



WHITE PAPER

What is PXE?

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This white paper answers common questions regarding Preboot Execution Environment (PXE) and outlines the benefits today's networked organizations can expect to gain from it.

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What Is PXE?

Almost every corporate PC purchased since 1998 is "Wired for Management" (WfM) compliant. WfM is an industry standard, initiated by Intel to improve the manageability of client PC systems, and is part of the Intel and Microsoft PC98 specification. The Preboot Execution Environment (PXE) is part of the WfM specification. What exactly is PXE? How does it help reduce cost of ownership and simplify client PC management?

PXE is an open industry standard developed by a number of software and hardware vendors. It was initially designed by Intel, with input from several other vendors including 3Com, HP, Dell, Compaq, and Phoenix Technologies. PXE works with a network interface card (NIC) in the PC, and makes the NIC a boot device. The PXE vision is to "Make the network interface a standard, industry-accepted PC boot device."¹ This means adding the NIC to the traditional list of standard boot devices, such as floppy drives, hard disks, and CD-ROMs, that load the operating system or set up programs on the PC. It allows the client PC to "network boot." Booting from the network opens up a vast array of management and support features.

PXE boots the client PC from the network by transferring a "boot image file" from a server. This file can be the operating system for the client PC or a pre-OS agent (see the section, "Pre-OS," later in this paper) that performs client management tasks. Since PXE is not operating system-specific, the image file can load any OS. It provides support for network

booting, of embedded and other operating systems.

Because PXE works with the NIC, it requires a PXE-enabled NIC. Most currently available NICs do support PXE, including those from 3Com, Intel, Digital, RealTek, and SMC. PXE is available either as a boot ROM chip that you add to the NIC, or as part of the system BIOS if the network interface is on the motherboard. PXE is specific to a type of NIC; a boot ROM for one type (for example, a 3C905C) will not work on another type of NIC.

PXE Versions

There have been two versions of PXE, the older 0.9x, and the current 2.00. (There never was an official version 1, although sometimes the 0.9x version is referred to as version 1). The WfM version 1.0 specification released in 1997 contained PXE version 0.9x. Version 2.0 of the specification, released in 1999, contained PXE 2.0. The last release of 0.99 was build n. As of March, 2001, the current release of 2.00 is build 82.

3Com's PXE-enabled boot ROM is called Managed PC Boot Agent (MBA). In addition to PXE, MBA also supports legacy network boot protocols, RPL and NetWare. MBA also adds some value-add features when PXE is being used.

3Com offers a disk-based version of PXE as well. This is mainly used in situations where the client PC or the NIC does not have PXE. Except for the fact that it's a bootable floppy or CD, this version works just like the boot ROM (however, some

¹ Intel PXE presentation, April 1998 (<http://download.intel.com/ial/wfrm/pxe.pdf>)

configurable options are not available). There are several advantages to using the disk, even when PXE is currently installed in the system:

- It supports additional network adapters not supported by a boot ROM, like the legacy 3C509 ISA NIC, the 3CXFEM656C LAN CardBus PC Cards, and the 3C460x USB Ethernet adapter
- It supports the 3Com 3CCFE575CT LAN CardBus PC Card in notebooks that have BIOSs that don't enable the CardBus. (Some PC BIOSs do not enable the CardBus until the OS is loaded, which prevents the PC Card from being accessible in a pre-OS environment.)
- It supports network booting of notebook clients (via the CardBus or USB Ethernet adapter).
- Because the single disk supports most 3Com NICs, you don't need a different disk for client PCs that have a variety of 3Com NICs.
- It overcomes the problem of switching to a newer PXE version when the boot ROM isn't easily updated (as in the case where the PXE is integrated into the PC's BIOS).
- There's no need to change NIC or BIOS settings to perform a network boot.

You can download 3Com's MBA on disk free of charge from 3Com's Web site: <http://www.3com.com/managedpc>.

Configuring PCs for Network Boot

A client PC may have PXE installed, but it may not be enabled by the BIOS. Most PCs support the BIOS Boot Specification (BBS), or other methods that let you order the PC's boot devices from a BIOS setup screen. To perform a network boot each time the PC is powered on, select PXE as the first boot device. Some BBS systems also support Network Service Boot (NSB). With NSB, you can set PXE lower in the boot order. A message, such as "Press F12 to boot from network" will appear while the PC boots. In this

way, you can use PXE only when then need arises. If the PC doesn't allow ordering of the boot devices, there is usually a method within PXE to switch between local and network booting. With a 3Com Managed PC Boot Agent boot ROM, you can set the default boot method in the built-in configuration screen or by using a configuration utility.

Advantages of Booting from the Network

Booting from the network is not a new concept. There have been several other methods: Novell has offered remote booting and IBM has supported RPL, both since the mid 1980s. In the past, network booting was largely limited to diskless devices such as thin clients and dedicated systems. However, that's no longer the case. PXE has standardized the process. Now software and hardware vendors can all support the same architecture, offering a wider range of applications.

