Deploying the Sun Ray Hot Desk Architecture

Technical White Paper

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Introduction 1≡

Sun's Hot Desk architecture and the Sun Ray™ enterprise system are compelling in their ability to deliver responsive, high performance computing to end users while providing the economic benefits of optimized utilization of computing resources and centralized administration. Though the Hot Desk architecture represents a fundamentally new model of computing, it preserves investments in existing applications and network infrastructure and compliments existing computational resources. No organization today can afford to abandon investments in existing computing infrastructure just to adopt an interesting new model — no matter what the advantages.

This document describes the Sun Ray enterprise system from an administrative perspective and offers considerations for deploying the Sun Ray 1 enterprise appliance into existing networked environments.

Sun's Hot Desk Architecture

Sun's Hot Desk architecture and the Sun Ray 1 enterprise appliance allow users to run Solaris™ Operating Environment and other UNIX® applications as well as Microsoft Windows NT applications from a single, integrated desktop environment. In addition, interactive responsiveness and performance for appliance users are usually in line with powerful UNIX workstations. The Hot Desk architecture also provides significant advantages for administrators.

- *Low-cost Stateless Appliance*

  The inexpensive Sun Ray 1 enterprise appliance is stateless, giving users immunity from data loss in the event of a desktop hardware failure. All application state for user sessions is maintained on servers running *Sun Ray enterprise server software* or on other servers throughout the network.

  Unlike most common desktop systems which tend to be uniquely configured, the Sun Ray 1 enterprise appliance is hot-plugable and requires no local software maintenance. If an enterprise appliance fails, a replacement can be simply plugged in its place with no configuration whatsoever.

- *Enhanced User Mobility*

  In addition to being stateless, the Sun Ray 1 enterprise appliance supports smart card technology to give users a high degree of mobility within the workgroup. User's desktop environments are now accessible from virtually anywhere within the Sun Ray enterprise system environment. Users can simply move to another appliance, insert their smart card, and return to their desktop computing environment exactly as they left it, reducing downtime and increasing productivity.

  The Sun Ray 1 enterprise appliance makes sharing desktop hardware a practical and secure reality. Multiple users (agents working different shifts or job sharing employees) can share the same appliance, each finding their customized desktop environment in the same state as they left it, with no danger of corrupting each other's files.

- *Strong Security*

  Unlike PC desktop systems, Hot Desk architecture provides an environment where users are uniquely authenticated, either by way of a login and password or by more stringent authentication schemes that can be coupled to a user's smart card (challenge/response, token card). In addition, because appliances have no local storage or removable media, users are prevented from loading software, introducing viruses, or accidentally corrupting applications or data.

- *Centralized Administration Model*

  All administration and software distribution is centralized in a Hot Desk architecture environment. The Sun Ray enterprise server software that supports the desktop appliances is managed from a Web-based interface enabling management from any Web browser. Appliance users execute applications on the server, taking advantage of significant economies of scale. *No software is installed, distributed, or maintained at the desktop!*

Hot Desk Architecture Overview

Sun's Hot Desk architecture succeeds by combining key advantages of existing architectures with today's inexpensive hardware components and high-speed networking technology.

As shown in Figure 1-1, Hot Desk architecture is comprised of three components: *application servers*, an *interconnection fabric,* and *desktop appliances*. The *Sun Ray 1 enterprise appliances* are small, stateless, "plug and play" appliances that contain a display device, keyboard, mouse, and integrated smart card reader. Local USB peripherals such as a printer or scanner can be attached directly to the Sun Ray 1 enterprise appliance. *Application servers* host applications for appliance users, and at least one server runs Sun Ray enterprise server software which provides the desktop environment for Sun Ray users. The *interconnection fabric* provides a high-speed, low-latency connection between appliances and service providers.
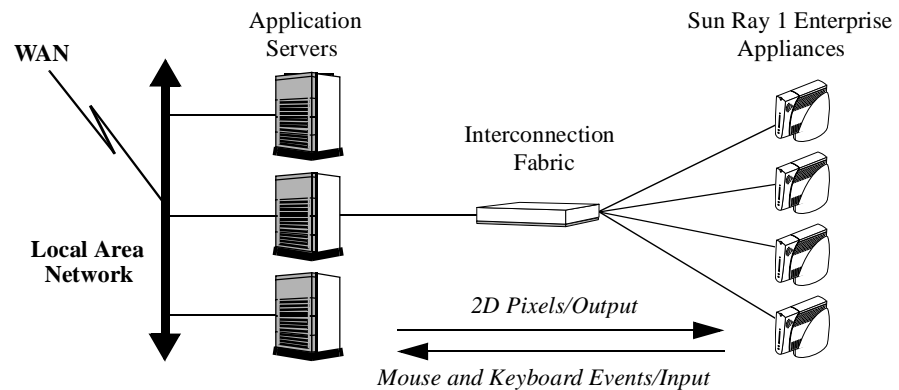
Figure 1-1   High-level perspective of the Hot Desk architecture

