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> **NFS Maestro™ Whitepaper**  
Hummingbird Connectivity™ Solutions

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## Overview

This document is designed to provide an overview of the NFS technology and to provide product and marketing information for the NFS Maestro™ product line. There are two parts in this document:

### **Part 1 — Network File System Overview**

In the first part of the document we will review the definition of Network File System, the evolution of the NFS protocol and some of the common usage of the NFS protocol in the enterprise inter-networking environments.

### **Part 2 — Hummingbird NFS Solution**

The second part of the document will introduce Hummingbird Ltd., and the NFS Maestro family. It also contains the top ten reasons why NFS Maestro is a best PC NFS solution in the market.

## Part 1 — Network File System Overview

### What is Network File System

The Network File System (NFS) was one of the most important technologies to emerge from the Ethernet-TCP/IP-UNIX environment of the 1980s. Sun® Microsystems introduced NFS to public in 1984 and since then NFS has become a de facto standard for distributed interoperable print and file services in multi-vendor inter-network environments. Interoperability is a major advantage that NFS holds over proprietary file systems, and its ability to enable transparent file and print service across heterogeneous inter-networks is unparalleled. Originally designed as a distributed file system to provide transparent file services in UNIX environments, NFS allows PC users to access and share resources with a wide range of host environments including: Mainframes, UNIX, VMS, OS/2 and Windows®-based platforms. NFS client and server product for personal computers are available for Windows XP, Windows 2000, Windows NT, Windows Me, Windows 98 and other common operating systems.

An NFS environment consists of client and server components:

**NFS Client:** The client machine is a computer that uses the NFS protocol to access network resources (such as file systems and/or printers) shared by another computer on the network. The computer that exports those resources is called the NFS server.

**NFS Server:** The NFS server software resides on a remote host (that is, a UNIX server, Mainframe computer, workstation, Windows PC, etc.), and allows the NFS client machines on a network to transparently access the host's shared resources. The server administrator can export (make available to users) filesystems or attached printers. Most server operating systems come with NFS server software.

### Evolution of NFS

In early 1980s, a few engineers at Sun Microsystems developed the first version of NFS. Since that time, NFS has undergone four major revisions:

NFS Version 1 was Sun's prototype network file system. This version was never released to the outside world.

The introduction of NFS to the outside world took place in 1984 when Sun Microsystems released the SunOS 2 operating system, in which NFS Version 2 was included. Numerous UNIX vendors licensed the Version 2 technology, and soon after a freely distributable and compatible version of NFS was developed in University of California at Berkeley. The wide acceptance and support for NFS by various vendors had helped establishing NFS as a de facto standard for distributed interoperable print and file services in multi-vendor inter-network environments.

Eight years after the release of NFS Version 2, Sun Microsystems began the development of the NFS Version 3 specifications. In 1995, NFS Version 3 was released to the public.

NFS version 2 and 3 were the descendents of the UNIX environment, therefore they have inherited the poor security architectures that were common to most UNIX operating systems. Besides, the previous NFS protocols were originally designed for Local Area Network which characterized by high-bandwidth and low latency. As the network architecture shifted from Local Area Network to Wide Area Network, the performance and security of NFS became issues that NFS Version 3 design could not easily handle. A new NFS protocol was required.

The design and development of the fourth generation of NFS was helmed by the Internet Engineering Task Force (IETF) NFS version 4 working group. In the summer of 1998, Sun Microsystems hand over the change control of the NFS Version 4 to the IETF working group. Prototypes were built and the specification was submitted to the Internet Engineering Steering Group in February 2000. Implementation work and interoperability testing started soon after. NFS version 4 is a new distributed file system, designed to provide fast, secure, interoperable and reliable service on the Internet.

Up until Version 3, NFS relied on an RPC service, MOUNT protocol, to provide the file handles, which was a piece of information needed for the client and the server to establish communication. However, the dynamic port assignment nature of the MOUNT protocol prohibited the efficient use of NFS on the Internet. By removing the MOUNT protocol from the NFS protocol requirements, together with the strong security implementation within the NFS version 4 protocol, firewall traversal has become easy and secure. The NFS version 4 is ready to expand its usage and implementation beyond LAN and WAN.

## Common Usage of NFS in Heterogeneous Networks

NFS is a de facto standard for distributed file system services in the heterogeneous computing environment. Throughout the 18 years, NFS has been adopted by many vendors and supported by many applications. In general the usage of the NFS protocol can be categorized into Data Access, Project Collaboration and Data Backup and Recovery.