There are several advantages and uses for network booting:

- Booting diskless systems such as thin clients and dedicated systems
- Deploying software and OS for new systems
- Automating system maintenance such as backups
- Automating system checking such as virus scanning
- Ensuring security where a guaranteed secure system is needed

The two main uses of network booting today are for installing an OS in a brand new client PC that has no operating system, (or re-installing in a client PC where the operating system has failed), and booting into a guaranteed "clean" system.

By booting a brand new system or a defective-OS system from the network, you can install a new OS and/or applications without visiting each client PC with a stack of installation CDs. Setting up a new

BIOS Basic Input/Output System

DHCP Dynamic Host Configuration Protocol

DOS Disk Operating System

FTP File Transfer Protocol

IPX Internet Packet Exchange

NCP NetWare Core Protocol

NIC Network Interface Card

OS Operating System

POST Power-On Self-Test

PXE Preboot Execution Environment

ROM Read-Only Memory

RWU Remote Wake Up

TCO Total Cost of Ownership

TCP/IP Transmission Control Protocol/Internet Protocol

TFTP Trivial File Transfer Protocol

client PC is as simple as connecting it to the network and powering it on. You can setup your servers to automatically detect the new clients and start installing the new software. This can dramatically reduce administration time.

The administrator no longer has to physically visit to reinstall the software when a user's computer crashes. A network boot does the re-install. It may now be more efficient to simply reinstall all the user's software than to try to determine the problem with the existing installation.

When you boot from the network, you get a guaranteed "clean" boot, with no boot-time viruses or user-modified files. The system boot files are stored on the server where they are protected from infection. You can also use the network boot to scan for viruses, ensuring that the local hard drive is clean before you boot from it. This is called a pre-OS boot.

Products that Use PXE

Several vendors currently support PXE in their client management products. Some current products include:

- 3Com Virtual LAN Drive
- Symantec Ghost
- Microsoft Remote Installation Services (RIS)
- On Technologies ON Command CCM
- Altiris Express
- HP OpenView
- IBM LANClient Control Manager (LCCM)

In addition to these products, software tools are available to help administrators setup their own network-booting environment.

These include:

- 3Com Boot Services
- Rembo Technologies Rembo
- bootix Technology BootManage

These tools include the PXE server side components and utilities to build boot image files. They enable administrators to set up a network booting environment to perform specific client management tasks using off-the-shelf utilities.

3Com has a series of papers on using Boot Services for OS deployment and client management. See the Boot Services URL at the end of this paper.

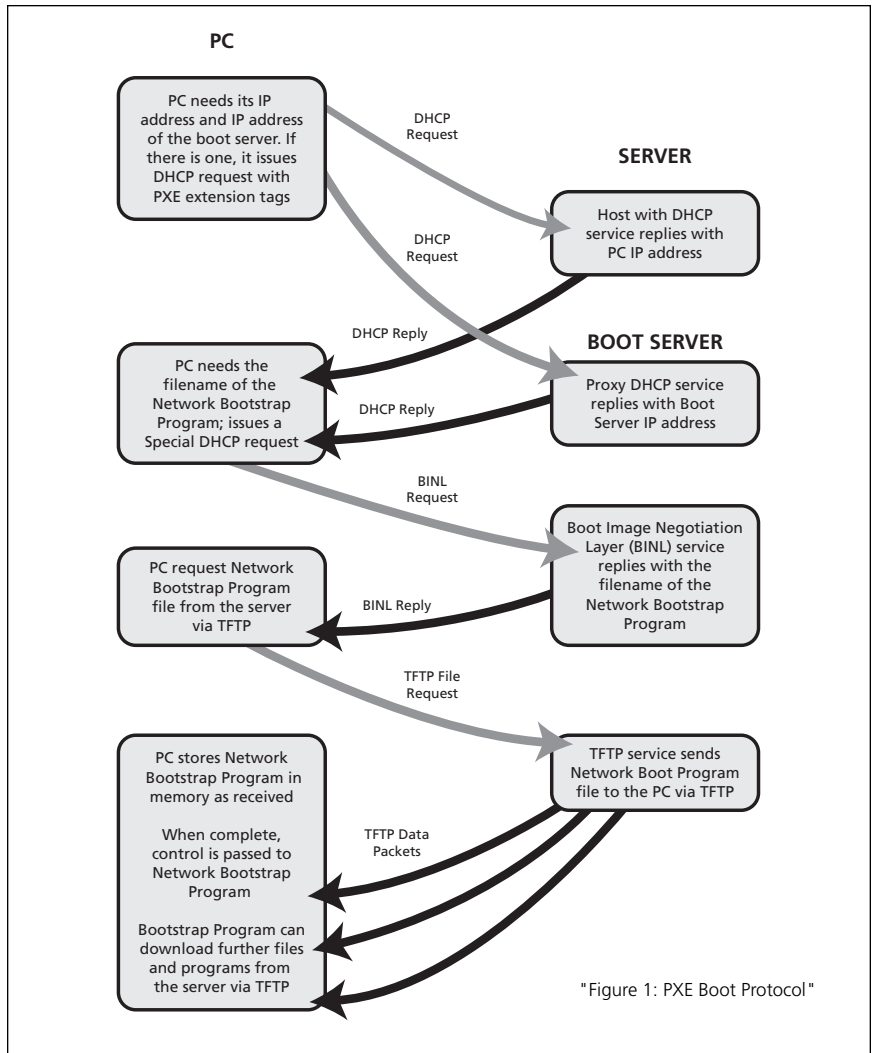
How Does PXE Work?

