HP Industry Standard Servers

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Technology Brief TC030615TB

Implementing Rapid Deployment Pack and PXE in an enterprise network environment

Table of contents

Abstract

The purpose of this document is to explain the prerequisites and methods for implementing Pre-Boot Execution Environment (PXE)[1] in a network environment.

Introduction

The HP ProLiant Essentials Rapid Deployment Pack was developed to automate repetitive tasks such as configuring and deploying servers. The Rapid Deployment Pack combines two powerful products: the Altiris eXpress Deployment Solution and the ProLiant Integration Module. The Altiris eXpress Deployment Solution utilizes PXE (pronounced "pixie") technology to provide complete hands off deployment of servers using a network boot process.

This paper provides an overview of PXE technology, describes the components in the Altiris eXpress Deployment Solution, and describes scenarios for implementing PXE. This paper assumes that readers have a basic understanding of networking terminology.

PXE technology overview

PXE provides a common set of pre-boot services that allow one or more PXE-enabled clients (PXE clients) on a heterogeneous network to acquire an IP address from a Dynamic Host Configuration Protocol (DHCP)[2] server and then download a boot image from a PXE boot server.

DHCP is an extension of the bootstrap protocol BOOTP. The DHCP server maintains a scope (a pool of IP addresses) for each subnet and dynamically assigns an IP address to each PXE client based on the subnet in which it boots. The PXE boot server maintains a set of boot images, also known as network bootstrap program (NBP) images. The PXE client uses the Trivial File Transfer Protocol (TFTP)[3] to download the boot image from the PXE server and then it executes that image, much like booting from a diskette.

The boot image usually uses the Universal Network Device Interface (UNDI) provided by the resident PXE client firmware to access the network. UNDI allows one boot image to work with a variety of different PXE-capable NICs because the specifics for each NIC are handled by the PXE client firmware.

Note: A driver that uses UNDI (UNDI Driver) is strongly recommended in the boot image. It is possible to use a NIC-specific NDIS2 driver instead of the UNDI driver; however, its use will cause the boot image to only work on computers whose NIC is supported by that driver.

Newer ProLiant servers have PXE support in their embedded NICs, while older servers support PXE through the addition of a stand-up NIC. Refer to the *HP ProLiant Essentials Rapid Deployment Pack Support Matrix* at www.hp.com for full details.

How PXE works

PXE can be implemented in an enterprise environment in three basic scenarios. These scenarios are based on the physical locations of the DHCP service, the PXE boot service, and the PXE clients as follows:

- The DHCP and PXE (boot) services are provided by different servers and are on the same subnet as the PXE client.
- The DHCP and PXE (boot) services are provided by a single server and are on the same subnet as the PXE client.
- The DHCP and PXE (boot) services are provided on a different subnet than the PXE clients.

Note: The terms “service” and “server” are used interchangeably depending on whether DHCP and PXE are located on the same server or on different servers, respectively.

[1] PXE is a component of the Intel Wired for Management (WfM) specification.
[2] DHCP is defined by RFC 1531, 2131.
[3] Trivial File Transfer Protocol (TFTP, Revision 2) to support NBP download is specified by IETF RFC 1350.

The first scenario is a typical environment where the DHCP service and PXE boot service are provided by different servers and are on the same subnet as the PXE clients (Figure 1).

Figure 1. DHCP and PXE boot services provided by different servers on the same subnet as the PXE clients

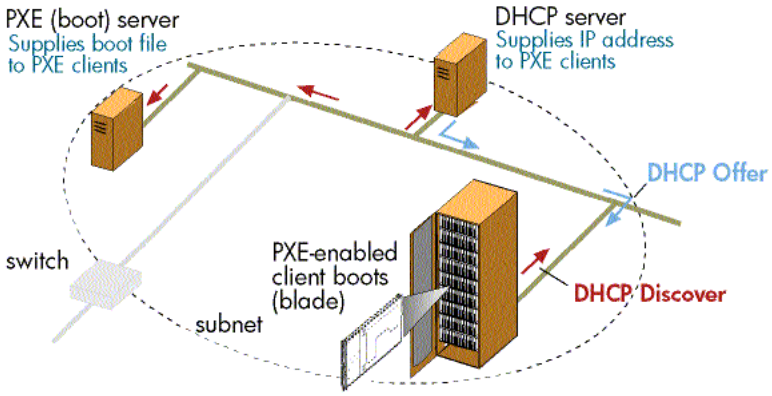
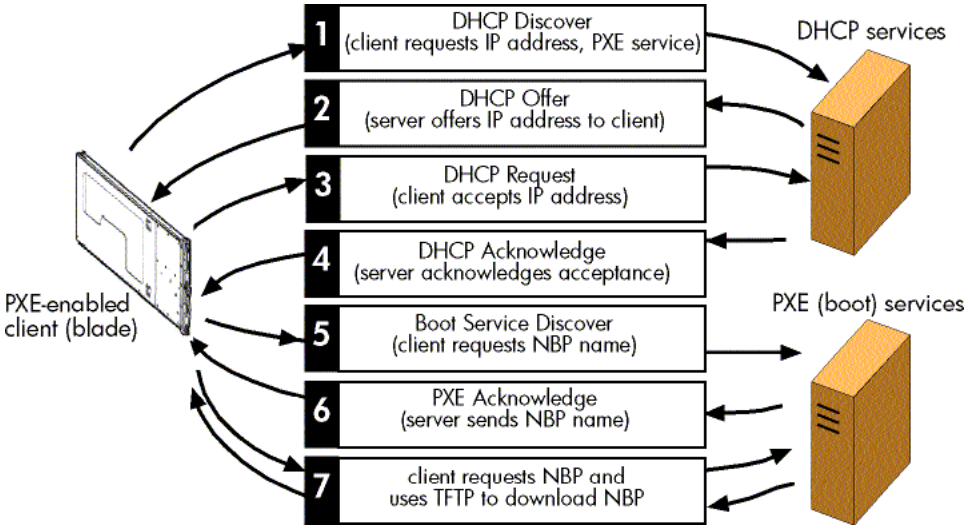


