

Inside NetBooting

About NetBoot Software

NetBoot is a suite of software that supports these features:

- Single point of administration-- As all computers that start up from a NetBoot server use the same client Mac OS image, you need only to manage this single image.
- Personal desktop--Users can log in to any computer connected to a NetBoot server and obtain their personalized Macintosh user experience.
- User authentication--Authentication provides a way to control who can log in to the computers connected to your server.
- Access control--You can decide which network resources (such as printers and applications) and which features of the Mac OS your users can access. Access control helps you to maintain desktop and network security.

The Three Types of Software in NetBoot

Your NetBoot network needs three types of software to make it work properly-- administration applications, server programs, and the client operating system.

You use administration applications to set up and manage your NetBoot server. Some of these administrative applications run on the server, and others are used from a network-connected client.

Server programs run on the server under the Mac OS X Server operating system. Some of these programs don't have a user interface. Although you won't "see" server programs, you need to know what they are and how they work to understand how your NetBoot environment operates. (You can use Process Viewer to check the status of a server program.)

The Mac OS used by your client computers is downloaded from the server when a client computer starts up. The client Mac OS stored as a single image on the server. Every client computer uses the same Mac OS image. You need only to manage this image to administer all NetBoot clients.

Administration Applications

- NetBoot Server Setup Assistant--The assistant guides you through the setup process step-by-step.
- Macintosh Manager --You use this application to manage information about users, user preferences, documents, client computers, and network resources.

- NetBoot Desktop Admin – This application “unlocks” the client Mac OS so you can install applications and customize the Mac OS for your users.

Server Programs

- BootP server--This server program assigns an IP address, subnet mask, router address, and domain name to a computer when the computer starts up. It also supplies the client computer with a “string path” to the client Mac OS ROM image stored on the server. This Mac OS ROM image, and the rest of Mac OS, is downloaded to the client using the Trivial File Transfer Protocol (TFTP).
- AppleFileServer-- This server program implements the AppleTalk Filing Protocol (AFP), which allows users to access files on a server as if they were on the client computer's hard disk. This is the same protocol used by AppleShare IP. This service allows NetBoot clients to mount the designated Mac OS and Applications volumes on their desktops.
- Macintosh Management server--This server program stores and looks up information about user accounts and workgroups, provides authentication services, and can assign a default location on the server for users to store documents. The Macintosh Management server can be used to administer client computers that start up from a local hard drive.

Note: You are not required to use Macintosh Manager server software on NetBoot Macintosh computers, although it is installed by default. It is possible for computers to startup from a NetBoot server without using Macintosh Manager software. See the section, “Starting up a NetBoot Client Computer Without Using Macintosh Manager” for more information.

It is also possible to manage Macintosh computers that start up from a local hard drive with Macintosh Manager. See the section, “Using Macintosh Manager to Manage Computers that Start Up from a Local Hard Drive” for more information.

Client Mac OS

- Your Mac OS X Server stores a single Mac OS image which is downloaded to all the client computers that start up using BootP. This allows changes that are made to that single image to be reflected in all Macintosh computers that start up from the server.

How a Computer Starts Up From a Server

This section describes the underlying processes that take place during startup and login. The information may be useful if you need to troubleshoot a problem in the future or if you're just curious about how this new type of networked Macintosh works.

Which Macintosh Computers can Start Up from a NetBoot Server?

Macintosh G3 machines manufactured after January 1999, and all Macintosh G4 machines, can be NetBoot clients. All iMacs, regardless of date of manufacture, can be NetBoot clients. iBooks can also be NetBoot clients, but ONLY via the Ethernet port. Use of the AirPort wireless system is not recommended or supported by Apple for NetBoot installations.

Insure that the NetBoot clients' Firmware has been updated, and that you have applied the latest patches for Mac OS X Server. The latest Firmware updates and Mac OS X Server patches can be found on the World Wide Web at <http://asu.info.apple.com/>

Setting Up a NetBoot Client

There are two ways to start up a computer from a NetBoot server:

- 1) Press and hold the "N" key as you start up the computer.
- 2) Open the Startup control panel and choose Network Disk.

Note: If Network Disk does not appear in the Control Panel, press and hold the "N" key as you start up the computer. Network Disk should then appear in the Control Panel.