In addition to PXE on the client PC, there are several PXE server components designed to work in conjunction with a Dynamic Host Configuration Protocol (DHCP) server. The network must include a PXE server. The PXE server can be on the same server as DHCP or on a different server, so you can add PXE to an existing network without affecting the existing DHCP server or configuration. The PXE server watches for DHCP discovery requests that include a special tag identifying the client as a PXE client. If the discovery request includes the tag, the PXE server replies to the client with configuration information, including the name of a boot image file. The boot image file is transferred to the client using TFTP, and this file is then used to boot the client.

Wired for Management includes other features that can be used with PXE. One that's very useful is Remote Wake Up, which can remotely power on a client PC. The client can be powered on, managed, and shut down, all from the administrator's desk. Updates can be scheduled to occur overnight, while the network is idle, avoiding user interruptions during the day.

For security, PXE can use Boot Integrity Services (BIS), which is also part of the WfM 2.0 specification. Using digital signatures and public key cryptography, BIS allows the PXE client to validate the image it received and confirm that the image was from a secure and trusted source. This

For more information on 3Com Boot Services, visit: www.3com.com/bootservices



prevents clients booting from a rogue server that might damage or infect a client PC.

For a system to use BIS, it must have a BIS-enabled BIOS. When the system administrator first configures the client PC, they record a public key in the system's non-volatile memory storage. The server software must also support BIS to create the digital signatures it uses to validate the server. When PXE boots a client PC, it checks to see if the BIOS supports BIS. If it does, it then uses BIS to validate the information from the server. BIS only validates the server; it does not encrypt the boot image file.

Pre-OS

PXE can do more than load the operating system or install a new system. It can also be used in a "pre-

OS' environment. Pre-OS is the process of loading a small operating environment to perform a client management task before loading the final operating system from the local hard drive. For example, with pre-OS you can scan the hard drive for viruses. This guarantees that the client is not infected before it starts. For more information on pre-OS see the 3Com paper: *"The When, What, Why, and How of Pre-OS"*.

More Than Just Network Booting

PXE includes an entire application-programming interface (API). The API offers several levels of protocol support: User Datagram Protocol (UDP), TFTP, and Universal Network Device Interface (UNDI). UDP and TFTP are the standard IP protocol layers. UNDI is the hardware dependent, low level interface that

actually communicates with the NIC. Software vendors can use these APIs without their software needing to know what NIC is actually in the system. There is also a Universal NDIS driver (NDIS 2) available that uses PXE, eliminating the need for NIC-specific drivers.

access configuration information and additional files. This makes the client agents and utilities NIC independent, so the software can be used on a wider range of clients. Without PXE in the system, the agents would need different network drivers for each NIC supported.

Most client management products use the API to communicate with management software on the server to

Conclusion

By letting network administrators manage and configure client PCs over the network, PXE can help reduce the cost of ownership and simplify client management. Administrators no longer need to visit clients to install a new operating system or update an existing system. The client can boot from the network and have the new software installed, regardless of the condition of the local hard drive. Also, booting from the network guarantees that the client boots from a clean, uninfected system, so local media can be checked before startup. Several client management products use these features to reduce the cost and complexity of supporting client PCs

For More Information

Wired for Management Baseline Specifications (including PXE and BIS):
<http://developer.intel.com/ial/wfm/wfmspecs.htm>

The PXE Product Development Kit (PDK) from Intel (for information on developing tools for PXE):
<http://www.intel.com/ial/wfm/tools/pxe/index.htm>

The PXE Software Development Kit (SDK) for Linux:
<http://developer.intel.com/ial/wfm/tools/pxesdk20linux/index.htm>

3Com Managed PC Boot Agent:
<http://www.3com.com/managedpc>

3Com Boot Services:
<http://www.3com.com/bootservices>

3Com White Paper, The When, What, Why, and How of Pre-OS:
<http://www.3com.com/bootservices>

About 3Com Corporation

3Com simplifies how people connect to information and services through easy-to-use connectivity products and solutions for consumers and commercial organizations. The company also provides access infrastructures and IP services platforms for network service providers.

For further information, visit: www.3com.com or the press site at www.3com.com/pressbox.

About Lanworks Technologies Company, a subsidiary of 3Com Corporation

With over 16 years of experience, Lanworks is the leading supplier of network boot firmware to OEM manufacturers worldwide. Lanworks products are included in a wide range of connected devices, including network interface cards, embedded PCs, point-of-sale systems, factory floor equipment and, data acquisition tools. The company's services include flexible licensing options, quick turnaround, in-house lab and production facilities, customized design, and dedicated OEM support team.

For further information, visit www.Lanworks.com



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