Figure 2 illustrates the PXE client's transactions with the DHCP and PXE boot servers during the network boot process. First, the PXE client broadcasts a DHCP Discover message to locate a DHCP server (1). The DHCP server responds by sending the client a DHCP Offer containing an IP address from its scope (2). The client sends a DHCP Request back to the DHCP server to accept the IP address that was offered (3). The DHCP server sends a DHCP Acknowledgement to acknowledge the client's DHCP Request (4).

After the client has an IP address, it sends out a Boot Service Discover to locate a PXE boot server (5). The PXE boot server sends the client its IP address and the name of a network bootstrap program (NBP) image to download (6). The PXE client downloads and executes the boot image using TFTP (7).

Note: For server deployment, the PXE client is usually assigned a static IP address later in the deployment process.

Figure 2. PXE boot process



The second scenario is a simple environment where the DHCP service and PXE boot service are provided by a single server and are on the same subnet as the PXE clients (Figure 3). This scenario is typical of labs, isolated networks or loading areas.

Figure 3. DHCP and PXE boot services provided by a single server and are on the same subnet as the PXE clients.

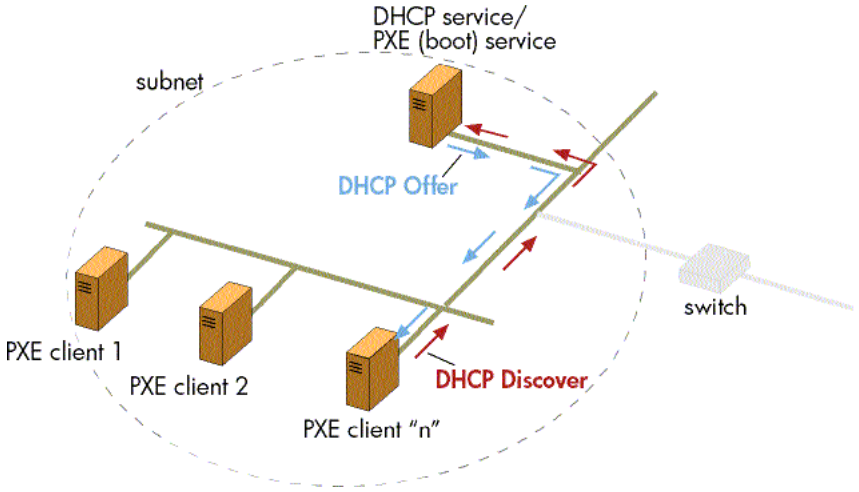
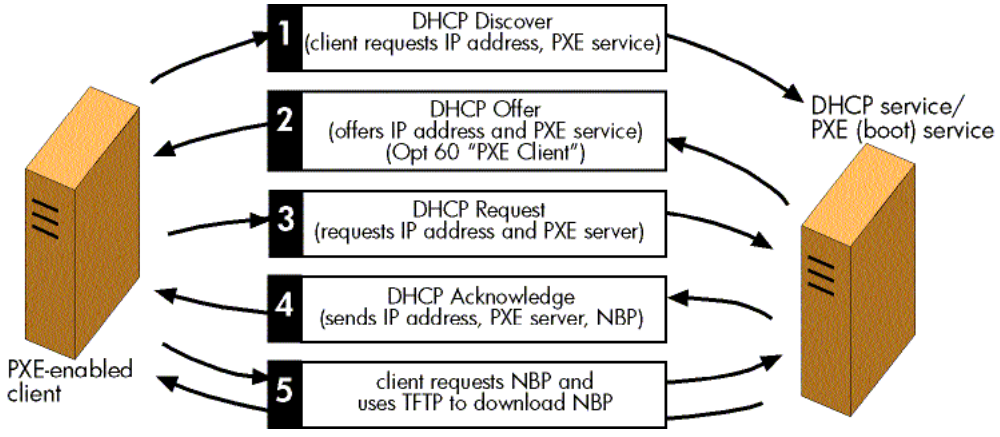