Unlike X-terminals and similar devices, all user applications in the Sun Ray enterprise system run on one or more centralized, server systems, including the X11 server and the Graphical User Interface (GUI). The enterprise appliance contains only the resources necessary for the *human interface* — input devices such as microphone, keyboard and mouse, and output devices such as the display and audio. No client software is stored or executed on the appliance.

Graphical output from applications is transmitted to an X11 server process on the Sun Ray enterprise server which renders the results to a *virtual device driver*, and then transmits them via the interconnection fabric to an attached Sun Ray 1 enterprise

appliance. Similarly, all user input (keystrokes, mouse clicks, etc.) is transmitted from the appliance through the interconnection fabric and on to the appropriate client application. The user sees a fully-functional CDE desktop environment and window system which provides a composite view of the user's currently active applications.

Because applications execute independently of the location of their input and output, this design creates a *virtual session* for the user. A user can be *switched* from one desktop appliance to another instantaneously by redirecting the input and output for the session. Session switching is done based on authentication information obtained from the desktop appliances smart card interface.

Virtual Device Drivers

All output to the Sun Ray 1 enterprise appliance is accomplished through the use of virtual device drivers on the Sun Ray enterprise server. For example, the X11 server runs on a virtual device driver that translates between the higher-level X11 protocol and the native Hot Desk technology native protocol as shown in Figure 1-2. Virtual device drivers also exist for the desktop appliances keyboard and mouse as well as any attached USB peripherals.
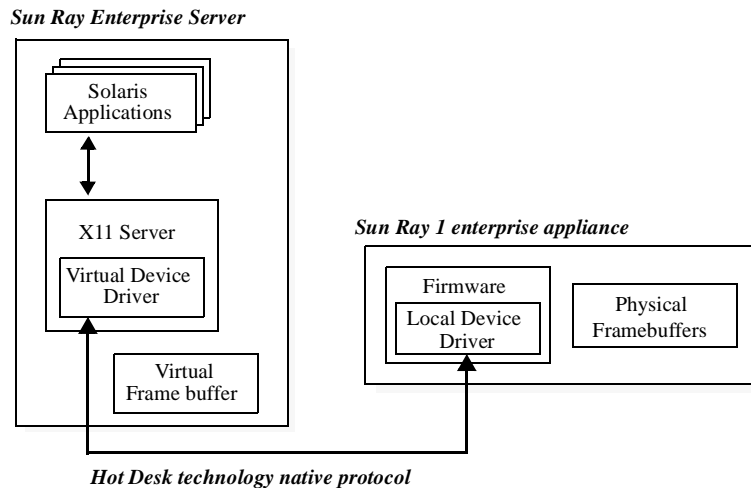
Figure 1-2   The display virtual device driver translates between the X11 protocol and the Hot Desk technology native protocol

For each Sun Ray user, the virtual device driver maintains a copy of the currently active desktop session in a memory-based virtual frame buffer on the Sun Ray enterprise server. All display rendering is performed on the server, and pixels are sent by the virtual device driver to the enterprise appliance across the interconnection framework. Keyboard and mouse events are sent from the desktop back to the virtual device driver on the server, transposed into X11 events, and then sent on to applications.

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The Hot Desk Application Environment 2≡

Before deploying the Hot Desk architecture, it is helpful to understand the software application environment to help ensure that applications run as expected. This section covers the Hot Desk architecture application environment and describes several helpful tools for managing a Hot Desk architecture deployment.

