

# WorkSpace On-Demand 2.0 Feature for Windows Clients Performance White Paper

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*September 1999*

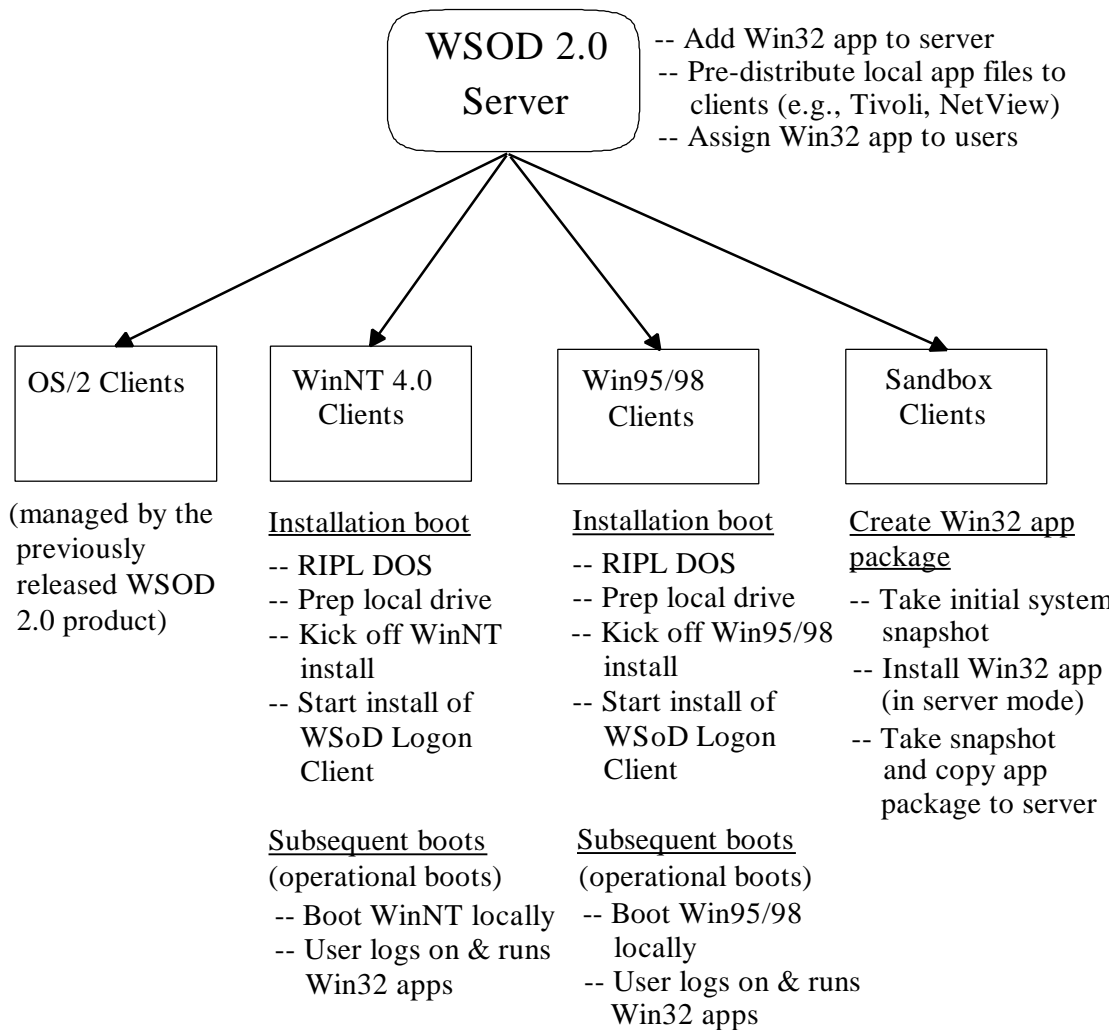
## 1. Introduction

The previously released WorkSpace On-Demand (WSOD) 2.0 provided OS/2 Warp Servers the capability to manage users and OS/2 applications running on OS/2 client machines. The *WorkSpace On-Demand 2.0 Feature for Windows Clients* (from hereby referred to as the *Windows Client Feature*, or more simply, the *Feature*) extends the capability of WorkSpace On-Demand 2.0 to manage Windows NT, Windows 95, and Windows 98 client machines. More specifically, from an OS/2 Warp Server running WSOD 2.0 (from hereby referred to as the *WSOD 2.0 server*, or more simply, the *server*), the Windows Client Feature allows a system administrator to support the following:

- Remote configuration and installation of Windows NT 4.0 Workstation, Windows 95, and Windows 98 operating systems to the client systems
- Management of users and Win32 applications on the clients
- Secure log-on and authentication
- Restricted client desktops
- A command-line interface for the system administrator

### 1.1. Technical Overview

*Figure 1* shows an overview of how the Windows clients are managed and what system administrator's actions are supported by the Windows Client Feature to manage the Win32 applications.