Where the System Software and Applications for NetBoot Client Computers are Stored

When NetBoot software is installed on the server, a disk image called NetBoot HD.img is installed on a Mac OS Extended (HFS+) partition on the server. The NetBoot HD image contains the Mac OS system software and applications that each of your NetBoot clients needs. NetBoot HD appears as a hard disk on the NetBoot client's desktop after the client has started up.

Establishing a Network Connection

When a user turns on a NetBoot client computer, the computer broadcasts a message to find the startup server program (a server process called BootP). The startup server program responds by sending information (such as an IP address) the client computer needs to establish a connection to the NetBoot server.

IP addresses used by NetBoot client computers are assigned from the range of addresses you entered when you used the NetBoot Server Setup Assistants. You can view the table of Ethernet hardware and IP addresses by using NetInfo Manager on the NetBoot server.

The first time a NetBoot client computer starts up from a BootP server, the server stores the client computers' Ethernet hardware address in the NetInfo database with an IP address it will use for that client. Each time the client computer starts up, the IP address stored in the table is used. Once assigned, a client computer will always uses the same IP address, and it cannot be reused for another client computer. Therefore, it is important that you provide enough IP addresses for every client computer you plan to connect to the NetBoot server.

Copying the Mac OS to a NetBoot Client Computer

Once a connection is established between a client computer and the server, the Mac OS ROM image is copied from the server to the random access memory (RAM) in the client computer. This is done using Trivial File Transfer Protocol (TFTP).

Note: The /private/tftpboot directory on Mac OS X Server contains a link which points to the Mac OS ROM file, located in the folder that contains the NetBoot disk image. Be sure not to move or delete this link or the original file. If you should add newer machines to your network over time, this file may need to be updated with a new ROM file to support your new hardware.

Next, the Mac OS ROM that has been copied to the client computer's RAM mounts the NetBoot HD image and opens the System file. This is done using AFP protocols, and is the reason the AppleFileServer program must be running on your server to use the NetBoot feature. You will see an icon on the client's screen that indicates the Mac OS is starting up.

Logging Into Macintosh Manager

To implement Macintosh Manager, you must set up options using the Macintosh Manager administration application. For more information see the installation manual that came with your software, or use the online Help menu after starting the Macintosh Manager administration application.

The first time a client starts, Macintosh Manager and other extensions load. A server selection dialog box appears. The user must choose a Macintosh Manager server from those listed in the dialog box. On subsequent startups, the client will automatically connect to this Macintosh Management server if it is available on the network.

After the client connects to the server, the login window appears. The user enters his or her Macintosh Manager user name and password into the log in window. If the name and password are valid, Macintosh Manager copies the Preferences files for that user to the client computer. At that point, the user sees the Mac OS environment and can begin using the computer. The environment the user sees--Panels, Restricted Finder, or Finder--depends on how options are set in Macintosh Manager.

In the Finder and Restricted Finder environments, the Mac OS image and the Applications image appear as mounted volumes on the desktop. A Finder user has access to any application in these images. Restricted Finder users, though, can only access those items allowed by the Macintosh Manager administrator. Panels users don't see the Finder at all, but a screen which contains icons representing applications that they may use as defined by the Macintosh Manager administration application.

How User Preferences are Handled

A user's environment is defined by settings, such as a desktop picture, that personalize the desktop for that user. On a stand-alone Macintosh, when a user changes a setting, the setting is saved in the Preferences folder located in the System Folder. Computers that start up from a NetBoot server all share the same client Mac OS image, so a user's preferences cannot be saved in the usual manner.

For NetBoot client computers, you use Macintosh Manager to set options that define which preferences and settings can be saved. When user preferences are changed, the changes are stored in a location on the server that's referred to as a "shadow volume." The shadow volume contains the differences between the Mac OS image and what the user has changed. For example, if the user changes the desktop pattern to show Bubble Poppy instead of the Mac OS default, the changes to the Mac OS image to store this user preference are written to the shadow volume instead.

The server uses a special disk driver called a "block driver" to deflect what is written to the shared Mac OS image into the shadow volume, and to determine when to read from the shadow volume instead of the shared Mac OS image when retrieving data.

When the user logs out, changes to preferences that are being saved are stored in a file in the Macintosh Manager Items folder located in the Macintosh Manager sharepoint.