Application Support

Hot Desk technology provides support for applications running under the Solaris Operating Environment and other UNIX applications along with optional support for Windows NT applications. Most existing applications are able to run without modification.

Solaris Application Support

The Sun Ray enterprise server provides the full X11/CDE environment to desktop appliances. Consistent with the X11/CDE environment, a wide range of applications are supported.

- *X11 Applications*

Hot Desk technology supports both local and remote X11 applications. Local X11 client applications run along with the X11 server on the Sun Ray enterprise server. virtual frame would be running on the CSP. Remote X11 client applications, including

those running on non Sun platforms, simply display to the X11 server running on the Sun Ray enterprise server by using the X11 remote windowing display capability ("x-hosting" via the X11 DISPLAY environment variable).
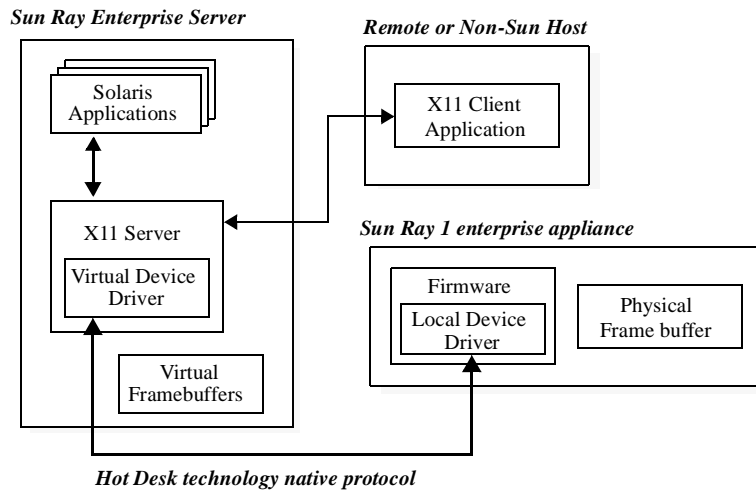
Figure 2-1   X11 application displaying from a remote or non-Sun host

As shown in Figure 2-1, both local and remote X11 applications appear the same to the Sun Ray 1 enterprise appliance.

- *Java*™ *Technology Applications*

  Java technology-based front-end client applications execute on the Sun Ray enterprise server and may communicate with other Java components or other applications running either on the server system or elsewhere on the network. Since Sun Ray enterprise servers are typically well-endowed computational resources with significant memory and processing power, Java code typically performs quite well in a Sun Ray enterprise system.

- *Multimedia Applications*

  Multimedia applications that display video and audio data also work within the Sun Ray enterprise system. The enterprise appliance contains both video and audio connectors and is capable of exchanging bi-directional multimedia data with applications running on the Sun Ray enterprise server. The Java Media Framework is the recommended API for Multimedia applications which will run on the Sun Ray enterprise server.

- *3D Applications*

  3D applications work in the Sun Ray enterprise system but because they execute on Sun Ray enterprise server systems, they are limited to software rendering performance. 3D graphics applications that depend on hardware acceleration to function correctly may not provide acceptable levels of performance.

Windows NT Support

In many organizations, users require full and easy access to popular office productivity applications running on Windows NT servers. The Sun Ray enterprise system supports the display of applications running on Windows NT machines with the addition of MetaFrame software from Citrix Systems. After installing Citrix MetaFrame software on an available Windows NT server(s) and corresponding Citrix ICA client software on a Sun Ray enterprise server running the Solaris Operating Environment, the Windows NT server can redirect output from Windows applications to Citrix clients running on the Solaris system as shown in Figure 1-2.