**Figure 1. Architectural Overview**

This Windows Client Feature has three main components:

Win32 Boot Management

This component allows a WSOD 2.0 server to support unattended, remote installation of Windows 95, Windows 98, or Windows NT operating system (OS) to the client machines. The system administrator specifies which of the three Windows operating systems to be installed to each client. The Windows OS installation images are stored on the WSOD 2.0 server. The server first performs a remote boot (RIPL) of a DOS image to a client system in order to set up the environment for the Windows installation at the client. The Windows

installation is unattended, driven by response files. After the Windows OS has been installed to the client machine, a WorkSpace Logon Client will be installed, again unattended and driven by response files, to the client machine to provide users the capability to log on to an OS/2 Warp Primary Domain Controller (PDC). The WorkSpace Logon Clients are the modified versions of the existing IBM Networks Client for Windows 95 and IBM Networks Primary Logon for Windows NT products.

After this initial installation of the Windows OS and the WorkSpace Logon Client to the client system, any subsequent boot (or power-on) will be very fast as the client will boot the Windows OS from its local disk instead of from the server over the network.

More specifically, the boot management component supports the following system administrator's actions:

- ◆ Create / define Windows client machines on the WSOD 2.0 server
- ◆ Create / define client install images for Windows client machines
- ◆ Set up and initiate the unattended installation of the appropriate Windows OS to a client
- ◆ Automatically install and execute the appropriate WorkSpace Logon Client to provide secure log-on and authentication

### Win32 Application Management

This component provides the system administrator the capability to manage Win32 applications and control user access to these applications. Where these Win32 applications reside physically depend on the characteristics of those applications. For many applications, such as Microsoft Office97 and Lotus Smartsuite97, most of the applications files and all of per-user files reside on a WSOD 2.0 server with a small portion of files residing locally on the client machine. It is the responsibility of the system administrator to install the files that need to be on the client machines; they can be defined as part of the client install image that is sent down to the client systems by the boot management component, or they can be copied down to the client systems using a third-party product, such as Tivoli Management Agent (TMA). For all Win32 applications that are supported, this component gives the system administrator complete control over what Win32 applications a given user has the ability to access or use.

More specifically, this component supports the following system administrator's actions:

- ◆ Create Win32 application "packages" on "sandbox" clients
- ◆ Install / define Win32 application packages to the WSOD 2.0 server
- ◆ Assign Win32 application packages to users
- ◆ Provide restricted user desktops on the clients
- ◆ Provide secure log-on and authentication (through the WorkSpace Logon Clients)

### Product Installation

This component allows the Windows Client Feature to be installed on top of WorkSpace On-Demand 2.0 using the Feature Installer (FI). A graphical user interface (GUI) is provided

to assist the user during installation. Both CD-ROM and network-based (CID) installations are supported.

## **1.2. Platforms Supported**

### *Server platforms supported*

The Windows Client Feature is a feature of WorkSpace On-Demand 2.0, and thus, it requires that WorkSpace On-Demand 2.0 be first installed on the server. The supported server environment is the same as that of the WorkSpace On-Demand 2.0 product, which includes the following OS/2 Warp Server versions (with the latest fixpaks):

- IBM OS/2 Warp Server SMP
- IBM OS/2 Warp Server 4.0 Entry
- IBM OS/2 Warp Server 4.0 Advanced
- IBM OS/2 Warp Server for e-business (Aurora)

### *Client platforms supported*

The Windows Client Feature requires a full copy of Windows OS installation files to be stored on the WSOD 2.0 server. The system administrator can use the WCF utilities supplied with this Feature to copy the Windows OS installation files from their CD-ROMs to the appropriate directories on the WSOD 2.0 server. Please refer to the Administrator's Guide for more information. The following Windows operating systems are supported on the clients:

- Windows NT 4.0 Workstation
- Windows 98 (retail version)
- Windows 95 (OSR2 OEM version), which is available only on systems where Windows 95 is pre-installed

The Windows Client Feature also requires that the Windows operating systems used be compatible with the 16-bit version of the File Allocation Table (FAT16) file system. Only operating systems that can modify, or convert, a FAT16 partition to another file system as part of the unattended installation process can use alternate file systems. One such example is Windows NT 4.0, which can convert a FAT16 partition to a Network Terminal File System (NTFS) partition as part of the Windows NT installation process if the conversion is specified in the Windows NT response file (*unattend.txt*).

### *Client hardware requirements*

The Windows Client Feature only supports client systems with the following hardware capabilities:

- A network adapter that supports Remote Initial Program Load (RIPL)
- The system BIOS must support booting from a network device

- The default disk partition size is 250 MB (up to 2 GB maximum). The maximum hard disk size supported is 8 GB.

It should be noted that **any data on the client's boot drive will *not* be preserved during an installation boot (when a new client install image is installed)**. Other drives on the client will not be affected.