### Data Access

NFS is often used to present a consistent environment to users. One of the most common uses is to have all the user directories centralized in an NFS server. Using the NFS automount feature (in conjunction with directory services, such as NIS, NIS+ and LDAP), users will get a consistent access to their home directories. Most Windows applications, such as Microsoft® Office, can access, store and retrieve files that is stored in NFS mounted directories.

Many in-house applications, developed by various companies, also use NFS as the obvious file access protocol for their applications because NFS has been widely accepted. Every network operating system has had NFS ported to it in one form or another, and it is used in almost every UNIX environment worldwide. It provides a convenient mechanism for sharing data across platforms, and is a relatively robust, nearly ubiquitous solution to centralized data storage problems. Engineers are familiar with it, users are accustomed to it, and developers continue to improve it.

Document management solutions, such as Hummingbird DM,<sup>™</sup> can also take advantage of the PC-based NFS solutions, or PC-NFS solutions, and allow Microsoft Windows users to access documents stored on the UNIX-based document servers easily and transparently.

### **Project Collaboration**

Data sharing for project collaboration is a common practice in industries such as software development, where a large number of software developers will be working on the different parts of the same project. Rational ClearCase is one of the software configuration management solutions that manages change and complexity associated with software development. PC-NFS solutions enable the software developers to access project files stored in the UNIX file systems from the Microsoft Windows operating systems.

### **Data Backup and Recovery**

Mission Critical Data backup is essential for a corporation to maintain smooth and continuous business operations without the interruption caused by data loss. NFS solution plays a big part in the cross-platform backup scenario. Backup solutions provided by vendors such as Veritas and Legato, can use PC-NFS solutions to access the UNIX-based data repository.

Network Attached Storage (NAS) is the rising star in the data storage, backup and recovery arena. In essence, it is a hard disk storage that is set up with its own network address rather than being attached to the department computer that is serving applications to a network's workstation users. Most of the NAS solutions support the NFS protocol allowing Windows users to access the data storage from Microsoft Windows operating systems using PC-NFS solutions.

### **Evolution of PC Desktop Host Access**

Network Computing demands technologies that deliver the computing power and information of the enterprise LAN and WAN resources to the desktop. The LAN-centric nature of the market in the early 90's created vast numbers of isolated, disparate networks, that solved the immediate need of departmental (or group) computing. The desire to "access anything from anywhere" is driving the Age of Distributed Computing.

Distributed computing requires technologies that deliver and distribute the information and computing power of the enterprise Local-Wide-Global Area Network and the Internet to the enterprise desktop. The new age of computing is fueled by the ever-increasing Personal computing power of Intel based PCs, wide adoption of standardized graphical user interfaces — such as Microsoft Windows and Web browsers — and the adoption of TCP/IP as the de facto interoperable protocol. WWW technologies — HTTP and HTML lightweight information, Java and ActiveX — have created the framework required for an Object Oriented thin client architecture. Thin client computing is fed by the desire to drastically reduce the burden of administering enterprise desktops, a major impediment to technology shifts, such as distributed computing.

## Multi-vendor Inter-network

Today's enterprise network is a multi-vendor inter-network comprised of many different platforms based on proprietary and open systems technology. With the prohibitive cost of back-end server replacement (migration), any technology shift of the future is required to service the accessibility needs of today. Enterprise PC users require a wide range of TCP/IP-based internetworking software to access enterprise-wide information and applications, including multiple terminal emulations, X application access, remote file system access, and database query and reporting tools.

During the 1990's, personal computers rapidly evolved to become the standard enterprise desktop device, driven by Microsoft's focused effort of providing a standardized user interface. In the recent years, networking over the airwave slowly becomes the main driving force behind the PC technology evolution. In 2002, over 130 million PCs were shipped worldwide, and in 2004, over 160 million were shipped.

TCP/IP is the de facto infrastructure or highway upon which enabling technologies and applications travel. TCP/IP is now the standard deployed interoperable protocol of enterprise inter-networks and desktops worldwide. Over the years, TCP/IP has rapidly replaced legacy desktop proprietary protocols such as IPX/SPX. Microsoft's endorsement and inclusion of TCP/IP in Windows XP 2000/NT and Windows Me/98 has enabled the construction of a worldwide TCP/IP highway.

## Part 2 — Hummingbird NFS Solution

### Hummingbird NFS Maestro Product Family

Hummingbird NFS technologies deliver access to corporate information and resources from all Windows-based desktops. The NFS Maestro product family, consisting of NFS Maestro Client,<sup>™</sup> NFS Maestro Solo,<sup>™</sup> NFS Maestro Gateway<sup>™</sup> and NFS Maestro Server,<sup>™</sup> is a comprehensive line of network file system solutions designed for seamless access to PC desktops and host computer systems.

