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As computers become ever more integral to the functioning of society and its institutions, the ability to share data in a meaningful way has become increasingly important to the point where the inability to do so may well be considered to be a fatal shortcoming.

This paper provides some background on computer system interoperability, discusses the different approaches Hewlett-Packard has used for HP-UX® and Windows® interoperability, and discusses Hewlett-Packard's current approach to UNIX®/Windows file system interoperability and common user authentication using the Common Internet File System protocols.

Interoperability between computer systems has been sought after ever since the first computer systems were manufactured, sold, and put to work performing different application tasks such as accounting, inventory and engineering control, manufacturing planning, and product design. Initially, interoperability meant the ability to communicate data by means of common networking protocols, an appreciable challenge in its day. Much effort was expended defining proprietary protocols and in reverse engineering these protocols on non-native hosts to provide a measure of interoperability. Several programs and events worked together to change this aspect of networking forever.

The first program which was to have a profound effect on computer networking was the Arpanet program of the Defense Advanced Projects Agency (DARPA, later renamed to ARPA once the defense affiliation was dropped). This program included the implementation of non-proprietary networking protocols and was the basis for the invention of TCP/IP. For many years the Arpanet and related networking protocols were of interest primarily to the academic and scientific communities. However, in the mid 1990's the emergence of the first internet browsers and the subsequent explosive growth of the worldwide web, standard networking protocols and services rapidly became the rule and not the exception. Today, networking interoperability is largely a given today with the ubiquity of TCP/IP networking protocols and the worldwide web.

The Arpanet protocols, because of their close association with the academic community, have also been closely associated with UNIX, the dominant operating system in the academic community. The close association between the Arpanet protocols and UNIX led to UNIX becoming the primary operating system of the internet landscape.

Computing today, particularly the internet computing landscape, is dominated by two operating environments: UNIX and Windows. While it is true that there are variants of both of these (HP-UX, AIX, Solaris, Linux, Windows 95/98, Windows NT, Windows2000) there is enough commonality between the variants that UNIX and Windows can be thought of the two primary operating system environments. Clearly, these are not the only operating systems in use but a a very strong case can be made that these are the most widely used and will dominate the computing landscape for years to come. Both environments continue to receive large investments from their suppliers.

Networking for Windows had a different point of departure than UNIX networking. Windows networking beginnings lay in the file sharing protocols developed for use with the Local Area Networking technologies that began to emerge in the mid-1980's, particularly Ethernet. A protocol known as SMB (an acronym for Server Message Block) was cooperatively developed between Microsoft, Hewlett-Packard, and 3COM. SMB sat on top of TCP/IP on the Ethernet link and allowed PCs connected via a Local Area Network to share files and print services.

Windows and UNIX today offer very good networking interoperability with both boasting robust native TCP/IP networking stacks. Both operate well in the internet environment with both serving as platforms for both web servers and web browsers.

During the 80's and most of the 90's UNIX and Windows tended to be found in homogenous environments, that is, most environments were either exclusively UNIX or exclusively Windows. During the 90's UNIX came to dominate mission-critical commercial and technical computing environments while Windows dominated the desktop. The main point of intersection between UNIX and Windows was the use of UNIX systems as file servers for Windows platforms on a local area network. At this point in their life cycle PCs generally did not have the scalability and performance to function effectively as file and print servers whereas UNIX was much more scalable in terms of performance and capacity. To this end Microsoft licensed the server portion of its SMB protocols to AT&T who then ported the Windows file serving software to UNIX. Many UNIX vendors, including HP and Sun Microsystems, released UNIX file server to Windows client products based on the SMB server code ported to UNIX by AT&T. Generically these products were known as Advanced Server for UNIX (ASU). In this way Windows-based networking services began to find their way into the UNIX world.

Despite the availability of ASU for UNIX systems, file system integration of UNIX and Windows remained problematic. Advanced Server for UNIX, being a port from the Windows environment, did not have the look and feel of UNIX and suffered from poor integration with basic UNIX utilities. UNIX system administrators were forced to learn the idiosyncrasies of Advanced Server in order to administer it. In particular, Advanced Server for UNIX kept file security information outside the UNIX file system. UNIX backup utilities, lacking knowledge as to the whereabouts of this security information, performed backups that were incomplete.

