. With Sun StorEdge SAM-FS, data centers have the flexibility to choose a variety of storage media and devices without having to rely on primary storage on servers. The storage management system migrates data from expensive online disk to more affordable secondary storage such as optical or tape media, while giving users what appears to them as “infinite disk.”

Some of the key features offered by Sun StorEdge SAM-FS include:

- *Automated, flexible policy management*
  Administrators can configure automatic archiving policies that specify when, where, and how information is stored. Policies can be changed without adversely affecting previously archived files.
- *Complete transparency to the user and application*
  Acting as middleware between the OS and applications, Sun StorEdge SAM-FS automates the storage management process, without requiring intervention from a user or administrator.

- *Fast recovery*
  In the event of a business disruption, users can access files as soon as meta data is restored (typically within minutes or hours), rather than waiting for all data to be restored (which can take several days).
- *Heightened data access security*
  Enhanced policy-based administration and security features let you set quotas and define access control lists (ACLs) to manage space consumption and data access.
- *Scalability*
  By holding file attribute information in separate files, a Sun StorEdge SAM-FS file system can be dynamically enlarged, and can currently scale to accommodate up to 252 terabytes.
- *Advanced hierarchical storage management (HSM)*
  Sun StorEdge SAM-FS acts as a true extension of online storage, migrating and accessing data simultaneously from multiple storage devices while maintaining an online look and feel to the end user.

Sun StorEdge Performance Suite QFS Software

The Sun StorEdge Performance Suite incorporates the Sun StorEdge Quick File System (QFS), which helps provide maximum scalability, performance, and throughput for the most data-intensive applications. The software suite includes a robust shared file system with fully integrated volume management, discovered direct I/O, and other leading features that can help simplify storage pooling in Network Area Storage (NAS) and SAN configurations. Sun StorEdge QFS is a high-performance 64-bit Solaris OS file system that allows for large healthcare data sets, such as digitized medical images, to be available at device-rated speeds when requested by one or more users. The Sun StorEdge QFS file system's inherent scalability helps organizations to accommodate growing storage demands.

For more information about Sun StorEdge QFS Software, visit http://www.sun.com/storage/software/performance/

Along with offering an easy-to-use GUI, some key features of Sun StorEdge QFS include:

- *Shared file access*
  Multiple applications and users can share the same files and volumes on the network.
- *Automated, transparent data management*
  The file system continually and automatically manages the online, nearline, and offline data transparently to users and applications. Additionally, users read and write to files as though they were on primary storage.
- *Support for multiple file formats and platforms*
  The file system accommodates many file types—including test, image, audio, video, and mixed-media—in one logical place.
- *Heightened data access security*
  Administrators can set quotas and define access control lists to simplify management, heighten data access security, and improve storage resource allocation.
- *Scalability*
  The Sun StorEdge QFS software currently scales up to 252 terabytes.

Chapter 8

Hardware

Sun's end-to-end, high-performance hardware solutions support heterogeneous platform environments while also offering world-class performance and scalability. Whether a customer's healthcare organization wants to integrate an additional server, build additional sites, or migrate an entire platform, Sun has the right solution for them.

Medical imaging processing and storage, patient privacy, remote system access by physicians, and insurance transaction processing are just a few of the healthcare industry's specialized functions and concerns. Though the Sun OpenR_x Framework encompasses all of Sun Microsystems' hardware offerings, the following technologies are of particular interest:

- Sun Ray thin clients
- Sun servers including the Sun Fire V880z Visualization server and the Sun Fire Blade platform
- Sun Crypto Accelerator Board
- Sun StorEdge systems

Sun Ray Thin Clients

The Sun Ray thin client is a stateless device: all processing is performed by the server. No maintenance is required for desktop software. The flexibility of the device is ideal for patient rooms, ambulatory settings, intensive care units, and nursing stations. The Sun Ray thin client has a built-in Java Card reader and hot-desking feature which enable care-givers to use a Java Card to access their session exactly where they left off—even if they did not save the session—from any Sun Ray thin client in the enterprise. Care-givers can move their session from desktop to desktop, supporting increased mobility, collaboration, and the ability to share desktops. The Java Card also helps promote security and HIPPA compliance.

Minimal set up is required for Sun Ray thin clients because they are stateless. Once plugged in, they are automatically discovered and connected to the enterprise network. This dramatically reduces the time and costs required to install and maintain desktops over traditional personal computers.

Sun Ray thin clients are VESA-mount compatible, and can be mounted on the wall or on a bracket with a moveable arm. The device can also project images by attaching an LCD projector.

Sun Servers

With optimal scalability, flexibility, and performance at a low total cost of ownership, Sun servers offer excellent investment protection for your applications and hardware. Customers can flexibly choose from high-end, midrange, midframe, and entry-level platforms. Each server is designed to provide a seamless, smooth upgrade path with a common UltraSPARC® architecture, along with binary compatibility and a common Solaris or Trusted Solaris OS. Additionally, Sun's range of x86 hardware has been certified as compatible with Red Hat Enterprise Linux, and certifications for SuSE Linux are forthcoming.

For more information about Sun servers, visit http://www.sun.com/servers/.

For a list of server models and corresponding URLs, see Appendix A.

For more information about the Solaris, Trusted Solaris, and Red Hat Enterprise Linux, visit http://wwws.sun.com/software/product_categories/operating_systems.html/

Linux and Solaris applications are compatible today using Java technologies and common interfaces and tools, such as lxrun and Linux Compatibility Toolkit (LinCAT).

Sun Fire V880z Visualization Server

The Sun Fire V880z visualization server with the Sun XVR-4000 graphics accelerator is a powerful, highly affordable solution that meets the visual quality and performance needs of the high-end medical imaging market. The systems-level and graphics performance of the Sun Fire V880z visualization server helps process the large data sets manipulated in collaborative, visualization environments.

With the UltraSPARC III architecture and a large memory capacity, the Sun Fire V880z visualization server provides the technology and scalability to run compute-intensive, 64-bit visualization applications. The Sun XVR-4000 graphics accelerator provides excellent visual quality through sophisticated, programmable anti-aliasing chips and dedicated frame buffer and texture memory. Anti-aliasing features on the Sun XVR-4000 graphics accelerator virtually eliminate *jaggies* on a 3-D surface and allow precise rendering of complex data with sub-pixel accuracy. The Sun XVR-4000 graphics accelerator also features advanced functionality such as support for framelock, genlock, stereo displays, S-video output, and dynamic video resizing.

Sun Fire Blade Platform

The Sun Fire Blade Platform lets you mix, match, and manage SPARC® and x86 architectures, Solaris and Linux operating systems, and specialty blades through a 16 slot Intelligent Shelf and the N1 Provisioning Server software. Designed for customers who require high availability, horizontally scaled processing power, and lower total cost of ownership, the Sun Fire Blade Platform can be quickly integrated into current IT environments, and quickly respond to changing business requirements.

For more information about the Sun Blade Platform, visit http://www.sun.com/servers/entry/blade/index.html/

By integrating different platform blades in one shelf, and gaining the ability to manage resources in a virtual pool through the N1 Provisioning Server, customers can boost resource utilization and help reduce management costs in existing data center environments.