Figure 4 illustrates the PXE client's transactions with the DHCP and PXE boot services during the network boot process when the PXE boot service and DHCP service are located on the same server. This situation is known as Boot Information Negotiation Layer (BINL) proxy mode. First, the PXE client broadcasts a DHCP Discover message to locate a DHCP service (1). The DHCP service responds by sending the client a DHCP Offer containing an IP address from its scope and the name of the PXE boot service, which is on the same server (2). The DHCP service accomplishes this by having DHCP option 60 "PXE client" present in its scope to notify the client to make a BINL request to the same server to retrieve boot information. The client sends a DHCP Request back to the DHCP service to accept the IP address that was offered (3). The DHCP service sends a DHCP Acknowledgement containing the client's IP address, PXE service IP address, and the name of the boot image to download (4). The PXE client downloads and executes the boot image using TFTP (5).

Figure 4. PXE boot process in BINL proxy mode



The third scenario is an enterprise environment where the DHCP and PXE boot services are provided on a different subnet than the PXE clients.

When a PXE client attempts a network boot, it broadcasts a DHCP Discover message to search for a DHCP service. However, switches are intended to constrain broadcast traffic to certain subnets so, by default, they do not forward these DHCP messages.

To forward DHCP requests and responses between the PXE client and a DHCP service on another subnet, customers must use a "DHCP relay agent." A computer (Proxy DHCP server), or a switch (configured to forward requests and responses) can act as a DHCP relay agent. The installation of DHCP relay agents allows the use of one centralized DHCP service for a large network.

Figure 5 illustrates how a Proxy DHCP server can be used to forward requests and responses between the PXE clients and the DHCP and PXE boot services. A Proxy DHCP server is required in each subnet. If the DHCP and PXE boot services are running on different servers, then the Proxy DHCP server must be configured to forward all requests to both servers.

Proxy DHCP server software can be obtained for both Windows and Linux. For Windows, Microsoft provides the Microsoft DHCP Relay Agent. For Linux, the Internet Software Consortium provides the Internet Software Consortium DHCP Relay Agent.

Figure 5. Representation of DHCP and PXE boot services provided on a different subnet than the PXE clients and using a Proxy DHCP Server for forwarding messages.

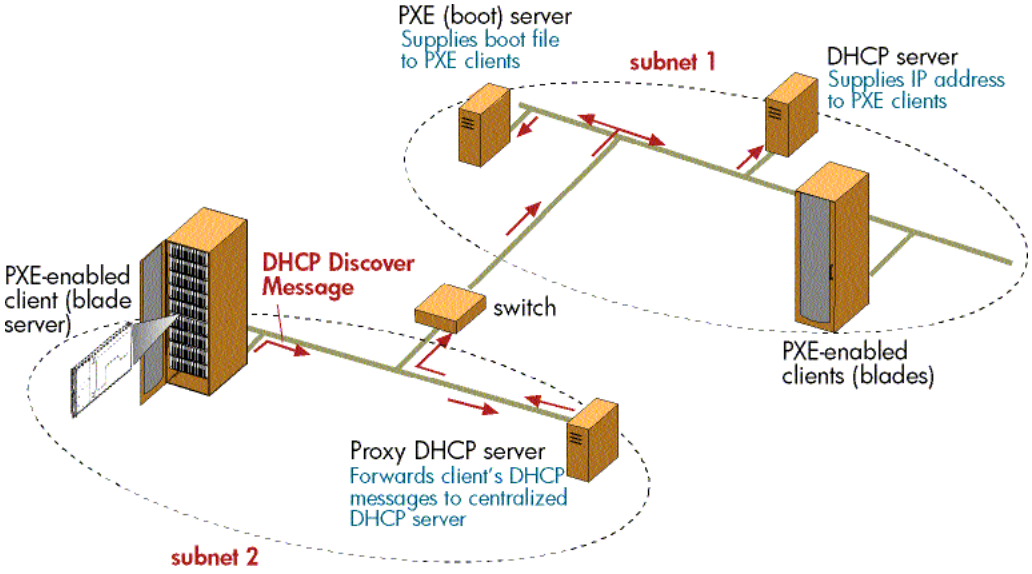
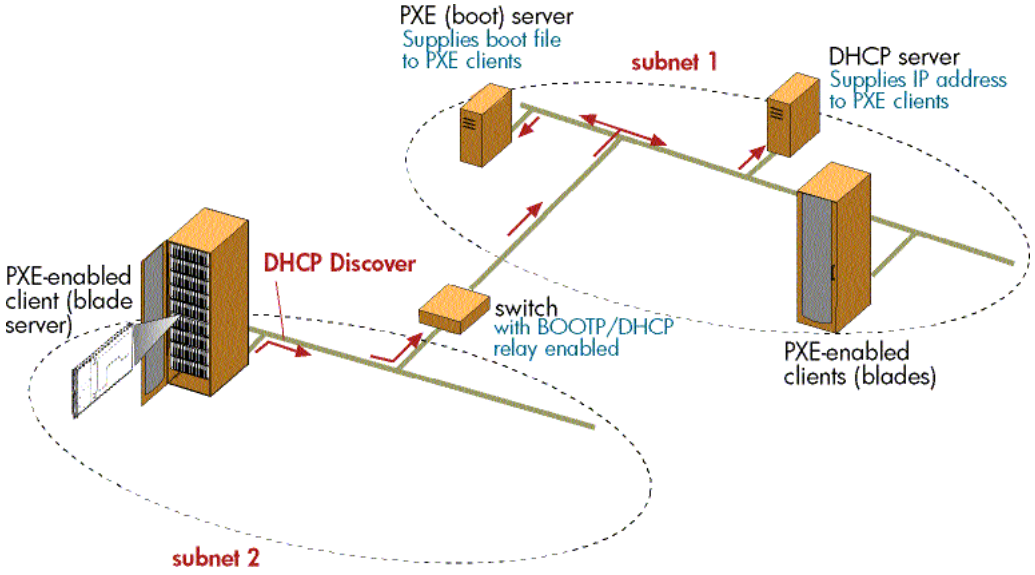