In approximately the same timeframe, Samba, an open source UNIX file serving to Windows product became available. Samba was a native UNIX implementation of file serving capabilities for Windows. While Samba did not have the drawbacks of originating as a port from the Windows environment, it also did not have technical support of the vendor community at large. Because of this, UNIX file serving to Windows frequently defaulted to ASU for which technical support from AT&T and the vendor community was available.

As of the writing of this paper the future of Advanced Server for UNIX is uncertain at best. Microsoft has no announced plans to license the SMB server code from Windows2000 as it did with Windows NT. Without the licensing of the SMB server code from Windows2000 it is highly likely that UNIX with ASU will begin to lose the ability to function as a file server for Windows clients and that those requiring file system interoperability between the UNIX and

Windows will need to look elsewhere. Some compatibility problems between current ASU implementations and Windows2000 have already been reported.

Ironically, at the same that Microsoft is decreasing its support for Advanced Server for UNIX the requirements for UNIX and Windows interoperability are increasing. In particular, several trends emerged in the late 90's to create a need for increased interoperability and integration between UNIX and Windows:

1) Mixed UNIX and Windows environments began to emerge.

2) Corporations began to implement corporate intranets that are accessed by both Windows and UNIX clients.

3) Multinational companies felt an increasing for global collaboration in product development, a trend driven by increased levels of global competition.

In general, there have been few good solutions for UNIX and Windows file system interoperability. The primary technology for file system interoperability between UNIX systems is the Network File System or NFS as it is commonly called. The primary technology for file system interoperability between Windows systems is the Common Internet File System or CIFS, as it is commonly called. CIFS grew out of the System Message Block (SMB) protocol which was developed to give PCs file sharing capabilities over the nascent local area networking technologies, particularly Ethernet. CIFS is built-in on every Windows platform since Windows 95 including Windows 98, Windows NT, and Windows2000.

Using NFS to provide interoperability between UNIX and Windows is possible but somewhat problematic. NFS is not native to Windows and must usually be purchased from a 3rd party, thus leading to a higher and potentially substantial cost of deployment. Additionally, NFS for Windows tends to present issues in the areas of performance, security, and functionality.

In early 1999 HP began to recognize the need for better UNIX and Windows interoperability and integration. Enterprise customers were beginning to implement mixed environments of UNIX and Windows, thus creating demand for UNIX and Windows interoperability and integration solutions.

In a related development, enterprise customers began to search for ways to unify the multiple user authentication methods in their intranets. Windows platforms normally use NTLM (NT Lan Manager) for network user authentication while UNIX normally uses Network Information Services (NIS). With UNIX and Windows using different methods of user authentication, IT departments have been required to maintain two databases of user ids and passwords, thus consuming valuable IT department bandwidth and preventing the creation of user id’s and passwords that were global to the organization.

After a technical investigation, HP decided that the best way to meet these emerging needs was to implement the Common Internet File System on HP-UX. HP-UX 11 was selected as the

platform of choice because of the availability of some user authentication technologies not available with earlier versions of HP-UX.

The selection of the Common Internet File System (CIFS) provided a number of advantages:

- CIFS was standard and native in all of the common Windows platforms (with the exception of Windows 3.0 and Windows 3.1)
- The implementation of CIFS for HP-UX 11 could be native (not a port) and therefore have the look and feel of UNIX and be tightly integrated with HP-UX 11
- Better wide area network performance could be achieved with the aggressive caching policies and large block transfers of the CIFS client
- Common authentication would be possible between UNIX and Windows clients

Early on it was decided to adopt the open source Samba product as the basis for the server portion of HP's CIFS product for HP-UX 11. The Samba product is reasonably robust and has a history of providing effective file and print sharing services to Windows clients from UNIX platforms. In the decision to adopt an open source product as the basis for the server part of its CIFS product, HP accepted the obligation of supplying the open source community with HP enhancements to the Samba code base.

Work on the new product began in early 1999 and continued throughout 1999. The new product, given the name CIFS/9000, became available on the HP website in February of 2000 and began shipping as a standard part of HP-UX 11 on HP 9000 Servers and Workstations beginning in March, 2000.