The Sun Fire Blade Platform includes the following hardware components:

- 16 Slot Intelligent Shelf (employed by each Sun Fire Blade server)
- General purpose blades
- Speciality blades
- Sun Fire B100s (SPARC) Blade Server
- Sun Fire x86 Blade Server
- Sun Fire SSL Proxy Blade
- Sun Fire B10n Content Load Balancing Blade
- Sun StorEdge 3310 NAS

Sun Crypto Accelerator Board

The Sun Crypto Accelerator 4000 board helps efficiently deliver network security on Sun servers running the Solaris OS and the Sun Java System Web Serving Service software or Apache Web server software. By combining Gigabit Ethernet functionality with specialized hardware that off-loads and accelerates the cryptographic operations of IPsec and SSL industry-standard security protocols. Ideal for companies using IPsec over virtual private networks, the board helps provide the high-bandwidth connections and optimized performance required to efficiently protect your server-to-server communications. Specifically, the Sun Crypto Accelerator 4000 board is designed to:

- Improve server response times and availability for secure Web transactions
- Help lower the cost and complexity of secure networking
- Increase resource utilization and traffic handling capacity by off-loading cryptographic functions from system processors
- Help reduce dropped connections by supporting multiple simultaneous secure connections for increased customer satisfaction
- Provide tamper-proof, centralized security key and certificate administration for Sun Java System Web Serving Service software

Sun StorEdge Systems

For more information about Sun StorEdge systems, visit http://www.sun.com/storage/

The Sun StorEdge product family offers a wide range of flexible, scalable storage systems for desktop, workgroup, midrange, and data center environments. Sun StorEdge systems are particularly adept at handling very large volumes of medical information such as digital medical images and clinical data repositories. The product family includes disk and tape appliances as well as support for other media such as optical. Each device is optimized to support the Sun StorEdge SAM-FS and QFS software, as well as the Solaris operating system. The product family also supports heterogeneous environments, offers leading-edge solutions for High Performance Computing (HPC) and enterprise SAN implementations, and state-of-the-art storage virtualization technology for maximum business performance.

By deploying products such as the Sun StorEdge SAM-FS and QFS software on appropriately sized Sun StorEdge storage systems and tape libraries, healthcare organizations can quickly realize the benefits of a digital asset management system—while also providing the agility required in fast-paced environments. Sun OpenR_X Framework's use of open interfaces and industry-standard components allows customers to make choices that best meet business requirements, help achieve lower total cost of ownership, and release proprietary constraints. Additionally, Sun StorEdge products offer built-in enterprise scalability—up to 252 terabytes—so customers can

add digital content or expand their user community, while also scaling performance, storage resources, and accessibility to meet changing demands.

Chapter 9

Sun OpenR_X Framework Model Architectures

The following model architectures illustrate how the Sun OpenR_X Framework can be used to create end-to-end healthcare solutions. A common theme throughout the model architectures is the establishment of a standards-based, network computing infrastructure that connects healthcare constituents across the healthcare value chain. There are common foundational elements and design considerations that span all of the model architectures:

- Federated network identity (for example Liberty SAML)
- Common directories (e.g., LDAP)
- Standards-based application to application messaging (e.g., HL7)
- Healthcare-specific transaction sets (e.g., X.12N and/or NCPDP SCRIPT)
- Multi-platform programming languages (e.g., Java technologies)
- 2D/3D APIs (including interfaces between Java technologies and MUMPS)
- Standardized medical terminology services (e.g., LOINC and SNOMED)
- Hardware (such as Sun Ray thin clients and Java Cards)
- Access technologies (such as RFID Tags and biometric devices)

Sun OpenR$_x$ Framework Model	**Description**	**Industry Standards / Key Components**
Community Health Information Infrastructure	• Patient-centric network computing infrastructure • Helps healthcare organizations exchange data electronically internally and across a community • Allows for the creation of a patient-centric electronic health record that spans organizational boundaries • Highly scalable	• HL7 • X.12N • LOINC • SNOMED • Liberty SAML • EMPI • Java Card • BiObex • NCPDP/SCRIPT • jMT Java/MUMPS • Sun StorEdge technologies • Sun Java System and Sun ONE software
Disease and Bio-Surveillance Grid	• Grid infrastructure • Facilitates the exchange, analysis, and response to infectious disease and bio-terror health events • Helps public health agencies and healthcare facilities to detect and respond to epidemic health events	• HL7 • LOINC • SNOMED • ICD-9 • CPT-IV • Liberty SAML • jMT Java/MUMPS • J2ME • Sun Java System and Sun ONE software • Sun StorEdge technologies
Java Health Card	• Network computing infrastructure • Supports the distribution and use of smart cards in healthcare • Helps ensure positive patient identification • Helps secure access to sensitive patient information by healthcare employees	• HL7 • X.12N • LOINC • SNOMED • Liberty SAML • EMPI • Java Card • BiObex • NCPDP/SCRIPT • jMT Java/MUMPS • Java Card toolkit • X.12N • Sun Ray thin client • Sun Java System and Sun ONE software
Outcomes and Research Data Warehousing	• High performance computing infrastructure • Supports the clinical quality goals of evidence- and outcomes-based medicine • Helps improve quality of care through the measurement of standardized treatment protocols	• HL7 • LOINC • SNOMED • EMPI • jMT Java/MUMPS • RDBMS • Sun StorEdge technologies • Sun Java System and Sun ONE software

Sun OpenR$_x$ Framework Model	**Description**	**Industry Standards / Key Components**
Medical Imaging Grid	• Distributed grid infrastructure • Facilitates the digitalization, capture, remote interpretation, archival, and real-time delivery of medical diagnostic images at the point of care • Enables remote community-based physicians to receive diagnostic image interpretation from specialists	• EMPI • HL7 • jMT Java/MUMPS • X.12N • RDBMS • Sun StorEdge Utilization Suite (SAM-FS) • Sun StorEdge Performance Suite (QFS) • Java 2D/3D API • RDBMS • Sun Java System and Sun ONE software • Liberty SAML • Sun Fire V-880z Visualization Server • XVR-4000
Personalized Healthcare	• Real-time computing infrastructure • Monitors health status through 'wearable' and 'implantable' medical devices • Offers technologies that medical device manufacturers can use to develop remote sensing and response systems that can help improve patient monitoring and drug delivery processes	• JXTA • J2ME • Liberty SAML • NCPDP/SCRIPT • X.12N, EMPI • Sun Java System and Sun ONE software • Sun StorEdge technologies
Real-time Healthcare Enterprise	• Network computing infrastructure • Electronic business process integration between disparate systems and across the healthcare value chain • Helps improve relationships among healthcare partners • Helps reduce costs associated with manual processes	• X.12N • HL7 • LOINC • SNOMED • ICD-9 • CPT-IV • Liberty SAML • Business process integration tools • Java Card • Sun Java System and Sun ONE software • Sun StorEdge technologies
Smart Medical Supply Network	• End-to-end automated supply chain network • Real-time communication across the healthcare value chain • Helps reduce costs and inefficiencies in the healthcare supply chain	• Auto-ID (RFID) • X.12N • NCPDP/SCRIPT • Sun Java System and Sun ONE software • Sun StorEdge technologies
ePrescriber Network	• Electronic medication order and administration network • Real-time communication between care-givers and other healthcare constituents such as PBMs and pharmacies • Helps improve communication regarding medication dosage and delivery to reduce medical errors	• NCPDP/SCRIPT • X.12N • Liberty SAML • Sun Java System and Sun ONE software • Sun StorEdge technologies

Community Health Information Infrastructure

Today, the data required to establish a comprehensive patient record is housed within paper charts and disconnected systems found in hospitals, clinics, and physician offices. Cost inefficiencies and patient safety concerns are consequences of patient records not being available when needed. For instance, when clinical data is not readily available at the point of care, redundant tests might be performed, or prescribed medications could induce an adverse event. Additionally, most healthcare organizations exchange data—such as eligibility, authorizations, and claims—using their own parochial business requirements. Not only is the clinical data not made readily available in an aggregated way to care-givers, it is frequently unavailable in a meaningful way to the patient.