### 1.3. Scope Of This Paper

In a server-managed network computing environment for which the Windows Client Feature is targeted, the client boot process is very important to a system administrator because it is through this process that the client install images, including the Windows operating systems, and potentially, Win32 applications, are distributed to the clients. It can consume a lot of network bandwidth. As a result, the primary purpose of this paper is to present some performance data collected for the client boot / install process, the data analysis, and some performance recommendations derived from this data. This paper will not cover in detail the performance of Win32 applications on the clients as it is application-dependent and of secondary concern to this paper's target audience -- the system administrator. However, factors which can affect the performance of Win32 applications, as well as the log-on performance, will be discussed.

## 2. Boot Process Overview

Since the primary focus of this white paper is on the boot performance, a high-level overview of the boot process is given here. For more details, please refer to the information sources listed at the end of this paper (Section 5).

After installing the Windows Client Feature on a WSOD 2.0 server, the system administrator should copy the Windows OS installation files ("cabinet" files) from the Windows CD-ROMs to the appropriate directories on the server, using the WCF utilities provided with the Feature. He then needs to define the Windows client systems and their install images on the server. A *client install image* includes pointers (file and path names) to the following on the WSOD 2.0 server:

- Windows OS installation files
- Windows device drivers
- Win32 Java Virtual Machine (JVM) files
- Tivoli Management Agent (TMA) files
- WorkSpace Logon Client files

These pointers are stored in *response files*, which are used to drive the unattended installation of the Windows OS, device drivers, Win32 JVM, TMA, and the WorkSpace Logon Client at the client. In addition, the system administrator may also specify Win32 application package files to be part of the client install image.

After a client has been created and defined with a client install image, all files referenced by the client install image, including the response files, will be downloaded from the WSOD 2.0 server and installed on the client the next time the client is rebooted or powered up. This process of

downloading and installing the client boot image on the client system is referred to as the *installation boot sequence*.

## 2.1. Installation Boot Sequence

To keep track of all the clients on the WSOD2.0 server, the base WorkSpace On-Demand 2.0 product maintains a file called *RPL.MAP*. For each client, there is an entry in the *RPL.MAP* file that points to a RIPL boot image which will be sent down to the client when the client makes a boot request to the server. For a Windows client, its entry in the *RPL.MAP* file initially points to a **DOS RIPL boot image** which is specified during the client definition phase. This DOS RIPL boot image contains an *autoexec.bat* which, when invoked on the client, will start the network requester on the client and establish network connections to the WSOD 2.0 server.

The Windows Client Feature also uses another type of boot image called the **hybrid boot image** (*hdboot.com*). This hybrid boot image is a small bootstrap executable, which, once loaded into memory of a client, will perform the following:

- Read the first sector of the local hard disk of the client
- Load the Windows OS bootstrap program located on the local hard disk
- Give control to that Windows OS bootstrap program

Effectively, the function of the hybrid boot image is to initiate the Windows OS boot from the local disk of the client. The use of this hybrid boot image will become clear later in this section.

After a client has been defined with a new client install image, the following steps will happen when the client is rebooted or powered up:

- 1) The client sends its MAC network address and issues a 802.2 RIPL boot request to the WSOD 2.0 server.
- 2) The server sends a DOS RIPL boot image down to the client. As mentioned previously, this DOS RIPL boot image contains an *autoexec.bat* which starts the network requester on the client and establishes network connections to the server.
- 3) A DOS utility, called ***state.exe***, is started on the client from the *autoexec.bat* in the DOS RIPL image. This ***state.exe*** utility will perform the following:
  - a) Check the *state.fil* on the WSOD2.0 server. Each client has its own *state.fil* file on the server which contains the client's current state and other status information.
  - b) If the client state = NEW (initial state)
    - ◆ Use Int13 to get the client's disk capacity
    - ◆ Issue FDISK command to create a disk partition
    - ◆ Set the client state = PREP and reboot the client.

When the client is rebooted, steps (1), (2), and (3) will take place again. However, the client state is now PREP, so it will continue with step (3c) below.

- c) If the client state = PREP
- ◆ Issue FORMAT command to format the newly created disk partition
  - ◆ Set client state = COPY1 and reboot the client

When the client is rebooted, steps (1), (2), and (3) will take place again. However, the client state is now COPY1, so it will continue with step (3d) below.

- d) If the client state = COPY1
- ◆ If client type = Windows 95 or 98
    - ✓ Copy Windows OS installation files from the WSOD 2.0 server to the client (Windows NT installation files will be copied later)
  - ◆ For all client types:
    - ✓ Copy response files from the WSOD 2.0 server to the client (these response files will be used to drive the unattended installation of the Windows OS and other software specified in the client install image at the client)
    - ✓ Copy Win32 application package files from the WSOD 2.0 server to the client if they are specified as part of the client install image
    - ✓ Set client state = COPY2 and reboot the client

When the client is rebooted, steps (1), (2), and (3) will take place again. However, the client state is now COPY2, so it will continue with step (3e) below.