Figure 6 illustrates the use of a switch to forward requests and responses between the PXE clients and the DHCP and PXE boot services. The switch must be configured to forward messages to the IP address of the DHCP server. For Cisco switches, this is accomplished by using the "IP-helper address" command. If the DHCP and PXE boot services are running on different servers, the switch must be configured to forward all requests to both of them. This option is preferred because no additional software needs to be running in each subnet.

Figure 6. Representation of DHCP and PXE boot services provided on a different subnet than the PXE clients and using a switch for forwarding messages.



Altiris eXpress Deployment Solution

The Altiris eXpress Deployment Solution server and client software components are described below.

Server components

The Altiris eXpress Deployment Solution server components include the following software:

- Deployment Server
- Deployment Server Database (Microsoft SQL or MSDE)
- Deployment Server Console
- Deployment Server Client Access Point
- Altiris eXpress PXE Server

Deployment Server

The Deployment Server controls the flow of the work and information between the managed servers and the other management components. The managed servers connect and communicate with the Deployment Server to register their information. This information is stored in the Deployment Server Database.

Deployment Server Database

The Deployment Server Database maintains all of the information about the managed servers such as hardware information, serial numbers, computer names, MAC and TCP/IP addresses, deployment history, and device and service information. The Database can be Microsoft SQL Server 7 (or higher) or Microsoft Data Engine (MSDE).

Deployment Server Console

The Deployment Server Console is a drag and drop graphical user interface (GUI) application that provides the main point of control over all of the other components. The Console application is used to manage the deployment process, including creating tasks and jobs, assigning jobs to computers, and scheduling jobs. The Console application can exist on its own server.

Deployment Server Client Access Point

The Client Access Point is a file share where the Deployment Server program files are installed and the image files, script files, and other deployment packages are stored. This server must have enough disk space to hold all of the images that will be deployed.

Altiris eXpress PXE server

The Altiris eXpress PXE Server provides PXE clients with a boot image. Altiris uses Windows 9x DOS as the basis for its images. There are two boot images:

- The "New Computer" image is given to a PXE client that is not listed in the Altiris Deployment Solution Database. This image runs the BootWorks program to discover information about the client, and places that information into the Database. The client is displayed in the New Computers group of the Deployment Server Console and, by default, waits for an operator to initiate deployment.
- The “Managed Computer” image is used for a PXE client that is listed in the Database and has been assigned a task to perform, or has a pending operation that requires booting to DOS.

By default, the Altiris eXpress PXE server uses Multicast TFTP (MTFTP) to send a PXE boot image to multiple clients at the same time. Multicasting is different from broadcasting. Multicasting refers to sending a message to a select group of clients whereas broadcasting refers to sending a message to every client connected to a network. Multicasting allows IP data to be sent to a virtual group of clients using a single IP destination address. Some network environments do not support multicasting. For example, many switches are configured to not allow multicast packets. In this case, PXE must be configured to use TFTP to send the boot image to each PXE client individually.

Note: Multicasting PXE boot images only saves network bandwidth when booting many PXE clients simultaneously.