The following model architecture shows how Sun OpenR_x Framework components can be integrated to build a community health information infrastructure that facilitates:

- Electronic clinical and administrative data interchange across healthcare systems
- Standardized medical terminology and code set mapping
- Electronic health benefit transactions for authorizations, eligibility, and claims
- Positive patient and care-giver identification
- Master patient index and duplicate record remediation
- Electronic medication prescription communications
- Secure electronic messaging and instant communications
- Single sign-on for electronic medical record access
- Consolidated Web presence
- Consolidated directory of patients, care-givers, and care delivery entities
- Highly available and scalable data repository

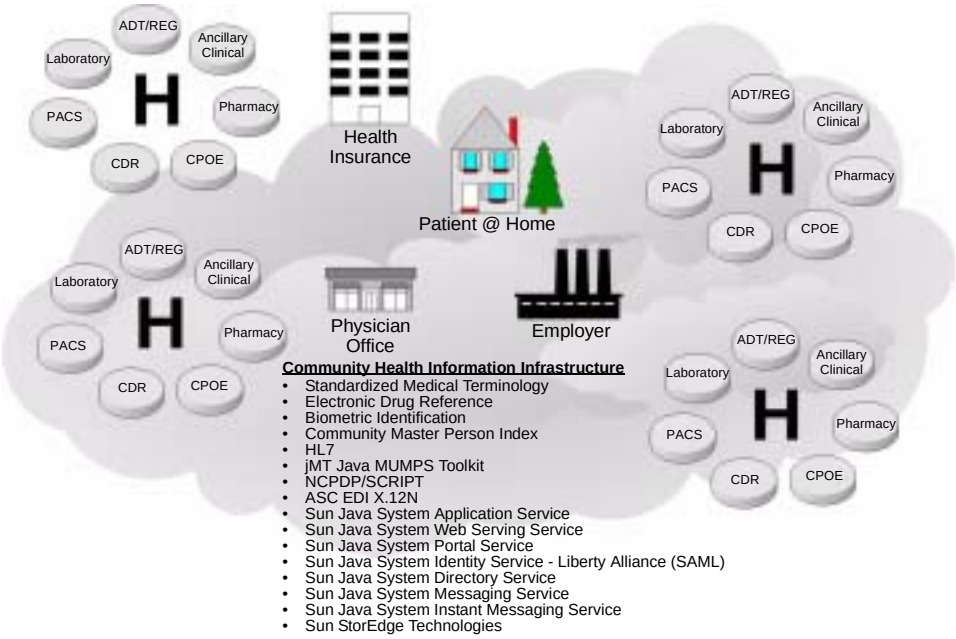


Figure 9-1: Community Health Information Infrastructure

Disease and Bio-Surveillance Grid

There is an increased need by government and local health agencies to rapidly detect and respond to infectious disease and bio-terror events. If an infectious disease or bio-terror event occurs, it is critical that all healthcare constituents understand their roles and receive consistent, near-real-time information so they can respond effectively.

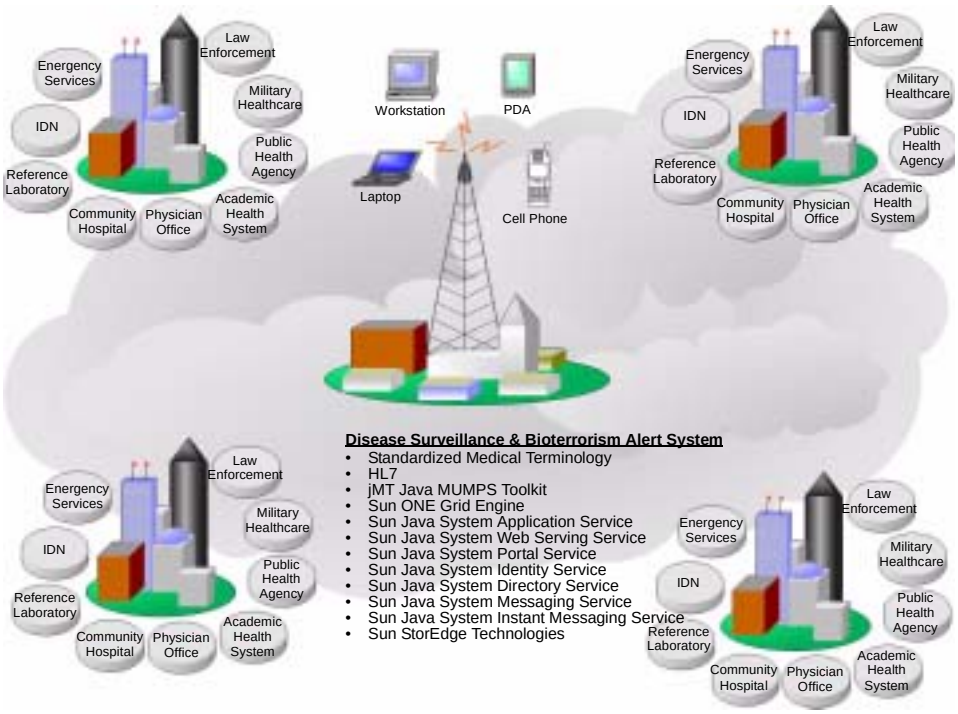
Today, relevant clinical disease conditions are usually collected on paper, while electronic data interchange among public health agencies, care-delivery organizations, and practicing physicians remains limited. To help ensure that disease surveillance is collected and quickly analyzed, data must be electronically collected and aggregated from all patient care delivery touch points. This involves the electronic communication of patients' signs, symptoms, and diagnosis to a centralized data center.

From a system design perspective, a centrally managed utility grid configuration is the most effective delivery vehicle for meeting public health needs. The disease and bio-surveillance grid provides a consistent means for collecting and distributing relevant clinical data from local health agencies, laboratories, physicians, and care delivery organizations.

The following model architecture shows how Sun OpenR_x Framework components can be integrated to build a disease and bio-surveillance grid that facilitates:

- Electronic clinical data transmission from local laboratories, physicians, and care delivery organizations to a centralized public health grid
- Standardized medical terminology and code set mapping
- Secure electronic messaging and instant communications to local public health agencies, physicians, first responders, health insurance companies, and care delivery organizations
- Consolidated Web presence
- Consolidated directory of all healthcare entities
- Mobile device communications
- Highly available and scalable data repository

Figure 9-2: Disease and Bio-Surveillance Grid



Java Health Card

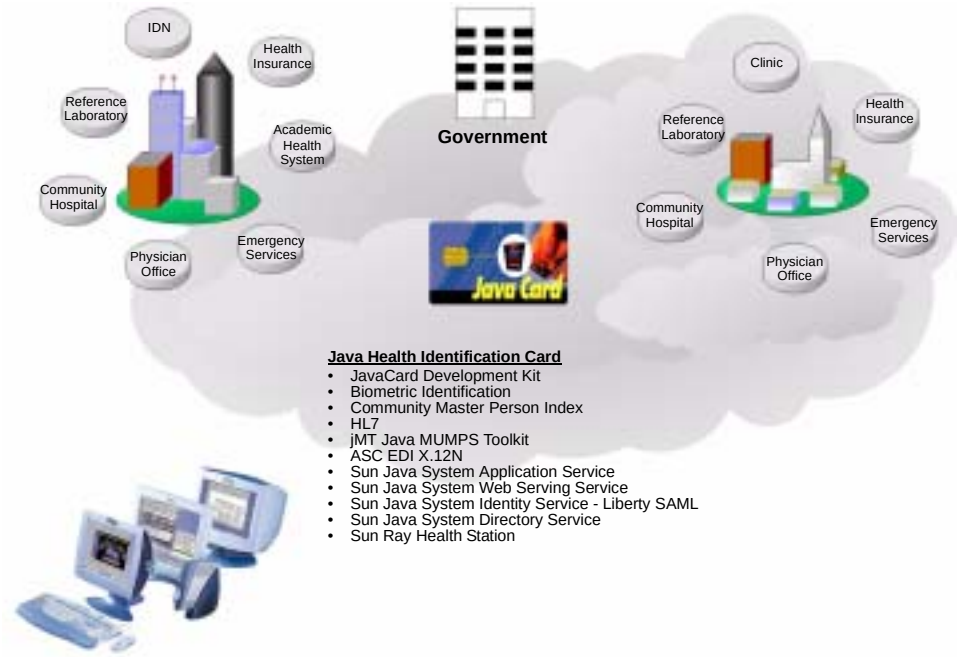
Government and private healthcare organizations have traditionally employed paper or plastic healthcare identity cards that include minimal information dictated by card size. Such cards have limited usefulness in terms of preventing identification fraud and addressing patient safety issues.