The next time the user logs in, his or her saved preferences are retrieved from the Macintosh Manager Items folder. Using the desktop pattern example discussed previously, information about the user's desktop pattern is saved when the user logs out and restored when the user logs in. The shared Mac OS image will not be modified. The shadow volume will contain all of the changes made during this procedure. The environment the user sees is a combination of the shared Mac OS image and the changes to it that are stored in the shadow volume.

Each preference or setting you allow users to save must be copied from the Macintosh Manager Items folder to the user's computer when the user logs in and from the user's computer to the Macintosh Manager Items folder when the user logs out. If the computer shuts down unexpectedly during a session, changes made during that session are lost.

The changes to the shared Mac OS image are maintained in the shadow volume until the client machine is restarted or shutdown. At this point all changes to the Mac OS image that were not saved by the Macintosh Manager are lost. A restart or shutdown is the equivalent of restoring the original system software on the client.

How User Files are Handled from a NetBoot Client Computer

If the user has permission to save files and folders, the items are saved to the disk images on the server, in a location you set up in Macintosh Manager. Users may also save items to another AFP server a local hard drive or other storage device if you set up permission in Macintosh Manager.

Shadow image storage requirements

The Mac OS X Server version 1.2 CDs use a Mac OS 9 system image for NetBoot clients. The use of Mac OS 9 produces a shadow image of approximately 4 MB.

Upgrading NetBoot images

The Mac OS X Server version 1.2 NetBoot CD contains a Mac OS 9 image with the Macintosh Manager 1.1 extension installed. It is installed as part of the NetBoot install or upgrade process.

Note for customers upgrading from previous versions of Mac OS X Server and NetBoot:

Using the Mac OS X Server version 1.2 NetBoot upgrade CD will wipe out any applications or extensions you have installed in the existing Mac OS 8.5 or 8.6 image. A “clean” Mac OS 9 image will be installed using this upgrade. Do NOT attempt to upgrade an existing Mac OS 8.5 or 8.6 the image in place with a Mac OS 9 CD and the NetBoot Desktop Admin utility. This will result in an unbootable client image.

After the Mac OS X Server version 1.2 NetBoot CD upgrade of the system is complete, the image can then be manipulated with the NetBoot Desktop Admin utility version 1.1 without any problem, allowing the addition of applications and extensions as appropriate,

Macintosh Manager version 1.1 and NetBoot clients

Macintosh Manager version 1.1 is included on the Mac OS X Server version 1.2 NetBoot CD. It will ONLY work with NetBoot or locally booted Mac OS 9 clients with the Macintosh Manager 1.1 extension installed. The Macintosh Manager 1.1 extension is already installed in the Mac OS 9 NetBoot images supplied on the Mac OS X Server version 1.2 CD.

Where to get more NetBoot information

Refer to Apple’s Technical Information Library at <http://til.info.apple.com> for more information. To find NetBoot related TIL articles quickly, click on “Advanced Search”, in Section 4 of the first page. On the Advanced Search page enter “netboot” in Section 1 and click on “Search” in Section 6 to see a list of the latest articles on NetBoot. Click on the title to display the article.

Starting up a NetBoot Client Computer Without Using Macintosh Manager

Macintosh Manager client software is installed into the Mac OS image as part of the NetBoot server software installation. It is possible to use the NetBoot server software without using the Macintosh Manager software. However, without Macintosh Manager you won't be able to preserve users' desktop environment, turn on security features, or authenticate users through the log-in process. To disable Macintosh Manager you must remove the Macintosh Manager client software from the client Mac OS image after unlocking the image with the NetBoot Desktop Admin software. If you remove the client software you can also remove the Macintosh Manager server program from the server.

Using Macintosh Manager to Manage Computers that Start Up from a Local Hard Drive

Macintosh Manager 1.1 can be used to manage locally booted Mac OS 9 clients.

Macintosh Manager 1.2, when available on the World Wide Web at <http://asu.info.apple.com>, can be used to administer locally booted clients running older versions of the operating system, back to Mac OS 8.1. Macintosh Manager 1.2 also manages locally booted Mac OS 9 clients.

Macintosh Manager 1.2 client computers running Mac OS 8.x must meet these minimum system requirements:

- Mac OS computer 68040 processor or later
- Mac OS version 8.1 or later
- At least 8 MB RAM (physically installed, not virtual memory, more is better)
- 2 MB available hard disk space
- Appearance control panel 1.0.1 or later
- Ethernet networking set up

Instructions for installing Macintosh Manager client software are in the About Macintosh Manager read me file.