Client components

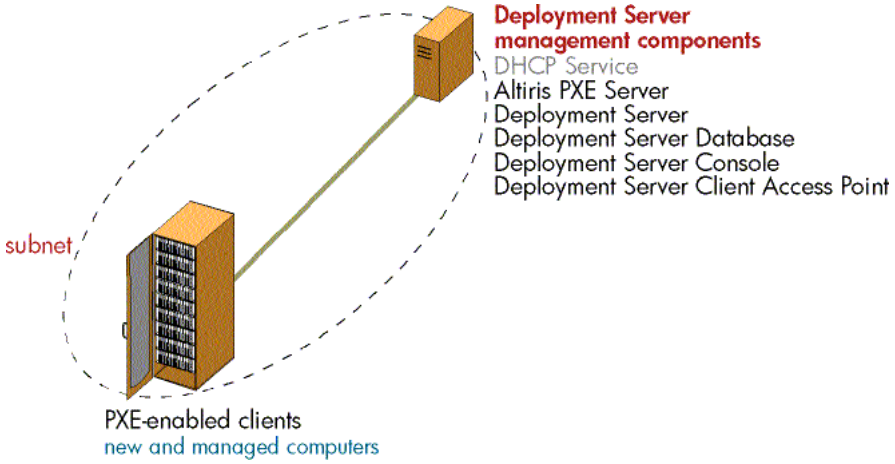
The eXpress Deployment Solution has three client programs: the Deployment Agent for Windows, the Deployment Agent for Linux, and the Deployment Agent for DOS (formerly known as BootWorks). The Deployment Agents for Windows and Linux enable servers to be managed by the Deployment Server. The Deployment Agent for DOS allows DOS-based scripting and applications, such as disk imaging, to be performed on a server.

Installation

For a simple deployment infrastructure, the Deployment Server, Deployment Server Database, Deployment Server Console, Deployment Server Client Access Point, and Altiris eXpress PXE server can be installed on the same server as the DHCP service (Figure 7). When installing the Altiris PXE server on the same machine as the Microsoft DHCP service, Altiris will automatically configure the Option 60 setting in the DHCP options, as this setting is required when PXE and DHCP reside on the same server.

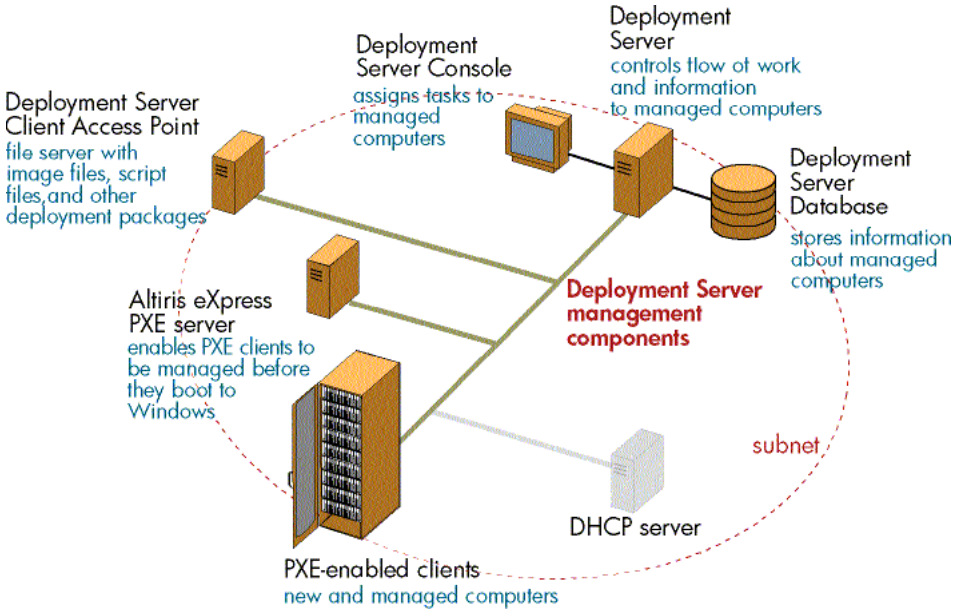
Note: A simple install may also be used when the DHCP service is running on a different server.

Figure 7. Altiris eXpress Deployment Solution simple install



For a flexible and scalable deployment infrastructure, some or all of the Altiris eXpress Deployment Solution server components can be installed onto separate, distributed servers (Figure 8).