Java health cards are not limited by card size. Instead, the cards can be programmed to contain system access rights. Java cards can be used by authorized healthcare providers to gain access to critical patient data such as demographics, allergies, current medication list, chronic illnesses, and insurance benefits. Additionally, the cards can be used in conjunction with the Sun Ray thin client to support hot desking, so care givers can access systems and close screens when they need to, where they need to.

The following model architecture shows how Sun OpenR_x Framework components can be integrated to build Java health cards that facilitate:

- Electronic extraction and transformation of administrative and clinical data from health insurers, laboratories, physician practices, government agencies, and care delivery organizations to the Java health card
- A Java technology development toolkit for building health card applications
- Sun Ray thin clients with integrated card readers
- Built-in support for open directory and unique person identification
- Built-in support for Biometric authentication
- Access to MUMPS legacy systems applications from Java technology-enabled applications
- Built-in support for secure federated identification across healthcare organizational boundaries

Figure 9-3: Java Health Card



Outcomes and Research Data Warehouse

Government and commercial healthcare organizations are developing systems that address the objectives and requirements for cost reduction, clinical process improvement, outcomes data collection, evidence-based medicine processes, and research. To meet these objectives, healthcare organizations require an IT infrastructure and architectural framework that can facilitate the collection and analysis of administrative and clinical data stored in disparate systems and formats.

Data warehousing strategies for the healthcare industry are the most challenging compared to any other industry. For example, the complexity and volume of clinical data in the healthcare industry is significantly greater than information in the financial or retail sector. A particular laboratory test has specific reference ranges that must accompany each discrete result. Each laboratory system may use a different nomenclature and reference range for the same data or test. Additionally, the medical terminology, coding, and vocabularies that may be employed by each clinical system vary greatly. The ability to reconcile varying data formats and vocabularies is critical. The wide array of data types and meta-data definitions increases the complexity of data extraction, logical and physical schema design, and data normalization.

The prevalence of MUMPS-based legacy systems in healthcare presents additional challenges. In particular, there is a need to provide extraction and transformational tools for MUMPS legacy data into relational schema.

Finally, a platform-independent language such as Java technologies is required to develop Web-based services that enable the promulgation of normalized outcomes data to help facilitate new evidence-based medicine applications.

The following model architecture shows how the Sun OpenR_X Framework components can be integrated to build an outcomes and research data warehouse that facilitates:

- Electronic extraction and transformation of administrative and clinical data from health insurers, laboratories, physician practices, government agencies, and care delivery organizations into an open data warehousing environment

- Web services application development and deployment environments for delivering evidence-based medicine systems
- Industry-leading database management systems for storing, maintaining, and scaling administrative and clinical data
- Normalized open directory of persons and other entities across data sources
- Transformation and normalization of medical terminology, vocabulary, and coding sets across data sources
- Native Java technology access to MUMPS legacy applications and data sources

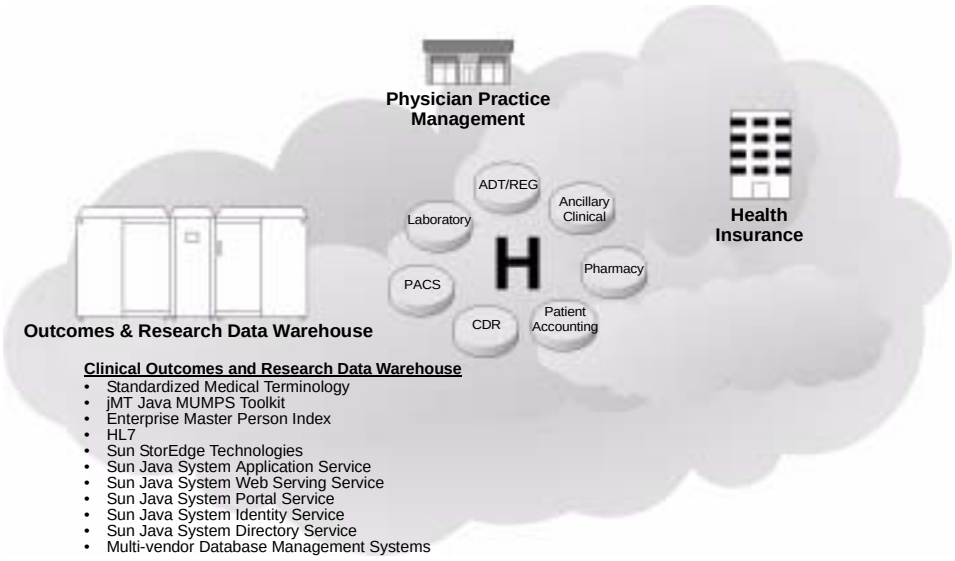


Figure 9-4: Outcomes and Clinical Research Data Warehouse

Medical Imaging Grid

The application of the grid computing paradigm in healthcare, particularly in remote diagnostic imaging analysis, has the potential to streamline care delivery processes, improve quality of care, and reduce costs. Healthcare grids generally include computing resources that provide services on a *utility* basis. Ideally, utility-based grid computing is delivered to healthcare constituents as a managed shared service, much like electricity or water services.

The diagnostic interpretation and archiving of medical images is an ideal application of the grid and utility computing paradigm. In the pre-digital medical imaging era, there were inherent inefficiencies attributed to the physical storage and delivery of film-based images. As more medical images are digitally captured and stored, grid computing can further streamline the process of accessing images at the point of care.

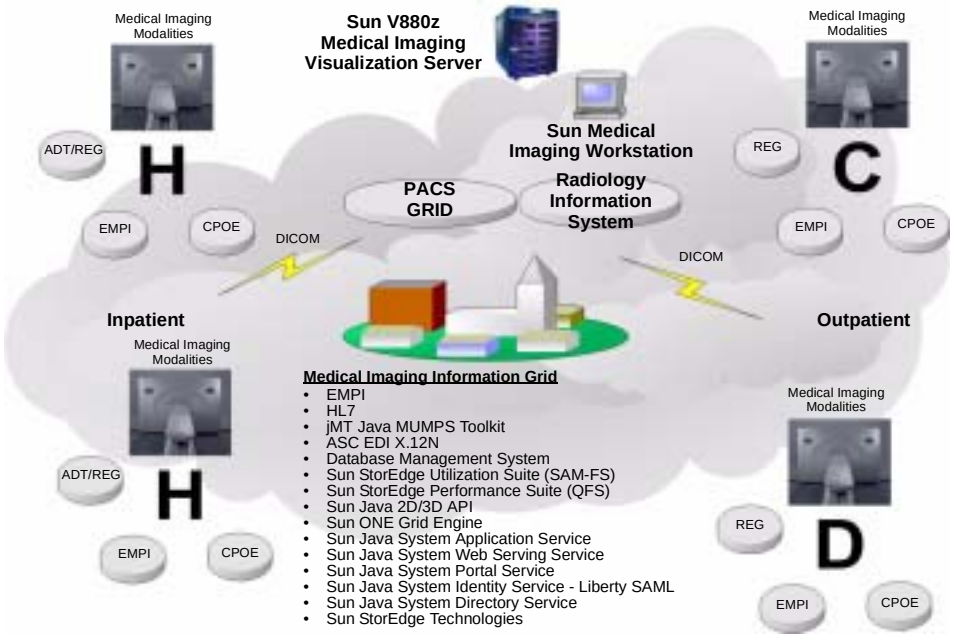
By leveraging digital medical imaging systems, grid computing, and the Internet, new healthcare business models can be created to support more efficient care delivery processes. For example, rural community clinics can capture medical images and electronically send them to a utility that provides remote interpretation services by highly trained radiologists. Once the images are interpreted, the utility posts or sends the diagnosis to the primary care physician and other referring specialists as required. In this model, the grid service manages the storage and archiving of the images to help ensure secure, timely information exchange.