#### **NFS Maestro Client**

Hummingbird NFS Maestro Client provides solutions for connecting PCs to NFS resources. From Windows 98/Me and NT/2000/XP desktops, users can connect to a variety of computing environments, such as UNIX, VMS, Macintosh computers, IBM mainframes, and the Internet. Desktop users on a network can access remote file systems and printers in a familiar graphical Windows environment without having to understand UNIX, NFS commands, or underlying network complexities.

#### **NFS Maestro Solo**

NFS Maestro Solo, a member of the NFS Maestro family, is the first Windows 2000 certified PC NFS solution that provides the file and print accessibility from Windows PC to NFS enabled hosts. It provides the essential NFS functionalities without the extra Terminal Emulation software, such as Telnet, TN3270 and TN5250, and the extended suite of TCP/IP applications. NFS Maestro Solo supports all standard NFS protocols including NFS Version 4 protocol, NFS over TCP and WebNFS. Unique tuning capability, NFS Network Browser and NIS/NIS+ Auto. Map support make NFS Maestro Solo the most flexible and powerful PC NFS product in the market.

#### **NFS Maestro Gateway**

Hummingbird NFS Maestro Gateway is a service that connects clients on a Server Message Block (SMB) network, such as Windows NT, to exported resources on a Network File System (NFS) network. The service runs on a Windows NT/2000 server. Using NFS Maestro Gateway, you can link NFS resources to local drives on a Windows server and share them across an NT network. Non-NFS clients can then access the NFS resources as they would any other Windows share. NFS Maestro Gateway supports NFS versions 2, 3, and 4.

#### **NFS Maestro Server**

Hummingbird NFS Maestro Server is a server implementation of the Network File System (NFS) protocol for PCs running Windows NT/2000/XP. Once NFS Maestro Server is installed, any remote NFS client machine can access Windows-based resources (including Windows NT/2000/XP file systems, printers, and CD-ROMs) on the NFS server. The remote NFS client can be a PC, a UNIX machine, an Apple Macintosh, or any other machine running NFS client software.

## Advantages of NFS Maestro Product Family

There are three major reasons why NFS Maestro Product is the best PC NFS solution in the market: the first in the industry to support NFS Version 4 standard; the only PC NFS vendor to have the full capability to communicate with the most enterprise directory servers; and NFS Maestro supports RPCGSS\_SEC security flavor.

### **NFS Version 4 Support**

Hummingbird is one of the many companies that are actively involved in the design and the development of the NFS protocol. Hummingbird shows its determination and dedication to the NFS technology by being one of the first vendors who embraced the new standard, and integrated NFS Version 4 into the NFS Maestro product family. Here are some of the NFS Version 4 features that are supported by NFS Maestro:

**File Locking:** The file locking mechanism presented in NFS Version 3 can be problematic when working with the Windows file locking semantic. NFS Maestro supports the new lease-based file locking mechanism that becomes part of the NFS Version 4 protocol. The new file locking mechanism will resolve the file locking conflicts.

**Security:** RPCSEC\_GSS (Kerberos v5) has become an integral part of the NFS Version 4 protocol and it is integrated with Microsoft SSPI and Microsoft Active Directory. NFS Maestro has been supporting RPCSEC\_GSS security flavor since version 7.0.

**User Name Space:** NFS Version 4 uses a more generic user name space which is friendlier to Windows.

**ACLs:** UNIX has proprietary ACL implementations that were a non-standard add-on to NFS Version 3. Windows advanced ACL implementation could not be easily utilized. Thanks to integrated ACL in NFS Version 4, ACL can now be directly mapped to Windows ACLs.

**Extended and named attributes:** NFS offers very limited number of file attributes and they do not match one-to-one between Windows and UNIX. NFS Version 4 provides more file attributes to closely match those of Windows. Named attributes is a feature of the native Windows file system.

### **Directory Services**

Directory Services are widely used by companies to store and disclose network information such as host names, user IDs, and available resources. At Hummingbird, we understand that medium and large organizations utilize the directory services to reduce the administrative overhead by consolidating the information pertaining to the entire system to a single database where users can read, browse and search for enterprise or individual information, including the user passwords and the automount maps. This is the reason why NFS Maestro is the only PC NFS vendor in the industry to have the full capability to communicate with the most directory services in the market: NIS, NIS+, LDAP and Microsoft Active Directory. The directory services support allows users to access the directory services for host name resolution, user password and security key lookup, password synchronization and AUTOMOUNT information lookup. NFS Maestro provides a Windows Explorer-like interface for users to access and query directory services without leaving the familiar Windows environment.