Shadow Volumes and Computers that Start Up from a Local Hard Drive

Shadow volumes are only used by computers that start up from a NetBoot server. Macintosh Manager clients that started up from a local hard drive do not use shadow volumes. Local-startup computers still store preference information on the Macintosh Management server when they log out.

Where NetBoot Server Software Is Installed

One of the hard drives in your server has at least two partitions. One partition is formatted for Mac OS X Server, using User File System (UFS) format. The other partition is formatted using Mac OS Extended format. The NetBoot installer puts some components in the UFS partition and others in a Mac OS Extended partition.

Components Installed on the UFS Partition

- Startup server (BootP) program (located in the /usr/libexec directory)
- Macintosh Management server program (located in the /usr/sbin directory)
- NetBoot Server Setup Assistant (located in the /System/Library/Assistants directory)
- AppleFileServer program (this program can only share items on HFS and Mac OS Extended Partitions, and is located in /usr/sbin directory)
- Mac OS ROM image (a link located in the /private/tftpboot directory points to the ROM image, which is located in a folder at the root of the Mac OS Extended (HFS+) volume you selected in the NetBoot Installer)

Components Installed on the Mac OS Extended Format Partition:

- Mac OS system and Applications image--This image is mounted on a NetBoot client computer when it starts up. It contains the system software used by the client, as well as any applications that have been installed using the NetBoot Desktop Admin utility.
- Administration folder--This contains Macintosh Manager software and Macintosh Manager Help. You use these applications from a client computer connected to the server, when you need to set up or change your Macintosh Manager configuration. The NetBoot Desktop Admin utility version 1.1 and other utilities are located in this folder.

Where Administrative Applications are Located

Some administration applications are used from the Mac OS X Server computer, and some are used from a client computer. You access administration applications stored on Mac OS X Server by choosing Server Administration from the Apple menu. You may need to provide an administrator or root-level password to use an administration program. See the onscreen help provided with Mac OS X Server for more information about network administration.

Administration programs such as Network Manager let you see information in the users and groups databases. Utilities such as ProcessViewer let you check whether or not a server program is running. It's best to use these program and utilities to view, but not to change, information. You should use the appropriate set up assistant to make changes to the Mac OS X Server

configuration or to the NetBoot server. To access the Setup Assistant, open the Apple menu, choose Server Administration, then choose Assistant.

To access administration programs that are used from a client computer, you must log in a client computer as an administrator or other user with system access, and you must choose System Access as your workgroup. Then you must use the Chooser to mount the NetBoot server volume. From the client computer, you use Macintosh Manager to set up and maintain the Macintosh Manager configuration. You use NetBoot Desktop Admin to make changes (such as install applications or change the system configuration) to the client Mac OS.

You use Web-based tools to set up and manage the AppleFileServices program. You can use WebAdmin from any client computer connected to the server, provided you logged in to the client computer as an administrator or user who has system access.