Another benefit of a medical imaging grid is to facilitate medical research. A by-product of the imaging grid would be the collection and aggregation of medical images and interpretations from diverse population groups. For example, researchers studying a particular population of women with breast cancer could be more effective if they had ready access to a cross-section of patient images and interpretations.

The following model architecture shows how the Sun OpenR_x Framework components can be integrated to build a medical imaging grid that facilitates:

- Electronic data interchange standards across healthcare legacy systems, including HL7 and DICOM
- Application development platform for delivering 2D and 3D Java technology-based medical imaging applications
- Industry-leading database management systems for storing, maintaining, and scaling digitized medical images and interpretation results
- Normalized open directory of persons and other entities across data sources
- Transformation and normalization of medical terminology, vocabulary, and coding sets across data sources
- Native Java technology access to MUMPS legacy applications and data sources
- Specialized workstations and servers designed for medical imaging applications
- Specialized grid computing servers and system management tools
- Secure electronic messaging and instant messaging technology

Figure 9-5: Medical Imaging Grid



Personalized Healthcare Infrastructure

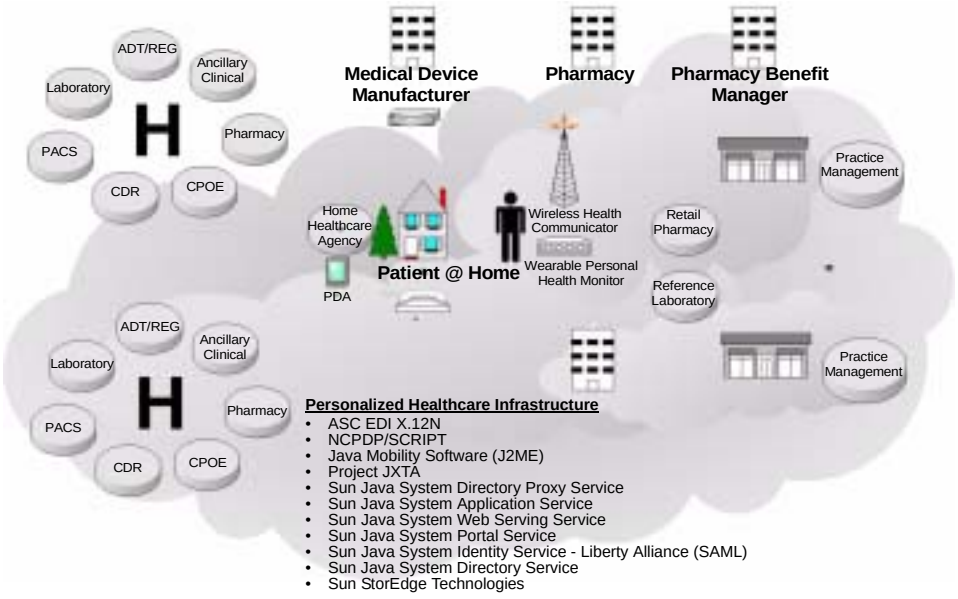
The notion of a medical device with an IP address that communicates its findings or delivers medications can soon be a reality. In the near future, physicians can offer around-the-clock monitoring and execution of treatment protocols by means of wearable medical devices and implantable silicon-based medication delivery systems. These wireless systems will be programmed to continually monitor and deliver specific treatment protocols in real time.

In this new paradigm, frequent visits and calls to the primary care physician and pharmacist will be obviated. Monitoring devices with embedded processors can regulate and dynamically adjust the flow of medications. Instant messaging and alerts could be generated and sent by the devices when medication levels are low, vital signs go beyond a given threshold, adverse events are detected, or malfunctions occur—whether the patient is in town, or out of town.

The following model architecture shows how the Sun OpenRx Framework components can be integrated to offer personalized healthcare services that facilitates:

- Standards-based electronic transactions and communications with administrative and clinical stakeholders
- A Java technology development environment for mobile applications
- Built-in support for secure e-mail and instant messaging protocols
- Built-in support for secure remote access services
- Built-in support for secure federated identification across healthcare organizational boundaries
- A Java technology development environment for network-enabled, peer-to-peer medical applications
- Highly available and scalable data repository

Figure 9-6: Personalized Healthcare Infrastructure



Real-time Healthcare Enterprise

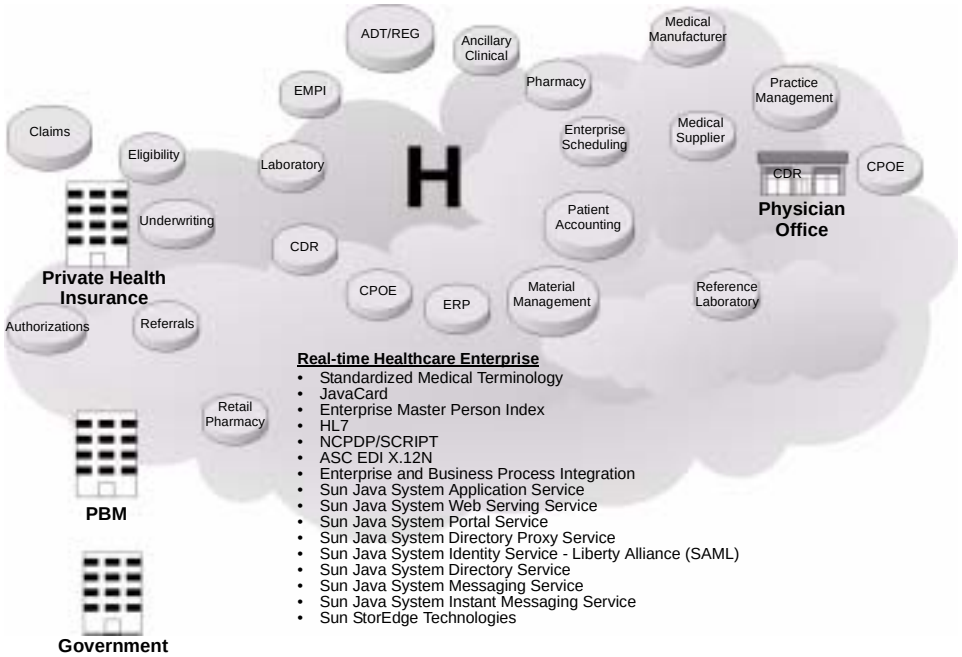
The healthcare delivery value chain consists of a complex web of fragmented and disconnected processes that span health insurance companies, retail pharmacies, pharmacy benefit managers, physician practices, medical device manufacturers, pharmaceutical companies, government agencies, laboratories, diagnostic centers, hospitals, and home health agencies. The various processes may be supported electronically or by paper-based systems. Different technologies and standards may be employed.