- e) If the client state = COPY2
- ◆ Copy the WorkSpace Log-on Client files from the WSOD 2.0 server to the client
  - ◆ Set client state = INSTALL and reboot the client

When the client is rebooted, steps (1), (2), and (3) will take place again. However, the client state is now INSTALL, so it will continue with step (3f) below.

- f) If the client state = INSTALL
- ◆ Set client state = HYBRID
  - ◆ Check for available DOS memory. If there is not enough memory left to start the unattended installation of Windows OS (a likely case for DBCS languages like Japanese), then perform the following:
    - ✓ Install minimal DOS to the client's hard disk
    - ✓ If client type = Windows NT, then copy the Windows NT 4.0 installation files from the WSOD 2.0 server to the client
    - ✓ Reboot the client. The client will then run this minimal DOS without networking support but with more memory available.
  - ◆ Start the unattended installation of
    - ✓ Windows OS
      - ❖ If (client type = Windows NT) & (network connection is available), then Windows NT install program copies the Windows NT installation files from the WSOD 2.0 server to the client
    - ✓ Win32 Java Virtual Machine (JVM)
    - ✓ Tivoli Management Agent (installed but not activated by default)

- ✓ WorkSpace Logon Client
- ◆ Clean up image files and reboot the client

In the mean time, on the WSOD 2.0 server, the **Server State Daemon** (*statedm.exe*) is monitoring the status of all the clients by looking at the *state.fil* of each client on the WSOD 2.0 server. As it reads the *state.fil* for each client:

- If client state ^= HYBRID, continue on to read the *state.file* of the next client
- If client state = HYBRID, then it does the following:
  - ◆ Calls Net32SetRIPLMachineInfo API to update the client entry in the *RPL.MAP* file to point to the *hybrid boot image*
  - ◆ Continue on to read the *state.file* of the next client

Consequently, as soon as *state.exe* sets the client state = HYBRID in *state.fil* in step (3f) above, the **Server State Daemon**, running on the server, will modify the client's entry in *RPL.MAP* to point to the *hybrid boot image*. As a result, when the client is rebooted at the end of step (3f), the WSOD 2.0 server will send the hybrid boot image down to the client, instead of a DOS RIPL boot image. This hybrid boot image will transfer control to the Windows OS bootstrap located on the local hard disk of the client. The Windows OS, which has already been installed on the client in step (3f) above, will then be booted up from the client's hard disk.

Once the Windows OS comes up, the following will take place:

- The WorkSpace Logon Client will be invoked
- The WorkSpace On-Demand Logon Panel will appear
- The user sitting at the client will be required to log on to the Primary Domain Controller (PDC).
- After the user logs on successfully,
  - ◆ The restricted desktop will be retrieved from the user's home directory on the PDC
  - ◆ System policy files and user profile (which control the desktop and user access) will be downloaded from the PDC and applied to the client

The user should now see a restricted desktop on his client system. On his desktop, he should only see the icons for those applications that have been assigned to him by the system administrator at the server.

## 2.2. Operational Boot Sequence (subsequent boots)

After the installation boot sequence, the client is in the HYBRID state, and its entry in the *RPL.MAP* file points to the *hybrid boot image*. As a result, whenever the client system is rebooted or powered up, the WSOD 2.0 server will send the hybrid boot image down to the client. In other words, the following steps will occur when a client is powered up or rebooted:

- 1) The client system sends its MAC network address and issues a 802.2 RIPL boot request to the WSOD 2.0 server.
- 2) The server sends the hybrid boot image down to the client.



- 3) The hybrid boot image transfers control to the Windows OS bootstrap program located on the local hard disk of the client.
- 4) The Windows OS will be booted and the WorkSpace Logon Client will be run to display the WSoD Logon Panel -- all from the client's local hard disk.

Because Windows will be booted from the client's local hard disk, these operational boots are very fast. There is minimal network bandwidth required for these boots.

If the system administrator has a new client install image for a client, he should issue a *netwin* `<client name> /reset` command at the WSOD 2.0 server to reset the client. This reset command will:

- Set the client state to NEW in the client's *state.fil*
- Set the client's entry in the *RPL.MAP* file to point to a DOS RIPL boot image (instead of the hybrid boot image).

The client will then go through the *installation boot sequence* as described in Section 2.1 to get the new client install image.

### 3. Performance Data & Analysis

In this section, a description of the performance measurement environment will be given first, followed by the presentation of some performance data that were collected. This data will then be analyzed to arrive at several performance recommendations.