Windows NT Server   *Sun Ray Enterprise Server*

```
┌─────────────────────┐         ┌──────────────────────────────────────┐
│  ┌───────────────┐   │         │  ┌────────────┐    ┌─────────────┐   │
│  │    Win32      │   │    ┌───▶│  │   Citrix   │    │   Solaris   │   │
│  │ Applications  │   │    │    │  │ ICA Client │    │Applications │   │
│  └───────────────┘   │    │    │  └────────────┘    └─────────────┘   │
│  Win32   ▲           │    │    │        OpenWindows                   │
│  Interface│          │    │    │        X11 Protocol                  │
│          ▼           │    │    │  ┌────────────────────────────────┐  │
│  ┌───────────────┐   │    │    │  │          X Server              │  │
│  │    Citrix     │◀──┘    │    │  │  ┌──────────────────────────┐  │  │
│  │  MetaFrame    │        │    │  │  │     Virtual Device       │  │  │
│  └───────────────┘        │    │  │  │        Driver            │  │  │
│                  Citrix ICA│    │  │  └──────────────────────────┘  │  │
│                  Protocol  │    │  └────────────────────────────────┘  │
└─────────────────────┘         └──────────────────────────────────────┘
                                                    │
                                            Hot Desk │
                                            Technology Protocol
                                                    │
                                ┌──────────────────────────────────────┐
                                │  ┌────────────────────────────────┐  │
                                │  │        Local Device            │  │
                                │  │          Driver                │  │
                                │  └────────────────────────────────┘  │
                                │           Firmware                   │
                                └──────────────────────────────────────┘
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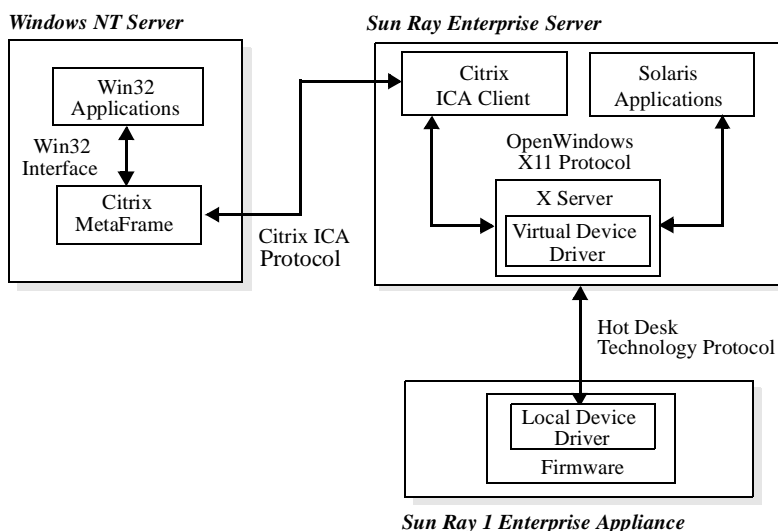*Sun Ray 1 Enterprise Appliance*

Figure 2-2   Optional MetaFrame software from Citrix Systems displays applications running on Windows NT servers onto Sun Ray 1 enterprise appliances

Like other UNIX applications, the Citrix client application is displayed onto the desktop appliances' screen through a virtual device driver within the X11/OpenWindows™ server. This approach combines high performance native

execution for Windows applications with the ease of administration of Solaris applications. For more information see the Sun white paper *Integrating the Sun Ray 1 Enterprise Appliance and Microsoft Windows NT.*

Application Considerations

Hot Desk technology changes nothing in the way that Solaris applications are executed and most well-behaved applications run without modification. However, by virtue of its shared-resource architecture, the Sun Ray enterprise system can expose less well-behaved applications that might have gone unnoticed in a single-user environment. In particular, applications that make assumptions about available hardware resources or assume a single-user computing environment may fail to run in a Hot Desk technology environment.

Identifying a User by IP Address

An Internet Protocol (IP) address identifies an individual network interface on a system, *not* an individual user on that system. Applications which use the IP address to identify a user will not operate correctly in a Sun Ray enterprise server since the desktop environment for many users is provided by single server system. Many conferencing applications assume that end-users are sitting at a single-user workstation which can cause problems in a Sun Ray enterprise system.

Assuming Exclusive File Access

Applications which assume exclusive file access to generically-named files can fail on Sun Ray enterprise servers. For instance, if an application writes temporary data to a particular file (*/tmp/foo*), another instance of the application might over-write that file, corrupting data from the previous session. Applications must provide user-specific naming for temporary files and should use appropriate file locking to enable exclusive application-appropriate write-access.

Hard-wiring the X11 DISPLAY Environment Variable

In the X-Window system, the DISPLAY environment variable is used to direct X11 client applications to the appropriate X11 display server. Though single-user systems typically have only one display, it is common for systems to be configured with multiple displays. In the Sun Ray enterprise system, the Sun Ray enterprise server runs many virtual X11 displays, one for each user session running on the system. Some