The application of technologies that link clinical and business processes across a multi-vendor systems environment will help streamline internal and external processes. Consequently, the healthcare value chain can realize substantial improvements in customer service levels, quality of care, and reduced costs.

The following model architecture shows how the Sun OpenR_x Framework components can be integrated to build a real-time healthcare enterprise that facilitates:

- Standards-based electronic transactions and communications with administrative and clinical stakeholders
- A Java technology environment for developing Web-based applications
- Built-in support for secure e-mail and instant messaging protocols
- Business process integration
- Built-in support for secure federated identification across healthcare organizational boundaries
- An open directory of people and entities that applications can interoperate across the healthcare value chain
- Highly available and scalable data repository

Figure 9-7: Real-time Healthcare Enterprise



Smart Medical Supply Networks

The current healthcare supply chain is characterized by limited electronic connectivity among manufacturers, distributors, hospitals, and physician offices. Smart medical supply networks employ Auto-ID and RFID technologies to give healthcare organizations the potential of achieving near-perfect supply chain visibility, improving the quality of the supply chain from drug or device manufacturer all the way to the patient. That is, healthcare suppliers and hospitals that deploy a smart medical supply network can know where every item in their supply chain is at any time.

Today, Using Auto-ID and RFID technologies to track materials, a bottle of antibiotics in a store room that has experienced temperature fluctuations can have the expiration date adjusted dynamically. Or, the server can send an alert to pharmacies, hospitals, or consumers so that the product is not sold or used. Ultimately, the consumer's medicine cabinet could *speak* to the primary care physician, or pharmacist, to refill a prescription.

The price of RFID tags has dropped to the point where they are an affordable solution for tracking many items by the pallet, case, or carton. Within a few years, RFID tags will be applicable even to individual products throughout the entire healthcare system.

The following model architecture shows how the Sun OpenR_x Framework components can be integrated to build a smart or automatic identification medical supply network that facilitates:

- Standards-based electronic transactions and communications between manufacturers, distributors, retail pharmacies, and healthcare organizations
- Instant communications across the healthcare value chain
- Automated material tracking
- Highly available and scalable data repository

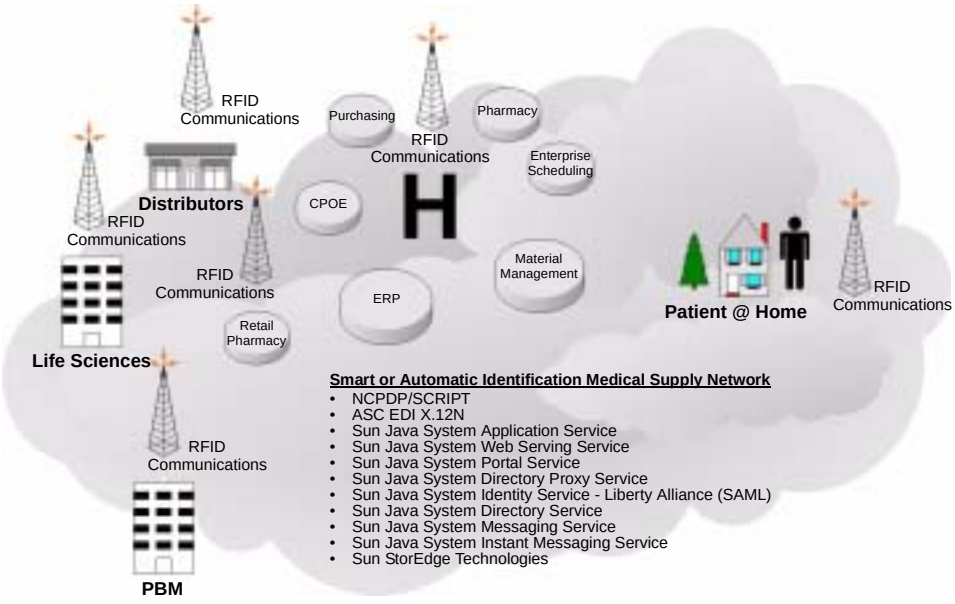


Figure 9-8: Smart or Automatic Identification Medical Supply Network

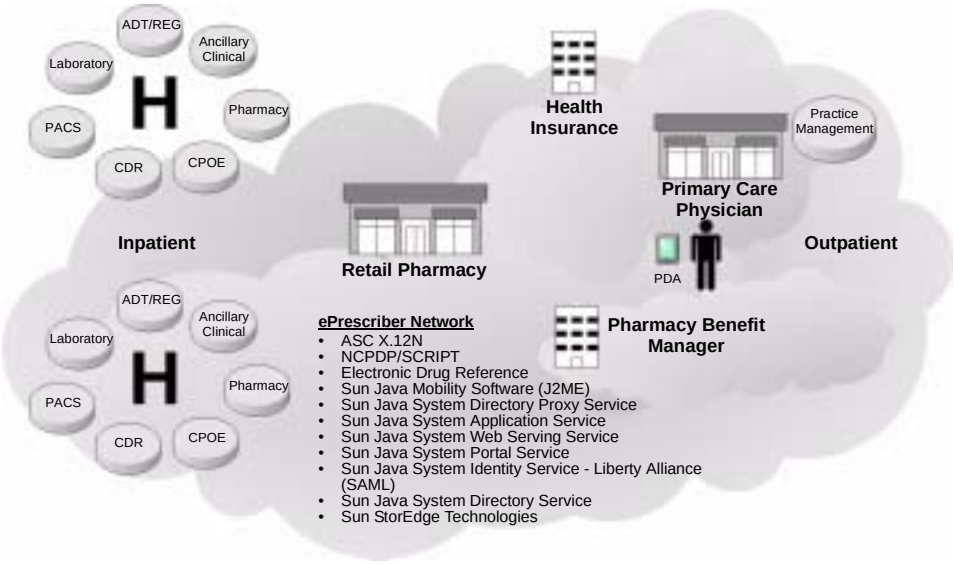
ePrescriber Network

When a patient receives a prescription today, it is most likely on paper. After driving to a pharmacy, the patient either drops the prescription off or waits for it to be filled. The process can be delayed if the prescription must be verified or if insurance benefits must be confirmed over the telephone.

ePrescriber networks connect physicians at the point of care with pharmacists, helping to reduce medication errors, streamline the prescription writing and renewal process, and reduce claims submission issues. The following model architecture shows how the Sun OpenR_x Framework components can be integrated to build an ePrescriber network that facilitates:

- Standards-based electronic transactions and communications between pharmacies and pharmacy benefit management companies
- Instant communications between care-givers across the healthcare delivery chain
- Highly available and scalable data repository

Figure 9-9: ePrescriber Network



Chapter 10

Conclusion

The Sun OpenR$_x$ Framework offers a comprehensive, end-to-end, high performance network computing infrastructure that can help healthcare organizations implement systems that:

- Reduce cost and complexity
- Offer mobility with security
- Improve reliability while enabling scalability

Healthcare organizations can choose from an assortment of Sun and pre-qualified third-party technologies that offer open-platform flexibility and support for industry standards—so your IT solution can flex to meet rapidly changing demands.

The Sun OpenR$_x$ Framework offerings include access management, Web and application services, messaging and collaboration services, Java technology development, provisioning and systems administration services, and hardware components.

Start treating your network like a computer: let the Sun OpenR$_x$ Framework help your enterprise deliver tomorrow's healthcare services today.

Appendix A

Alliance Solutions and Supported Technologies

This appendix offers URLs that you can visit to learn more about alliance solutions supported by the Sun OpenR$_x$ Framework, as well as Sun components, healthcare industry standards, and related technologies. Tables are organized as follows:

- Access management
- Application and Web services
- Messaging and collaboration services
- Software development tools
- Provisioning and systems administration
- Hardware platforms
- Operating systems
- Database management systems

Access Management

The following table provides URLs that you can visit to learn more about access management technologies supported by the Sun OpenR$_X$ Framework.