#### 3.1. Measurement Environment

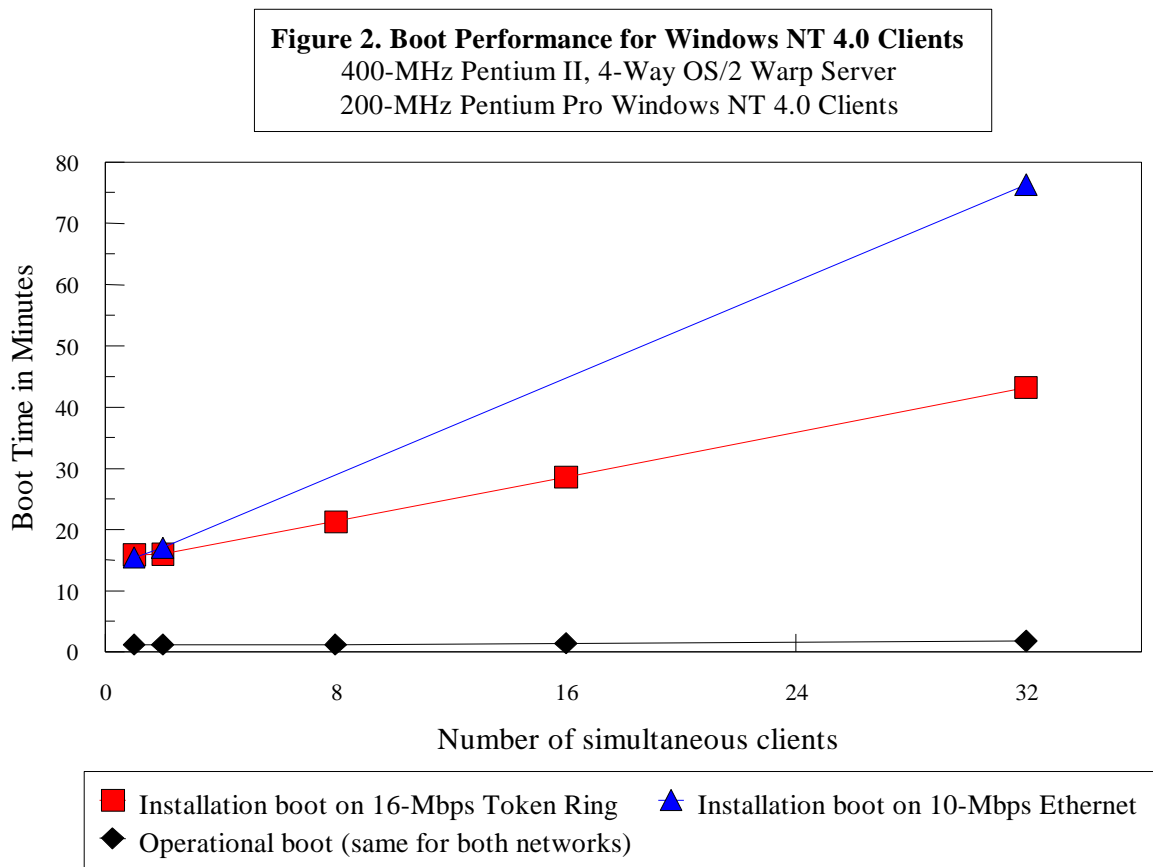
The following measurement environment was used to collect data for the Windows Client Feature:

- *WSOD 2.0 server*
  - ◆ Hardware: 400-MHz Pentium II, 4-Way SMP system
  - ◆ Software:
    - ✓ OS/2 Warp Server 4.0 with FixPak 40
    - ✓ WorkSpace On-Demand 2.0
    - ✓ HPFS386 File System with 128-MB cache
- *Windows clients*
  - ◆ Hardware: 200-MHz Pentium Pro
  - ◆ Software: (none pre-installed)
- *Networks*
  - ◆ 16-Mbps Token Ring (private - no other use)
  - ◆ 10-Mbps Ethernet (private - no other use)
  - ◆ 100-Mbps Ethernet (private - no other use)
- *Client install images*
  - ◆ Minimum Windows NT 4.0, Windows 95, or Windows 98 installation
  - ◆ VGA video driver