applications will set a user's DISPLAY environment variable upon startup — this task should be left to the Sun Ray enterprise server. In addition, user's standard login files (.login, .profile, .cshrc, etc.) should not explicitly set the X11 DISPLAY environment variable.

8-bit X11 Applications

The X-window system makes system display resources available through a software abstraction known as a an X11 visual which defines both plane group depth (i.e. 8- or 24-bit) and properties including whether the visual is static or allows colormap entries to be written by the application. By design, X11 specifies mechanism, not policy, leaving the negotiation to select color resources up to the application. Ideally, X11 applications negotiate with the X11 server and select a visual which is appropriate for their needs. X11 servers also export a default visual for applications that don't express a preference.

The Sun Ray 1 enterprise appliance contains a 24-bit frame buffer and the X11 server running on the behalf of the frame buffer exports a 24-bit TRUECOLOR default visual. Most applications written today understand the widespread move to 24-bit environments and have been written to be 24-bit aware (meaning that they can operate in an environment where only 24-bit visuals are available). Unfortunately, many legacy X11 applications were written when 8-bit graphics were common and either specifically request an 8-bit visual, or worse, select the default visual and assume that it is an eight-bit visual. Though both of these types of applications will initially fail when displayed to the enterprise appliance, the Sun Ray enterprise system provides considerable flexibility allowing users to work-around both of these situations.

The Sun Ray 1 enterprise appliance can be configured to provide both 8-bit and 24-bit visuals with either an 8-bit or 24-bit default visual. Table 2-1 lists the *utconfig* commands to reconfigure the enterprise appliance to support different visual configurations

X11 Visual Depths	Default Visual	utconfig Command
8-bit and 24-bit	24-bit	utxconfig -p on
8-bit and 24-bit	8-bit	utxconfig -p default
24-bit (default configuration)	24-bit	utxconfig -p off

Table 2-1   Utconfig commands for setting 8-bit and 24-bit visuals

8-bit support is provided through software emulation of a hardware color lookup table so configuring the enterprise appliance for 8-bit support does incur small performance penalty. Note also that configuring an 8-bit default visual is not without issue. Though most 24-bit applications are written correctly, some 24-bit applications may exist that accept the default visual and assume that it is a 24-bit visual, exactly the reverse of the initial problem. These applications may fail to run with an 8-bit default visual. This behavior is entirely typical of X11 applications and environments and is not related to the Sun Ray enterprise system.

Multimedia Applications

Multimedia applications often make assumptions about multimedia system hardware and assume that they have exclusive access to that hardware. For both platform independence as well as optimal performance in the VDA environment, multimedia application developers should utilize the Java Media Framework APIs. Also, audio applications should avoid using the system-specific */dev/audio* interface but should instead utilize the session-specific DEVAUDIO environment variable. Sun Ray enterprise server software automatically sets the DEVAUDIO environment variable to the virtual device driver representing the audio interface on the appropriate Sun Ray 1 enterprise appliance.

Sun Ray Enterprise Server Environment

Sun Ray enterprise server systems provide most of the computational resources for desktop appliances in the Sun Ray enterprise system and understanding their operating environment is essential to designing effective an scalable deployments. Sun Ray enterprise server systems include:

- *Solaris Operating System*
  Solaris (SPARC™ Platform Edition) Operating Environments 2.6 or 2.7 provide the environments for Sun Ray enterprise servers and the infrastructure for other server software. These environments also provide highly-tuned low-level networking support that enable an accelerated, low-latency interconnection framework.