TABLE 1 **Access Management**

Sun OpenR$_X$ Framework Component	Description or Vendor	URL
Biometric Authentication and Identification	AC Technology, Inc. BiObex™ multi-biometric authentication software	http://www.actechnology.com/
	Cross Match Technologies Verifier™ E Fingerprint Scanning devices	http://www.crossmatch.com/
Cryptography	Boosts the security, performance, and availability of healthcare applications	http://www.sun.com/products/networking/crypto.html/
Enterprise Master Patient Index	Initiate Systems Identity Hub Identifies and links duplicate patient/member records	http://www.initiatesystems.com/
Federated Network Identification	Liberty Alliance Project	http://www.projectliberty.org/
Security		http://wwws.sun.com/software/product_categories/security.html/
Trusted Solaris OS	Virtually unmatched levels of privacy Increased accountability Reduced risk of security violations Proven effective in government, intelligence, and security agencies	http://wwws.sun.com/software/solaris/trustedsolaris/index.html/

Application and Web Services

The following table provides URLs that you can visit to learn more about Web and application services supported by the Sun OpenR$_X$ Framework.

TABLE 2 **Application and Web Services**

Sun OpenR$_X$ Framework Component	Description or Vendor	URL
Application Server	Sun Java System Application Service	http://www.sun.com/software/ http://java.sun.com/downloads/
Desktop Office Productivity	Sun Java Desktop System, StarOffice	http://wwws.sun.com/software/star/staroffice/6.0/index.html/
Embedded Services	Sun Java Embedded Server	http://wwws.sun.com/software/embeddedserver/
Integration Server	Sun Java System Integration Service	http://wwws.sun.com/software/products/integration_srvr_eai/home_int_eai.html/ http://wwws.sun.com/software/products/integration_srvr_b2b/home_int_b2b.html
Office Productivity	Multi-platform, open-source office productivity suite	www.sunopenoffice.org/
Portal Server	Sun Java System Portal Service	http://www.sun.com/software/ http://java.sun.com/downloads/
Web Server	Sun Java System Web Serving Service	http://www.sun.com/software/ http://java.sun.com/downloads/

Messaging and Collaboration Services

The following table provides URLs that you can visit to learn more about messaging and collaboration services supported by the Sun OpenR_x Framework.

TABLE 3 Messaging and Collaboration Services

Sun OpenR_x Framework Component	Description or Vendor	URL
ASC X.12N	HIPAA-mandated EDI technology for transaction processing	http://www.x12.org/
	Ascential Software	http://www.ascential.com/
	Orion	http://www.orionhealth.com/
	Quovadx	http://www.quovadx.com/
	SeeBeyond	http://www.seebeyond.com/
	Tibco	http://www.tibco.com/
	Vitria	http://www.vitria.com/
Connector Builder	Sun Java System Integration Service	http://wwws.sun.com/software/product_categories/application_integration_messaging.html/
E-mail, Calendar, Collaboration	Sun Java System	http://wwws.sun.com/software/product_categories/email_calendar_collaboration.html/
Electronic Drug Reference Database	Micromedex	http://www.micromedex.com/
	FirstDataBank	http://www.firstdatabank.com/
HL7	Industry standard for application-to-application message interchange	http://www.hl7.org/
	Ascential Software	http://www.ascential.com/
	Orion	http://www.orionhealth.com/
	Quovadx	http://www.quovadx.com/
	SeeBeyond	http://www.seebeyond.com/
	Tibco	http://www.tibco.com/
Medical Imaging DICOM	DICOM is a medical imaging standard.	http://java.sun.com/products/java-media/jai/
	Java technology-based image viewers	http://www.dicom.org/index.shtml/
Medical Imaging JPEG2000		http://jj2000.epfl.ch/jj_download/index.html/
Medical Terminology Standards	Industry-standard medical terminology services (accessible using Java technologies) including SNOMED CT®, CPT™, ICD-9, ICD-10	http://www.apelon.com/
NCPDP Telecommunications	HIPAA-mandated NCPDP Telecommunication Standard Version 5.1 and Batch Standard Version 1.0 for pharmacy claims	http://www.ncpdp.org/
	Ascential Software	http://www.ascential.com/
	Orion	http://www.orionhealth.com/
	Quovadx	http://www.quovadx.com/
	SeeBeyond	http://www.seebeyond.com/
NCPDP SCRIPT	NCPDP specification for electronically transmitting prescription information	http://www.ncpdp.org/
	Ascential Software	http://www.ascential.com/
	Orion	http://www.orionhealth.com/
	Quovadx	http://www.quovadx.com/
	SeeBeyond333	http://www.seebeyond.com/

Software Development Tools

The following table provides URLs that you can visit to learn more about software development tools and technologies supported by the Sun OpenR$_X$ Framework.

TABLE 4 Software Development Tools

Sun OpenR$_X$ Framework Component	Description or Vendor	URL
2D Medical Imaging	Java 2D API	http://java.sun.com/products/java-media/2D/
3D Medical Imaging	Java 3D API	http://java.sun.com/products/java-media/3D/
Auto-ID	Identify devices anywhere automatically	http://autoidcenter.org/
Disease Surveillance	Java technology package for detecting disease and outbreak patterns for bio-terror tracking	http://www.health.pitt.edu/rods/sw/default.html/
ebXML Registries	Java technologies	http://java.sun.com/xml/downloads/jaxr.html/
J2ME Mobile Computing Application Development	Java technologies	http://java.sun.com/downloads/
Java Card	Java technologies	http://java.sun.com/products/javacard/
Java Multi-platform Enterprise Application Development	Java technologies	http://java.sun.com/downloads/
Medical Device Connectivity	Java technologies	http://www.jini.org/
Peer-to-peer Applications	Project JXTA	http://www.jxta.org/docs/DomainFAQTech.html
Web to MUMPS Services	jMUMPS is a set of open source Java libraries enabling Java developers to interoperate with MUMPS legacy systems.	Available on Request
XML Services	Java technologies	http://java.sun.com/downloads/

Provisioning and Systems Administration

The following table provides URLs that you can visit to learn more about provisioning and systems administration technologies supported by the Sun OpenR$_X$ Framework.

TABLE 5 Provisioning and Systems Administration

Sun OpenR$_X$ Framework Component	Description or Vendor	URL
Grid Computing	• Distributed management product • Optimizes utilization of software and hardware resources	http://java.sun.com/products/java-media/2D/http://wwws.sun.com/software/gridware/sge.html/
Provisioning, Virtualization, and Policy Management	Sun N1	http://wwws.sun.com/software/solutions/n1/index.html/
Storage Management	Sun StorEdge technologies	http://www.sun.com/storage/software
	Sun StorEdge Utilization Suite (SAM-FS)	http://www.sun.com/storage/software/utilization
	Sun StorEdge Performance Suite (QFS)	http://www.sun.com/storage/software/performance

Hardware Platforms

The following table provides URLs that you can visit to learn more about hardware technologies that are particularly useful to the Sun OpenR$_x$ Framework.