- ◆ Ethernet or Token Ring driver
- ◆ No Win32 application packages files

### 3.2. Boot Performance for Windows NT 4.0 Clients

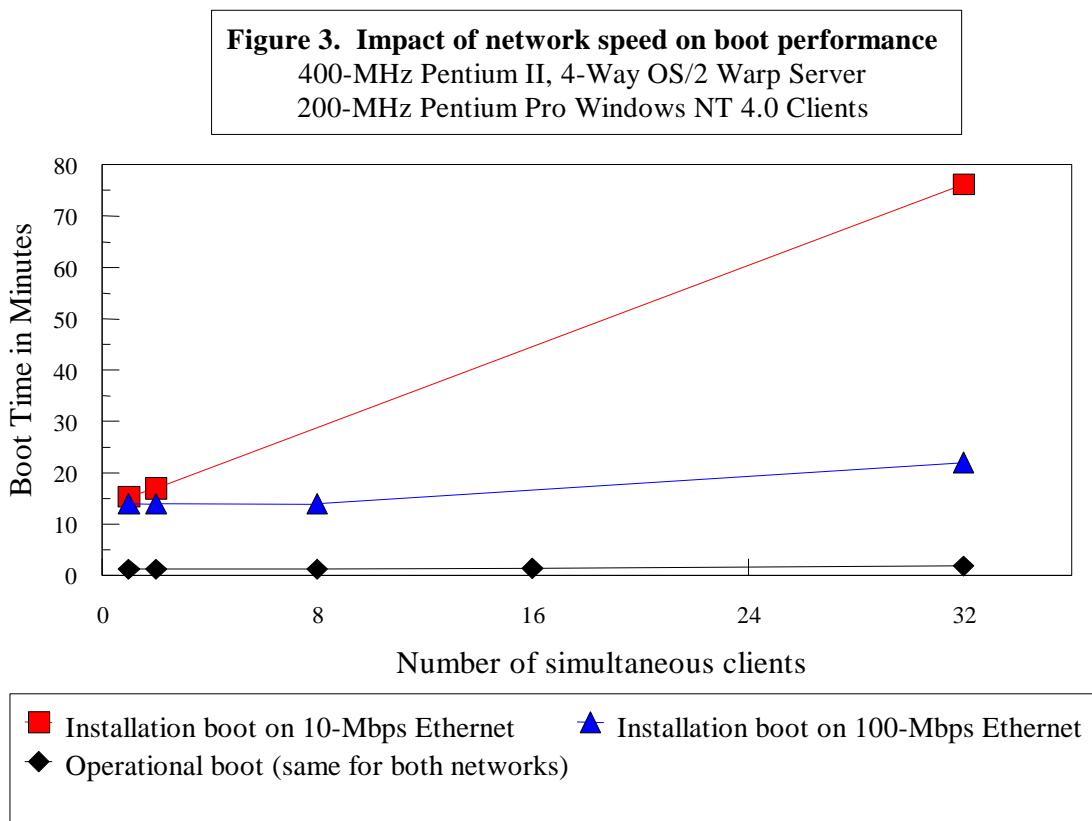
As can be seen from *Figure 2*, the installation boot time for a single Windows NT 4.0 client is approximately 15 minutes on both 10-Mbps Ethernet and 16-Mbps Token Ring networks. The networks are not fully utilized at this point: the peak network utilization is 40% and 60% for the 16-Mbps Token Ring and 10-Mbps Ethernet, respectively. As the second client is added, the installation boot time remains more or less the same at 15 minutes on the Token Ring because



there is still enough peak network bandwidth to support two clients. However, as more clients are added, the installation boot time starts to increase in a linear fashion as the 16-Mbps Token Ring network is fully utilized during “peak” periods. For the 10-Mbps Ethernet, the installation boot time starts to increase linearly after the first client as the network utilization hits 90% during “peak” periods. At 32 clients, the installation boot time increases to over 43 minutes with the 16-Mbps Token Ring and 76 minutes with the 10-Mbps Ethernet.

Now what are the “peak” periods? The “peak” periods are the periods in which the installation boot sequence requires heavy network bandwidth. As discussed in Section 2.1, *not* all of the installation boot sequence requires heavy network bandwidth. Only *steps (2), (3d), (3e)*, and for Windows NT 4.0 clients, a portion of *step (3f)*, involve network traffic as the DOS RIPL image, Windows OS installation files, response files, and other files specified in the client install image are copied from the WSOD 2.0 server to the client across the network. Other steps in the installation boot sequence execute locally on the client system without involving the network. In fact, with one client and no network contention, only 22% of the entire 15-minute installation boot time involves the network; the rest (78%) is dependent only on the speed of the client machine and remains constant regardless of how congested the network is. This helps keep the installation boot time within reasonable ranges for up to 32 clients and beyond.

*Figure 2* also indicates that the operational (subsequent) boots are very fast (under 2 minutes) because Windows boots from the local disk of the client, and therefore, does not require much network bandwidth at all. The operational boot time stays constant regardless of the number of clients on the network. *Deterministic, quick operational boot performance is the key performance advantage of the Windows Client Feature over previous WSOD products.*



*Figure 3* shows the impact of network bandwidth (or speed) on the installation boot time. With a 100-Mbps Ethernet network, the installation boot time remains at approximately 20 minutes at 32 clients -- just a little bit higher than the 14-minute boot time with only one client. In fact, since the “peak” utilization of the 100-Mbps Ethernet for one client is only 10%, it is

expected that the installation boot time would remain pretty much constant at around 15 minutes for up to 8 clients. The operational boot time is always constant at under 2 minutes.