CIFS/9000 is a bundled product with HP-UX 11. HP felt strongly that the CIFS capabilities should be a standard part of HP-UX 11, similar to the manner in which CIFS is a standard part of Windows platforms. Accordingly, if an order is placed including the factory installation (instant ignition) of HP-UX 11 (or later), CIFS/9000 is automatically loaded at the factory along with the HP-UX operating system. CIFS/9000 is also available as part of the Application Release (AR) and continues to be available from the HP software depot (www.software.hp.com).

CIFS/9000 consists of two parts, a server portion and a client portion. The server portion allows HP-UX 11 to act as a file and print sharing server to Windows clients and provides functionality similar to the file and print serving functionality provided by Advanced Server for Unix with the exception of the ability to function as a Primary Domain Controller (PDC) or Backup Domain Controller (BDC). The CIFS/9000 Server also serves as a file server to CIFS/9000 clients on other HP-UX 11 systems. Additionally, the CIFS/9000 server can map to both UNIX and Windows user information to provide integrated authentication for CIFS clients accessing the server.

The CIFS/9000 client allows HP-UX 11 users to access Windows file servers or other HP-UX 11 systems which have the CIFS/9000 server. The CIFS/9000 client also provides integrated user authentication between HP-UX and Windows domains using NTLM (NT Lan Manager), thus allowing an HP-UX 11 user to authenticate on the network in same manner that a Windows user does using NTLM and Windows Primary

and Backup Domain Controllers. This characteristic of CIFS/9000 has the potential for dramatically simplifying the administration of user ids and passwords in Enterprise IT environments which have both UNIX and Windows platforms. The CIFS/9000 client can be configured so that user authentication on the HP-UX 11 server and on the network with the Primary and Backup Domain Controllers occur in one seamless operation. This can occur because the CIFS/9000 client can perform mapping between the UNIX user logon and a Windows user account which is set up on the Windows Domain Controllers.

The CIFS/9000 product also contains features such as support for UNIX symbolic links and pipes which are useful for interoperability between UNIX systems. These extensions do not exist in the Windows platforms and are used only between UNIX systems.

The current version of CIFS/9000 on HP-UX 11 is interoperable with Windows95®, Windows98®, and Windows NT®. No additional components need be purchased or added to either Windows or HP-UX 11 to achieve the benefits of file system interoperability and common user authentication. Validation testing with Windows2000® is underway at the writing of this paper.

As proof of the capabilities of CIFS/9000, the product is currently being deployed worldwide by a multinational electronics company headquartered in the Netherlands. This electronics company has research and development facilities located in North America, Europe, and the Far East. These organizations use a mixture of UNIX and Windows-based systems and require the ability to collaborate using common data for product development. Data is stored centrally and then transferred via the Common Internet File System and rsync (rsync is public domain file synchronization UNIX software) to the remote work groups. Once the data is at the remote work groups it is distributed to Windows workstations via the common internet file system and to UNIX workstations via NFS. Authentication of both the Windows and UNIX workstations will be performed using the Common Internet File System and a corporate worldwide user id and password database. This will allow a company employee to access the corporate intranet using the same user id and password no matter what facility they may be visiting.

Hewlett-Packard has ambitious plans to increase CIFS/9000 functionality and capability. In June of this year (2000) Hewlett-Packard enhanced CIFS/9000 so that it is integrated with the MC/ServiceGuard product and can be failed over to a secondary system should the primary host system fail. The CIFS/9000 client was also enhanced to access files on systems with Advanced Server for UNIX (ASU). Additionally, performance benchmarking and sizing information have been released.

Future CIFS/9000 enhancements include integration with the Active Directory Services (ADS) from Microsoft with the PAM/Kerberos authentication module of CIFS/9000 to provide even more secure user authentication.

For the forseeable future, both UNIX and Windows will continue to be very prevalent in enterprise computing environments and it more likely that these environments will be a mix of UNIX and Windows. Therefore, it is important to consider the interoperability aspects of both when architecting and designing computing infrastructures. Hewlett-Packard, with CIFS/9000,

has exercised the initiative of providing strong interoperability between UNIX and Windows. This initiative has yielded the side benefit of delivering the possibility of global and common authentication between UNIX and Windows, thus eliminating the IT overhead of maintaining two password databases and providing global authentication between UNIX and Windows . . . the ability for an enterprise user to access the network, no matter where in the world they might be.