### RPCSEC\_GSS Security

NFS Version 2 and 3 were the descendents of the UNIX environment therefore, they inherited the poor security architectures that were common to most UNIX operating systems. In recent years, vendors and developers have been devoting time and resources to improve the security architecture and new security protocols and frameworks were created, amongst which is the GSS\_API framework and the RPCSEC\_GSS security flavor.

Hummingbird recognized the fact that the NFS users valued the abilities to securely transmit data over the NFS connections and we were proud to be the first in the industry to support RPCSEC\_GSS security flavor in our NFS Maestro product family. The RPCSEC\_GSS security flavor uses generic security service (GSS) to provide security services that are independent of the underlying security mechanism. RPCSEC\_GSS is capable of securing the authentication as well as the encryption of the entire body of the RPC request and response. NFS Maestro products use Kerberos v5 as the default authentication mechanism for RPCSEC\_GSS. Hummingbird has been supporting RPCSEC\_GSS in the NFS Maestro product family since version 7.0.

## Top Ten Reasons to Use NFS Maestro

### 1. Freedom of Choice

NFS Maestro offers the complete family of NFS solution for different types of users to share resources between UNIX's and Windows PCs.

- > Power users who want to access UNIX file systems on Windows PC. — *They need NFS Maestro Client*
- > Power users who want to access UNIX file systems from Windows PC without the extensive TCP/IP tools and application suite. — *They need NFS Maestro Client*
- > Casual users who only need occasional access to the UNIX file systems from Windows PC, without the burden of installing any software on the PC. — *They need NFS Maestro Gateway*
- > Giving UNIX users access to the Windows PC file systems from UNIX. — *They need NFS Maestro Gateway*

### 2. First in the Industry to Support NFS Version 4

NFS Maestro is the only product in the industry that supports the new NFS protocol standard — NFS Version 4. NFS Version 4 integrates file locking, strong security, operation coalescing, and delegation capabilities to enhance client performance on high-latency networks like the Internet. Remote file access across networks has never been faster!

### 3. Strengthened Security

Security is always a concern for any system administrator. NFS Maestro provides the most complete implementation of NFS related security in the market, including Secure RPC and RPCSEC\_GSS. Administrators can be confident that the communication channels between NFS Maestro client and an NFS Server are properly secured.

#### **4. Integration with Directory Servers**

Directory Servers are widely used by companies to store and disclose network information such as host names, user IDs, and available resources. NFS Maestro is seamlessly integrated with common directory servers such as NIS, NIS+, LDAP and Microsoft Active Directory. The integration allows users to access the directory servers for host name resolution, user password and security key lookup, password synchronization and AUTOMOUNT information lookup.

#### **5. Windows 2000 and Windows XP logo**

NFS Maestro is the only product in the market that is certified for Microsoft Windows 2000 and received the Designed for Windows Logo. The Certification and Logo prove that NFS Maestro is superior in quality and stability, taking advantage of the latest features offered in the Microsoft Windows operating systems. Hummingbird NFS Maestro is an outstanding application that is capable of delivering a high-quality computing experience.

#### **6. Performance**

Each NFS Connection can be individually tuned and optimized. NFS Maestro users will appreciate the flexibility, and allowing them to get the most out of their specific networking environment!

#### **7. Internationalization**

All products in the NFS Maestro family support localization in Portuguese, French, Italian, German and Spanish in addition to English.

#### **8. Research and Development**

According to Sun Microsystems, Hummingbird is the leader in NFS solutions. Hummingbird is the only organization committed to continually enhancing the NFS protocol. Indeed, Hummingbird is the only PC NFS vendor that is actively involved in the development of the NFS technology.

#### **9. Feature Requests and Customization**

With every organization operating differently, cookie-cutter, shrink wrapped products no longer satisfy an enterprise's host access needs. Hummingbird is the solutions company with the quickest response time to customer requests for new and enhanced features.

#### **10. Complete Connectivity Solution**

Hummingbird is the only company that provides a complete solution that satisfies all Enterprise Connectivity needs. From X window emulation; to Mainframe and Midrange Terminal access; to accessing UNIX and PC files systems through the NFS protocol; to Thin X technology; to the security components such as Secure Shell and SSL. Hummingbird is THE one-stop-shop solution provider.

Server > Desktop Consolidation > X Window > UNIX integration > NFS v4 > Mainframe > Terminal Emulation > Security > SSL > Web-to-host > Cost Reduction > AS/400 > Mobile Workers > Thin  
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