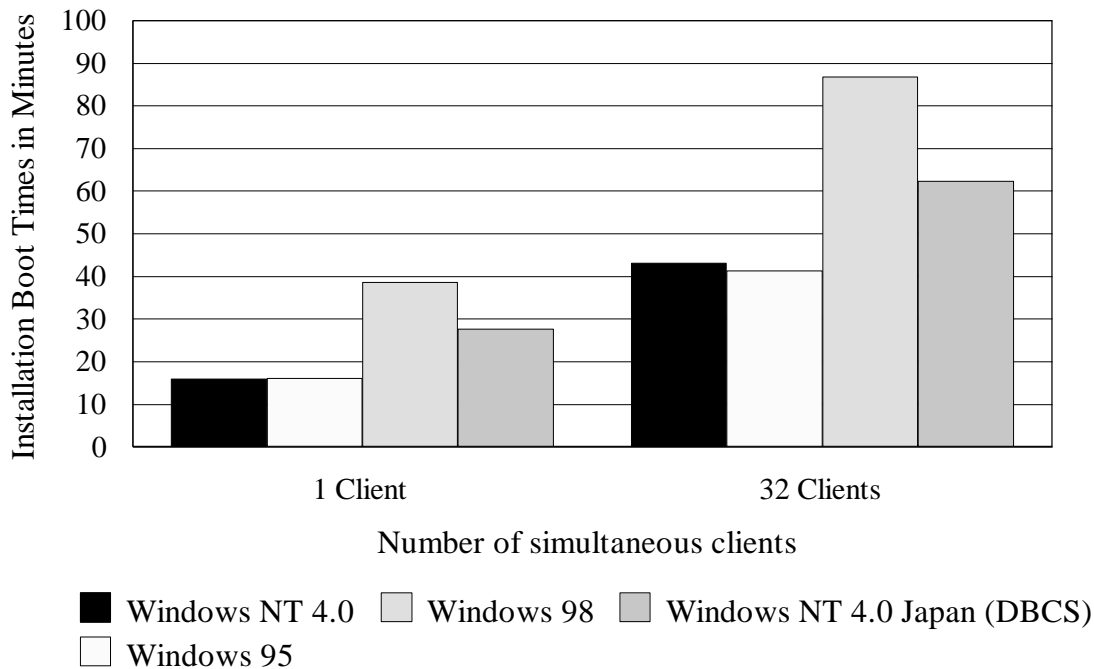
In summary, the data in *Figures 2 and 3* shows that:

- The installation boot time depends on the available network bandwidth, number of clients, and individual speed of the clients. Faster networks will keep the installation boot time within reasonable ranges for larger number of clients. Faster client machines will deliver faster installation boot time, but not by much if there are a lot of clients on the network and the network is fully utilized during “peak” periods.
- The operational boot time only depends on the individual speed of the clients. It is relatively quick and constant regardless of the network traffic. This is the key performance advantage of the Windows Client Feature.

It is important to note that *the data shown in Figures 2 and 3 represents the worst possible case because all of the clients are set up so that they go through the installation boot sequence simultaneously*. This means that all of the clients will contend for the network bandwidth at the same time. It is highly recommended that the system administrator should stagger the start of the installation boots on the clients in order to minimize the impact of the network on the boot time.

### 3.3. Boot Performance for Windows 95 and 98 Clients

**Figure 4. Installation Boot Performance for Different Windows OS versions**  
 400-MHz Pentium II, 4-Way OS/2 Warp Server  
 200-MHz Pentium Pro Clients & 16-Mbps Token Ring Network



*Figure 4* shows the installation boot performance for Windows NT 4.0, Windows 95, Windows 98, and the DBCS (Japanese) version of Windows NT 4.0 clients.

- The installation boot time for Windows 95 clients is slightly less than that for Windows NT 4.0 clients. This is because the client install image size for Windows 95 is slightly smaller than that for Windows NT 4.0: 96.6 MB for Windows 95 versus 105.7 MB for Windows NT 4.0 (assuming minimum installations with only VGA and Token Ring network drivers). As discussed in Section 2, the client install image, which includes the Windows OS installation files and others, is copied from the WSOD 2.0 server to the client during the installation boot sequence, so the smaller the install image size, the faster the installation boot time would be.
- The installation boot time for Windows 98 is much longer than Windows 95 and NT because of two reasons:
  - ◆ The client install image size for Windows 98 is much bigger: 196.6 MB for Windows 98, compared to 96.6 MB for Windows 95 and 105.7 MB for Windows NT 4.0 (again assuming minimum installations with only VGA and Token Ring network drivers). This translates into very long installation boot time for Windows 98 when there is much network contention (almost 90 minutes with 32 clients simultaneously going through installation boot sequence).
  - ◆ The time required to set up and install Windows 98 after the files are copied from the WSOD 2.0 server to the client is very long: it takes over 30 minutes for Windows 98, compared to only 12 minutes for Windows 95. Fortunately, this Windows 98 setup and installation phase runs locally on the client and does not involve the network.
- The operational boot times for all Windows OS versions, *not* shown in *Figure 4*, are always relatively fast and deterministic because they only depend on the speed of the clients, not the network (or the server).