TABLE 6 Hardware Platforms

Sun OpenR$_x$ Framework Component	Description or Vendor	URL
Sun Expert3D	• State-of-art handling of color and gamma correction • Advanced 3-D functionality • Hardware accelerated texture mapping • On-board texture memory • Supports monitor refresh rates of up to 112 Hz • Double-buffered/ Z-buffered support for 3-D graphics up to 1920 x 1200 • Support for stereoscopic 3D up to 1280 x 1024 resolution	http://www.sun.com/desktop/products/graphics/expert3d/expert3djtf.html/
Sun Expert3D-Lite	• Sun's most affordable 3-D graphics board • On-board 3-D geometry acceleration • Hardware-based texture mapping • High-resolution • 24-bit 3-D support for Sun's workstations	http://www.sun.com/desktop/products/graphics/expert3dlite/
Sun Fire SSL Proxy Blade	Supports the seamless integration of SSL encryption and decryption capabilities into the Sun Fire Blade Platform.	http://www.sun.com/products/networking/blades/ssl/
Sun XVR-100 Graphics Accelerator	Affordable solution for applications requiring 2-D, 24-bit color graphics	http://www.sun.com/desktop/products/graphics/xvr100/
Sun XVR-500 Graphics Accelerator	Affordable graphics card for demanding 3-D applications	http://www.sun.com/desktop/products/graphics/xvr500/details.html/
Sun XVR-1000 Graphics Accelerator	• High-end 3-D graphics boards • Ideal for medical applications • Larger texture memory • 30-bit color precision • Fast multi head output options	http://www.sun.com/desktop/products/graphics/xvr1000/
Sun XVR-1200 Graphics Accelerator	• High-quality graphics • 3Dlabs Wildcat graphics processing core • 400 MB of on-board memory • 128 MB of dedicated frame buffer memory • 256 MB of dedicated texture memory • 32 MB of display list memory	http://www.sun.com/desktop/products/graphics/xvr1200/
Data Center Storage		http://www.sun.com/storage/highend/
	Sun StorEdge 9970 system	http://www.sun.com/storage/highend/9970/index.xml/
	Sun StorEdge 9980 system	http://www.sun.com/storage/highend/9980/index.xml/
Midrange Storage		http://www.sun.com/storage/midrange/
	Sun StorEdge 3900 series	http://www.sun.com/storage/midrange/3900/index.xml/
	Sun StorEdge 6120 array	http://www.sun.com/storage/midrange/6000/6100/6120/index.xml/
	Sun StorEdge 6320 system	http://www.sun.com/storage/midrange/6000/6300/6320/index.xml/
	Sun StorEdge 6900 series	http://www.sun.com/storage/midrange/6000/6900/index.xml/
	Sun StorEdge A5200 array	http://www.sun.com/storage/midrange/a5200/index.xml/
	Sun StorEdgeT3 array for the enterprise	http://www.sun.com/storage/midrange/t3es/index.xml/

Sun OpenR$_x$ Framework Component	Description or Vendor	URL
Workgroup Storage		http://www.sun.com/storage/workgroup/
	Netra st A1000 and D1000 arrays	http://www.sun.com/storage/workgroup/netra_a1000/index.xml/
	Sun StorEdge 3310 NAS	http://www.sun.com/storage/workgroup/3000/3300/3310nas/index.xml/
	Sun StorEdge 3310 SCSI array	http://www.sun.com/storage/workgroup/3000/3300/3310scsi/index.xml/
	Sun StorEdge 3510 FC array	http://www.sun.com/storage/workgroup/3000/3500/3510/index.xml/
	Sun StorEdge D2 array	http://www.sun.com/storage/workgroup/d2/index.xml/
	Sun StorEdge A1000 and D1000 arrays	http://www.sun.com/storage/workgroup/a1000/index.xml/
	Sun StorEdge S1 array	http://www.sun.com/storage/workgroup/s1/index.xml/
	Sun StorEdge T3 for the workgroup	http://www.sun.com/storage/workgroup/t3wg/index.xml/
Workstations		http://www.sun.com/desktop/products/ws.html/
	Sun Blade 2000 workstation	http://www.sun.com/desktop/workstation/sunblade2000/
	Sun Blade 150 workstation	http://www.sun.com/desktop/workstation/sunblade150/
Thin Client Computing	Provide for a highly secure, low TCO desktop solution with integrated smart card reader.	http://wwws.sun.com/hw/sunray/index.html/
	Sun Ray 1 thin client	http://www.sun.com/desktop/workstation/sunblade150/
	Sun Ray 100 thin client	http://wwws.sun.com/sunray/sunray100/index.html/
	Sun Ray 150 thin client	http://wwws.sun.com/sunray/sunray150/index.html/
High-end Servers		http://www.sun.com/servers/highend/
	Sun Enterprise 10000 server	http://www.sun.com/servers/highend/e10000/index.xml/
	Sun Fire 12K server	http://www.sun.com/servers/highend/sunfire12k/index.xml/
	Sun Fire 15K server	http://www.sun.com/servers/highend/sunfire15k/index.xml/
Midrange Server		http://www.sun.com/servers/midrange/
	Sun Fire V1280 server	http://www.sun.com/servers/midrange/sunfirev1280/
Midframe Servers		http://www.sun.com/servers/midrange/
	Sun Fire 3800 server	http://www.sun.com/servers/midrange/sunfire3800/index.html/
	Sun Fire 4800 server	http://www.sun.com/servers/midrange/sunfire4800/index.html/
	Sun Fire 4810 server	http://www.sun.com/servers/midrange/sunfire4810/index.html/
	Sun Fire 6800 server	http://www.sun.com/servers/midrange/sunfire6800/index.html/
Entry-level Servers		http://www.sun.com/servers/entry/
	Sun Fire Blade platform	http://www.sun.com/servers/entry/blade/index.html/
	Sun Fire B1600 intelligent shelf	http://www.sun.com/servers/entry/blade/b1600/index.html/
	Sun Fire B100s Blade server	http://www.sun.com/servers/entry/b100s/index.html/
	Sun Fire B10n Content Load Balancing Blade	http://www.sun.com/products/networking/blades/lb/

Sun OpenR$_x$ Framework Component	Description or Vendor	URL
Entry-level Servers (continued)	Sun Fire V100 server	http://www.sun.com/servers/entry/v100/index.html/
	Sun Fire V120 server	http://www.sun.com/servers/entry/v120/index.html/
	Sun Fire V60x server	http://www.sun.com/servers/entry/v60x/
	Sun Fire V65x server	http://www.sun.com/servers/entry/v65x/
	Sun Fire V210 server	http://www.sun.com/servers/entry/v210/
	Sun Fire V240 server	http://www.sun.com/servers/entry/v240/
	Sun Fire 280R server	http://www.sun.com/servers/entry/280r/index.html/
	Sun Fire V880z server	http://www.sun.com/servers/entry/v880z/
	Sun Fire V480 server	http://www.sun.com/servers/entry/v480/index.html/
	Sun Fire V880Z Visualization server	http://www.sun.com/servers/entry/v880z/index.html/
	Sun Fire V880 server	http://www.sun.com/servers/entry/880/index.html/

Operating Systems

The following table provides URLs that you can visit to learn more about operating systems supported by the Sun OpenR$_x$ Framework.

TABLE 7 Operating Systems

Sun OpenR$_x$ Framework Component	Description or Vendor	URL
Operating Systems		http://wwws.sun.com/software/product_categories/operating_systems.html/
	Solaris OS	http://wwws.sun.com/software/solaris/index.html/
	Trusted Solaris OS	http://wwws.sun.com/software/solaris/trustedsolaris/index.html/
	Linux	http://wwws.sun.com/software/linux/index.html
	SuSE Linux	http://www.suse.com/us/business/products/server/

Database Management Systems

The following table provides URLs that you can visit to learn more about database management systems supported by the Sun OpenR$_x$ Framework.

TABLE 8 Database Management Systems

Sun OpenR$_x$ Framework Component	Description or Vendor	URL
Intersystems Cache′		http://www.intersystems.com/
Oracle		http://www.oracle.com/
Sybase		http://www.sybase.com/
MySQL		http://www.mysql.com/
IBM DB2		http://www.ibm.com/software/data/db2/
IBM Informix		http://www.ibm.com/software/data/informix/

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