Figure 8. Custom install of Altiris eXpress Deployment Solution



Network design examples

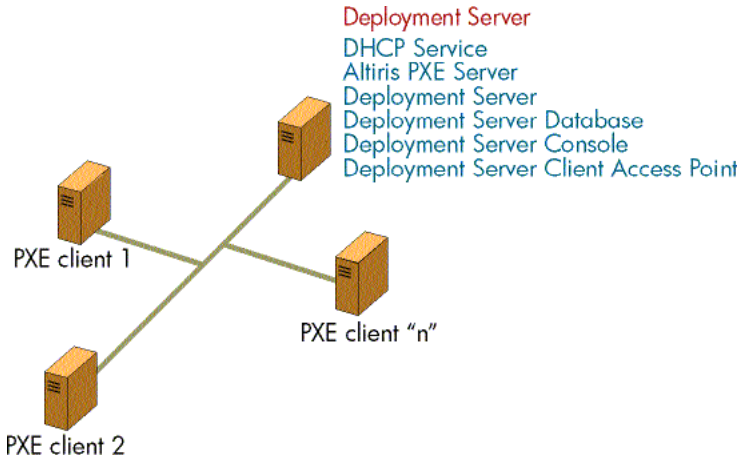
This section examines methods to implement Rapid Deployment Pack with PXE in various enterprise network environments. The following examples are considered:

- Simple networks
- Enterprise networks
- Virtual LAN-based networks (VLANs)
- Geographically dispersed networks (WANs)

Simple networks

Figure 9 illustrates how to incorporate the Rapid Deployment Pack into a simple, isolated network environment such as a lab, test bed, or loading area. To manage the PXE clients on the network, a single Deployment Server is added that contains the DHCP service and the Altiris eXpress Deployment Solution server components.

Figure 9. Simple network



Enterprise networks

This example illustrates how to incorporate the Rapid Deployment Pack into a network with multiple subnets. To manage the PXE clients on the entire network, a centralized DHCP server and a centralized Deployment Server are added to one of the subnets. A DHCP relay agent is added in each of the other subnets. This configuration has the benefit of eliminating the need for DHCP and PXE boot services on each subnet and reducing the labor required to set up and maintain multiple PXE servers. Figure 10 illustrates an enterprise network where each switch in the network is configured as DHCP relay agent.

Figure 10. Enterprise network with a centralized DHCP server, a centralized Deployment Server, and a switch for forwarding messages

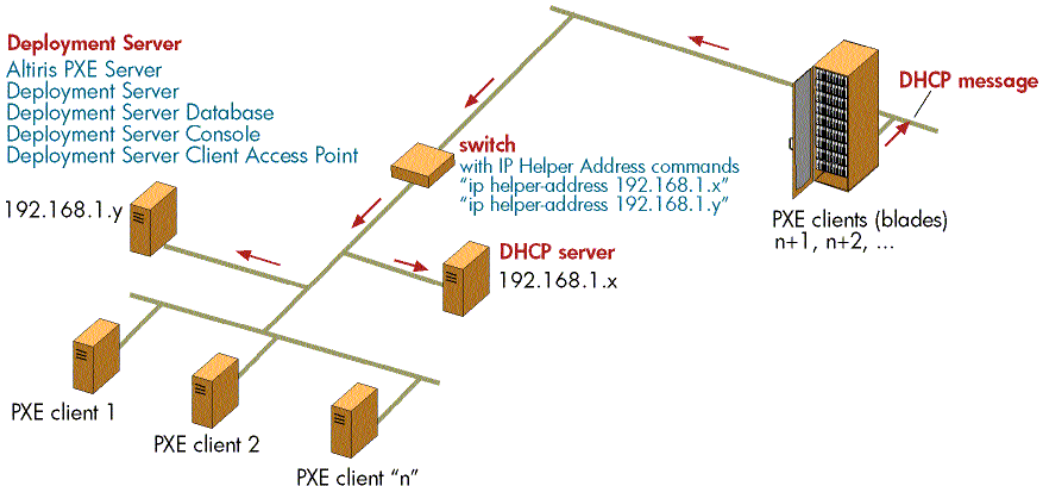
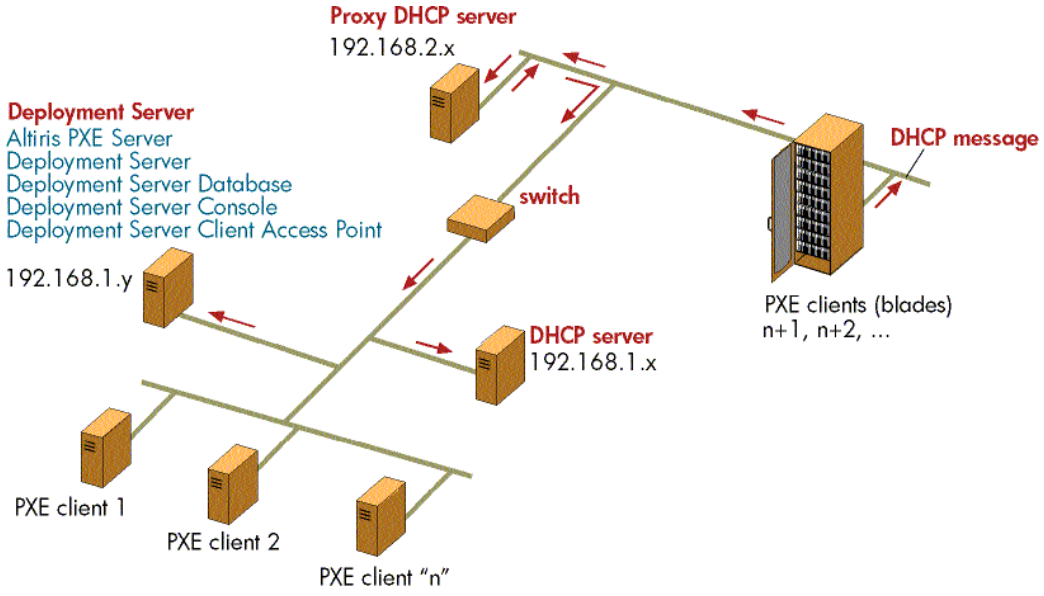