### 3.4. Impact of Double Byte Character Set (DBCS) Languages

The DBCS versions of the Windows Client Feature will have longer installation boot times than the US and SBCS versions (*Figure 4*). This is because of two reasons:

- The client install image size is larger because of the DBCS font support (135.7 MB for the Japanese version of Windows NT 4.0 versus 105.7 MB for the US version). Larger client install image size means more data would need to be copied from the WSOD 2.0 server, resulting in more network traffic.
- The large DBCS font support consumes so much more DOS memory that there is often not enough DOS memory left to run the unattended Windows installation on the client. As specified in *step (3f)* of the installation boot sequence in Section 2.1, not having enough memory to run the Windows installation means that the *state.exe* utility has to copy and install a minimal version of DOS to the hard disk of the client, as well as copy all of the Windows NT installation files to the client. This also requires an additional reboot of the client. All of these add more time to the installation boot.

The operational (subsequent) boot times for all types of clients are always fast and deterministic because they only depend on the speed of the clients, not on the network (and the server).

### 3.5. Factors Affecting Log-on Performance

To many users sitting at the client systems, the time required to log on to an OS/2 Primary Domain Controller is important. Although no actual performance data was collected in this area, the factors which affect the log-on process are noted here.

- If the user logs on after applications have just been assigned to the user by the system administrator
  - ◆ The WorkSpace Logon Client has to
    - ✓ Search and copy files, such as the user profile, desktop, system policy, registry changes, etc., from the server to the client
    - ✓ Apply user registry changes to the client
  - ◆ Log-on performance is relatively slow, depending on
    - ✓ Applications
    - ✓ Available network bandwidth
- If the user logs on with *no* new applications, then the log-on performance is relatively quick. It is more deterministic than in the case with new applications, but it is still dependent on the available network bandwidth and server activities because the WorkSpace Log-on Client still needs to retrieve the user profile, desktop, and system policy file from the server.

### 3.6. Factors Affecting Win32 Application Performance

When using the Windows Client Feature, there are several factors that should be taken into account by the system administrator to maximize the performance of Win32 applications. The administrator should consider the following:

- Applications run locally on the client, not on the server, so their performance depends in large part on the processing speed of the client system
- Application files are split between the client and the server, so the application performance also depends on the nature of the applications themselves
  - ◆ “Well-behaved” applications have most of their files reside on the server, so their performance depends on
    - ✓ Processing speed of the client (for application execution)
    - ✓ Speed of the server, server load, and file system on the server (for file accesses)
    - ✓ Available network bandwidth
  - ◆ “Ill-behaved” applications have most of their files reside locally on the client, so they have more deterministic performance which primarily depends on the speed of the client system, not on the server and the network, but at the additional costs of disk space on the client and installation time.

## 4. Performance Recommendations

Based on the performance data analysis in Section 3, the system administrator should follow the following recommendations to get the maximum performance and effectiveness when using the Windows Client Feature:

- Since the operational boot performance is very quick and deterministic, the system administrator should be discouraged from changing the client install images too often. A client must go through the relatively long installation boot sequence to get a new client install image.
- Even with no other network traffic and only one client, at least 22% of the installation boot time is spent in copying files from the WSOD 2.0 server to the client. During this file copying, the 16-Mbps Token Ring has a utilization of about 40%. Consequently, more clients doing installation boots simultaneously will quickly saturate the network, so the system administrator may want to stagger the start of the installation boots on the clients, so as to minimize the impact of these boots on the network traffic.
- Installation boots should be performed in off-peak hours, such as at night.
- The user is free to reboot his client system at any time because these operational boots do not consume much network bandwidth.
- To enhance the log-on performance, the system administrator should refrain from adding and/or deleting user access to applications frequently. Every time the administrator assigns a new application to (or removes one from) a user, that user's next log-on will be longer.
- Since Win32 applications run locally on the client, the client should have adequate processing power to run applications. Servers are used primarily as file servers by the applications, so the server's file system performance is also important.
- As with other server-managed network computing environments, the network bandwidth is the key performance factor.

## 5. Additional Information Sources

For more information on the Windows Client Feature, the reader is referred to the following documentation:

- "WorkSpace On-Demand 2.0 Feature for Windows Clients" (the *Red Book*) from the International Technical Support Organization, July 1999.
- "WorkSpace On-Demand 2.0 Feature for Windows Clients Administrator's Guide" that is shipped with the product.

Additional documentation and technical guidance can also be provided by the IBM Network Computing Software Division's Rapid Deployment Team.

More information on the WorkSpace On-Demand products is also available on the Internet at <http://www.software.ibm.com/network/workspace>.

## **6. Disclaimer**

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