- *Sun Ray Enterprise Server Software*
  Sun Ray enterprise server software provides the software environment for the Sun Ray 1 enterprise appliance and consists of an Authentication Manager, Session Manager, virtual device drivers, administration tools and peripheral device support for the desktop appliances.

- *User Desktop Environment*

For each active desktop appliance user, resource load on the server minimally includes the window system (X11 server and CDE window manager) in combination with end-user desktop applications.

- *Other Applications*
  Sun Ray enterprise servers need not be dedicated to serving Sun Ray 1 enterprise appliances and can be shared for other purposes if capacity allows. For example, a server running Sun Ray enterprise server software might also provide database services or act as a Web server to the workgroup.

Dedicated vs. Shared Sun Ray Enterprise Servers

Whether the Sun Ray enterprise server is dedicated to serving enterprise appliances or is shared with other applications, responsiveness and interactivity for the enterprise appliances is directly dependent on having sufficient computational server resources. What ever their configuration, Sun Ray enterprise servers must be correctly sized and tuned to maintain a productive environment for end-users.

Sizing requirements for Sun Ray enterprise servers are dependent on a number of factors including the expected application mix, memory and computational requirements of the applications in use, number of simultaneous active users, and the activity level of those users. Specific guidelines for applying these factors to server sizing is beyond the scope of this paper but can be found in the Sun white paper *Assessing Scalability of the Sun Ray 1 Enterprise Appliance.*

Like dedicated Sun Ray enterprise server systems, shared servers should be sized carefully in order to avoid impacting interactive performance for desktop appliance users. As a general rule, computationally-intensive tasks should not be run on the Sun Ray enterprise server unless the server has been specifically configured for that purpose. Sun's Solaris Resource Manager™ software can be an extremely useful tool for deploying effective shared server environment.

Solaris Resource Manager

Beyond simple time-sharing schemes, Sun's Solaris Resource Manager software provides fine-grained, hierarchical control of system resources for users, groups, and applications, allowing an equitable distribution of computational resources within a given Solaris system. The Solaris Resource Manager software is particularly effective for use in Sun Ray enterprise servers since it can prevent server resources from being usurped by rogue processes, abusive users, and large computational loads.

Solaris Resource Manager is recommended for deployments of both dedicated and shared Sun Ray enterprise servers because of its ability to provide minimum levels of interactive performance for users sitting at desktop appliances. If a Sun Ray enterprise server is used to support other services such as a Web or database server, or if a small subset of Sun Ray 1 enterprise appliance users occasionally run computationally-intensive applications, Solaris Resource Manager software can help ensure that interactive performance for all Sun Ray 1 enterprise appliance users isn't compromised.

CPU Resources

Solaris Resource Manager software employs a fair-share scheduling system to allocate CPU resources. Better than a simple percentage-based systems, administrators assign "shares" of the system to users or groups of users. Because of its hierarchical design, individual users within a group can receive larger or smaller numbers of shares depending on their needs. The assigned shares represent a minimum computational resource which is available to a given user or group of users.

Because Solaris Resource Manager software implements a minimum allocation scheme, unused capacity is free to be reallocated to other users and applications. When applications are idle or are consuming less than their designated CPU allotment, excess computational capacity is automatically available for use by other applications — computing resources aren't wasted, increasing resource utilization on Sun Ray enterprise servers.

Virtual Memory