Figure 11 illustrates an enterprise network where a Proxy DHCP server is installed in each subnet.

Figure 11. Enterprise network with a centralized DHCP server, a centralized Deployment Server, and a Proxy DHCP server for forwarding messages



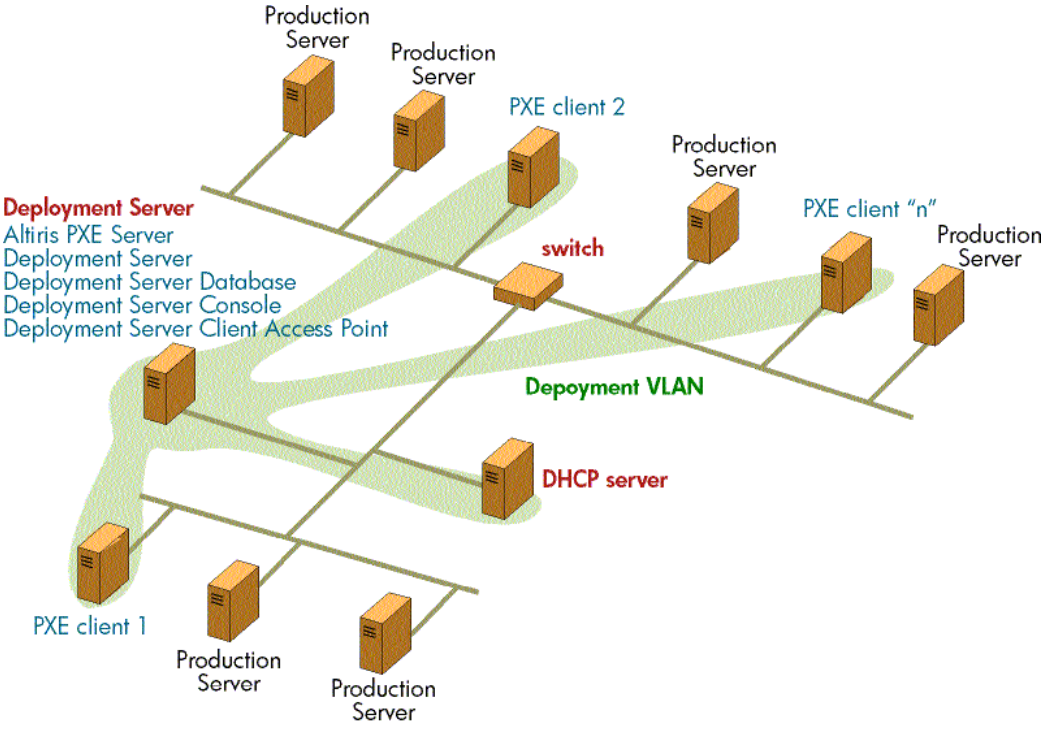
Virtual LANs

Figure 12 illustrates how to incorporate the Rapid Deployment Pack into a Virtual LAN (VLAN) network. The configuration of the deployment server in this example is very similar to the previous example. The difference is that the DHCP server and Deployment Server are placed into a "deployment" VLAN. When a PXE client needs to be deployed, it is placed into the deployment VLAN. Upon completion of the deployment operation, the PXE client is placed back into the appropriate "production" VLAN.

This process requires no special configuration of the Rapid Deployment Pack software. The benefit of a deployment VLAN is that it isolates all DHCP, PXE, and deployment traffic from the production network.

Note that DHCP Relay agents are not required because all DHCP messages are broadcast across the deployment VLAN. If desired, the DHCP service can also be installed on the Deployment Server to further simplify the configuration.