On Sun Ray enterprise servers, Solaris Resource Manager software is useful for intercepting unforeseen or runaway applications which place excessive demands on the server's virtual memory resources. The Solaris Resource Manager software calculates and limits the amount of virtual memory used by all processes and can also impose limits on per-process virtual memory. For example, an application with a memory leak that constantly requested memory without freeing it would be prevented from starving other processes and users.

Numbers of Processes

The Solaris Resource Manager software can also be used to impose limits on the number of processes that an individual user may run — protecting the Sun Ray enterprise server against intentionally or accidentally abusive users. Process limits can

be applied to groups of users or can be set for individual users by the system administrator. Users with a justifiable need for more resources can be accommodated while the system remains in a balanced state.

Accounting

Solaris Resource Manager software also provides accounting to allow system administrators to monitor and tune the Sun Ray enterprise server based on actual usage levels. Tuning might include adding more memory or additional processors based on increased application usage on the system. The Solaris Resource Manager software tracks CPU, virtual memory, numbers of processes, and numbers of logins.

Additional Recommended Server Tools

Sun supplies a number of other software packages and tools that may be useful for deploying Hot Desk technology.

Sun Enterprise SyMON™

Sun Ray enterprise servers can be managed by Sun Enterprise SYMON software, helping system administrators maintain high levels of uptime and productivity for appliance users. Through Sun Enterprise SyMON, administrators can combine the management of potentially thousands of systems onto a single unified management platform. Sun Enterprise SyMON can monitor the performance of Sun Ray enterprise servers and other application servers to predict potential performance problems as well as isolate and resolve bottlenecks. Sun Enterprise SyMON runs through an easy-to-use Java technology interface.

SunLink™ Client 3270 and SunLink SNA 3270 Gateway

Many organizations still employ IBM 3270 terminals for delivering limited-function legacy mainframe applications. Hot Desk technology has emerged as an extremely promising replacement for these aging, dedicated "green-screens". Deploying Hot Desk technology allows organizations to continue to support legacy 3270 applications while expanding the functionality of the user's desktop to include Web access, e-mail, and other office productivity applications. In addition, as legacy 3270 applications are re-engineered to utilize network computing through Java technology, user's appliance-based desktop environments remain consistent and desktop hardware doesn't need to be replaced.

IBM 3270 display terminal emulation can be provided on Sun Ray enterprise servers through Sun's SunLink™ Client 3270 software product. SunLink Client 3270, gives SPARC users access to IBM host 3270 applications running on IBM and compatible mainframes through a client TN3270 application. The client TN3270 application communicates with Sun's SunLink SNA 3270 Gateway or other TN3270 servers over TCP/IP. Sun's SunLink SNA 3270 Gateway provides IBM Physical Unit Type 2.1 (PU2.1) and Type 2.0 (PU2.0) emulation and includes a TN3270 server.

Hot Desk Interconnection Fabric 3 ≡

The Sun Ray 1 enterprise appliance relies on a low-latency connection to the Sun Ray enterprise server for each pixel and keystroke. Though off-the shelf network hardware is used to build the interconnection framework, following a few rules will help ensure a successful deployment.

Building an Effective Interconnection Fabric

A Dedicated Interconnect

The interconnection fabric is specified as a dedicated interconnect in order to provide sufficient quality of service for Sun Ray 1 enterprise appliance users. In addition, requiring a dedicated interconnection fabric simplifies installation and deployment since installation scripts and Sun Ray enterprise server software takes over the task of address management — greatly reducing the number of IP addresses needed to support a workgroup with individual PC's or workstations.

Requiring a dedicated interconnection between the Sun Ray 1 enterprise appliance and the Sun Ray enterprise server provides a reasonable level of assurance that a defined quality of service will be maintained. However, an unbalanced deployment of server interfaces and network components can produce latency and congestion-induced bandwidth problems.

Interconnection Fabric Bandwidth Needs

Because the interconnection fabric is a shared resource, it must be designed to absorb peak traffic patterns so that users don't adversely affect each other. Sufficient bandwidth must exist at a number of essential points within the interconnection framework as illustrated in Figure 3-1.
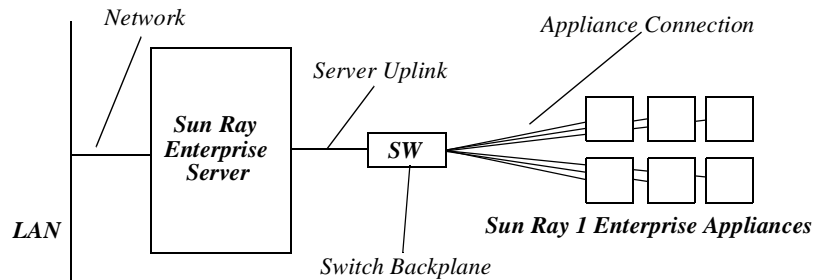

Figure 3-1   Potential choke-points for interconnection fabric bandwidth

- *Server Uplink Bandwidth*

Sufficient bandwidth must exist on the server uplink interface(s) to support the number of Sun Ray 1 enterprise appliances deployed in the workgroup under peak load conditions. Individual hubs and switches should be selected with uplink ports which can support the aggregate needs of their attached Sun Ray 1 enterprise appliances.

- *Internal Switch Bandwidth*

In addition, hubs and switches must provide adequate internal bandwidth to support the aggregate needs of the ports they provide. For example, a switch with four Gigabit Ethernet ports and an internal backplane which only runs at 1.2 Gigabits per second will not scale to serve the capacity advertised by its ports.

- *Client/application Bandwidth*

Interconnection fabric connections to enterprise appliances must be consistent with the expected peak usage patterns of the appliance. Because interconnection fabric traffic to a given desktop appliance is primarily dependent on the number of pixels being updated to the screen, a user displaying dynamic video has very different requirements than a user who primarily performs data entry.

- *Network bandwidth*

Beyond the interconnection fabric, designers must confirm that sufficient network bandwidth exists on the Sun Ray enterprise server's external LAN connection(s) to support the applications that will use the LAN.

Interconnection Fabric Topologies

Determining an appropriate topology is ultimately a function of the usage patterns (simultaneous usage) and applications used by the workgroup. Though a single Sun Ray 1 enterprise appliance can use up to 35Mbps of interconnect bandwidth, typical requirements are much lower. A small workgroup that experiences only casual desktop usage for productivity applications has different bandwidth (and therefore topology) requirements than a fully-staffed call center using a database with image or video data.

A wide range of possibilities exist for building the interconnection fabric. Several examples of supported topologies are illustrated here — for up-to-date information, on particular switches, please see the Hot Desk at Sun Microsystems (http://www.sun.com/nc/sunray1).

Direct Wired

Small workgroups of Sun Ray 1 enterprise appliances can be supported by directly connecting them to a server equipped with multiple Ethernet or SunFastEthernet™ ports, thereby eliminating the cost of network components (switches) entirely. As illustrated in Figure 3-2, an small server could be used to directly support eight Sun Ray 1 enterprise appliances with no network switching components.
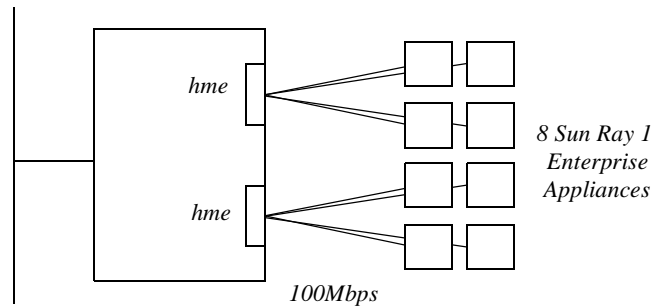

Figure 3-2   Direct wired scenario using multiple Sun QuadFastEthernet™ cards and UTP crossover cables

Since each connection in the direct wired scenario carries the traffic for only one appliance, either 10Mbps or 100Mbps technology could be used depending on the needs of the application.

Switch

For larger deployments, Ethernet or Fast Ethernet switches can be used to increase the number of Sun Ray desktops that are supported. In Figure 3-3 the Gigabit Ethernet port on the server carries the traffic for 96 Sun Ray enterprise appliances.
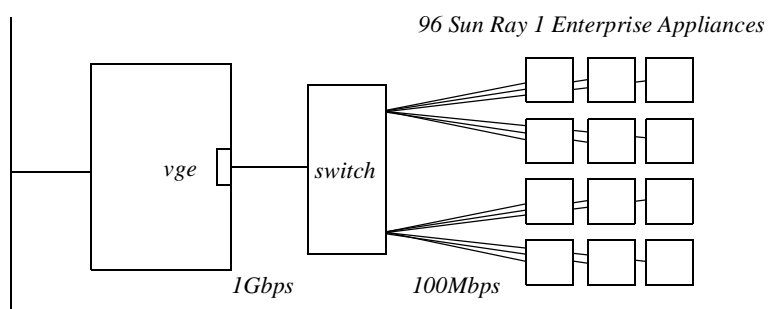

Figure 3-3   Topology using Gigabit/Fast Ethernet switches

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References

Sun Microsystems, Inc. posts product information in the form of data sheets, specifications, and white papers on its Internet World Wide Web Home page at: *http://www.sun.com*.

Look for the these and other Sun technology white papers:

Sun Ray 1 Enterprise Appliance Overview and Technical Brief, White Paper, Sun Microsystems.

Assessing Scalability of the Sun Ray 1 Enterprise Appliance, White Paper, Sun Microsystems.

Integrating the Sun Ray 1 Enterprise Appliance with Microsoft Windows NT, White Paper, Sun Microsystems.

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