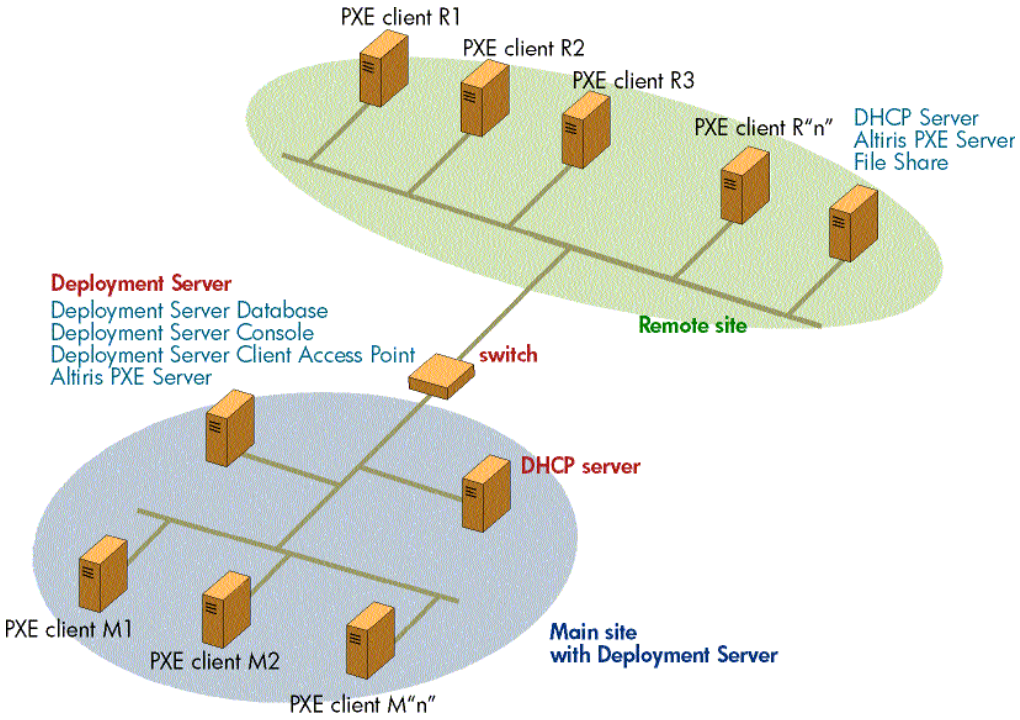
Figure 12. Deployment VLAN



WANs

Figure 13 illustrates how to incorporate the Rapid Deployment Pack into a geographically dispersed network. To manage the PXE clients across all sites, a centralized Deployment Server is added at a main site and a DHCP server, PXE boot server, and file share are added at each remote site. The benefits of this configuration are that it significantly reduces the network traffic across the WAN links, centralizes control of the deployment process, and provides a high level of scalability.

Figure 13. WAN with centralized Deployment Server and distributed DHCP server, PXE server, and file share



The steps to create this configuration are as follows:

1. At the main site, install a DHCP server and a Deployment Server.
2. At each remote site, install a DHCP server, the Altiris PXE server, and a Windows file share. The Windows file share should be shared as "eXpress" and the permissions should be set for "Everyone" with Full Control.
3. At the main site and each remote site, recreate the two default PXE boot images in order to add an additional file mapping. For the main site, map "G:" to the same location as "F:". For each remote site, map "G:" to the local file share. This is done on the Network Drive Mappings page of the Altiris Boot Disk Creator wizard.
4. At the main site, in the Altiris Configuration Utility, on the Drive Mapping tab, create an additional drive mapping. Map "G:" to the same location as "F:".
5. At the main site, in the Deployment Server Console, modify the jobs to use the local file share.
   a. For the supplied scripted install jobs, in the tasks and associated batch files, replace all references to "F:" with "G:".
   b. For the supplied image capture and deployment jobs, in the Create and Deploy Image tasks, check the "Local image store" option and then browse to the desired image file on "G:".

Note: Upgrading to a new version of the Rapid Deployment Pack will overwrite the batch files and possibly the jobs. Be sure to back up your files before upgrading.

6. From the main site, copy the ".\images" and ".\deploy" directories from the Deployment Server Client Access Point to each remote site's file share.
7. Be sure to keep the remote file shares in sync with the main site.

Troubleshooting

For troubleshooting information, please refer to the HP ProLiant Essentials Rapid Deployment Pack User Guide.

Conclusion

PXE is an industry-standard network protocol designed to simplify systems management. It provides automated network boot capability from system and NIC option ROMs in the server. This automated network boot allows systems to be deployed and updated from a centralized Rapid Deployment Pack installation.

Although the Rapid Deployment Pack does not require the use of PXE technology, PXE offers tangible benefits by providing a highly stable and reliable environment in which to boot an automated server deployment process. These benefits include a more efficient use of IT resources, improved system stability, decreased server recovery time, and the ability to redefine the function of the servers at a moment's notice.

For more information

Visit the HP Windows 2000 website at www.hp.com/partners/microsoft/ for the latest information about HP products, options, customer support, and documentation regarding Microsoft Windows 2000 products.

Feedback

To help us better understand and meet your needs for ISS technology information, please evaluate this paper by completing the short survey at http://www.zoomerang.com/survey.zgi?RLMHCG99TGCNQM3Q19P5RY9B.

Note: This URL will be active through 31 August 2003. Please send questions and further comments about this paper to: TechCom@hp.com.

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