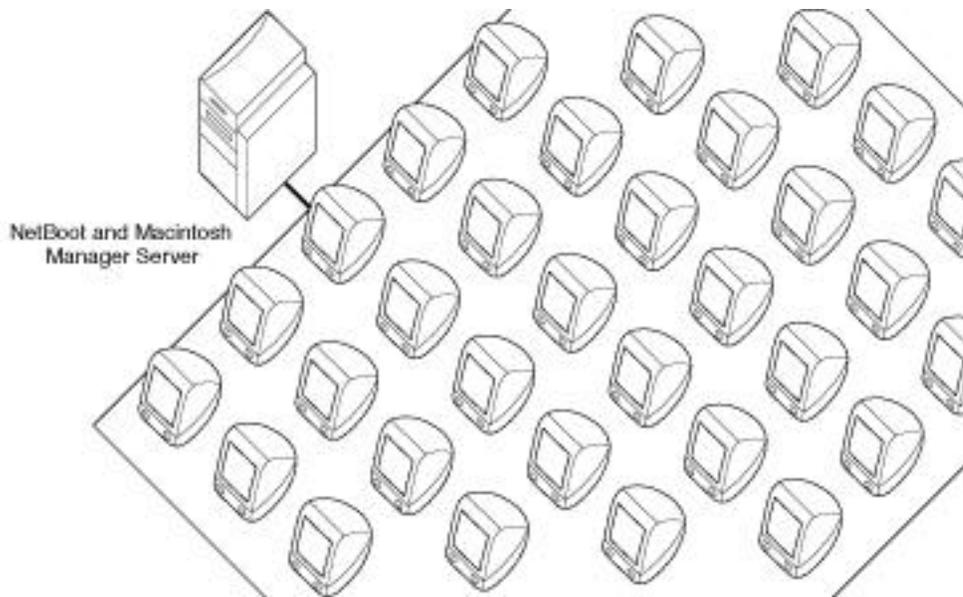
Examples of NetBoot Networks

You can use a NetBoot server and network-startup computers in a variety of computing environments. The simplest environment is a single lab that has one NetBoot server supporting network-startup computers. A more complex environment is an existing network of computers that spans buildings and crosses routers and that has a NetBoot server and network-startup computers integrated into it.

Each of the following sections describes a typical computing environment from simple to complex and shows how a NetBoot server can be used to support the technology objectives of each.

Setting Up a Lab That Contains Only NetBoot Client Computers

An elementary school equips a new computer lab.



Technology Objectives

- Support educational goals in various areas of instruction, such as reading and math.
- Ensure that each computer has the same software.
- Promote desktop security by protecting the computer and network resources from student tampering.
- Set up a network that's easy to maintain.

Network Strategy

- Use only network-startup computers.
- Use one server with both the startup server software and the Macintosh Manager server software installed. The server will store users' documents and applications.
- Use Macintosh Manager to set options that promote desktop security.
- Set up workgroup administrator accounts for teachers then show them how to use Macintosh Manager to manage user accounts and workgroups.

Summary

Network-startup computers use system software supplied by the NetBoot server to ensure that each computer has the same version of software and access to the same applications. Regardless of what a user changes during a session, network-startup computers return to the same system configuration after a user logs out.

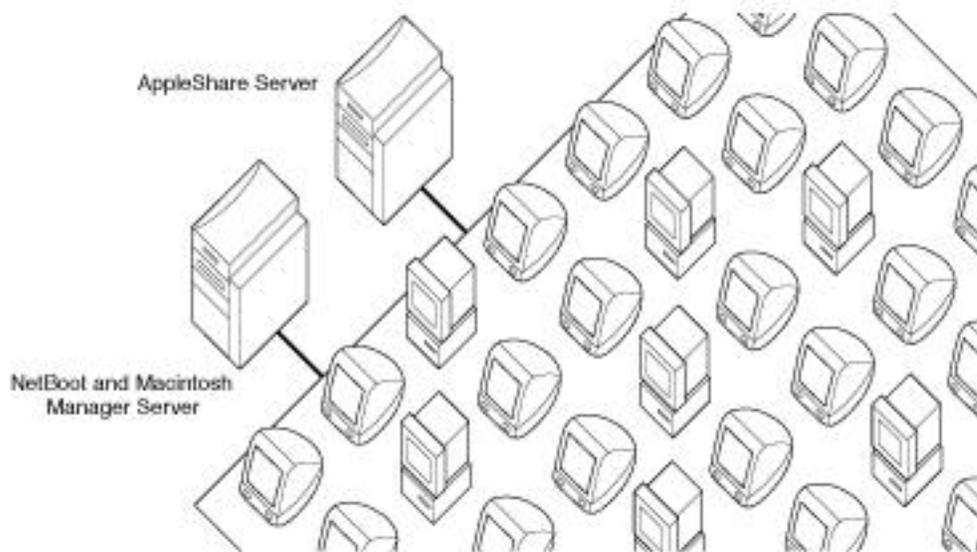
Using Macintosh Manager Administration to control which network resources students can access can ensure desktop security. You can protect the System Folder and Applications volume.

You can set options that promote password security, startup security, and security when using applications.

This network is easy to maintain because the users' applications need to be installed only on the startup server. The teacher can manage user accounts and workgroups from any computer connected to the server. Once the network is set up, there is very little daily management. Teachers can distribute and collect assignments through the network. A teacher can also make available network resources, applications, and CDs that promote teaching objectives for the class.

Integrating Local-Startup Computers with NetBoot Client Computer in a Single Lab

A large high school has an existing general-access computer lab with a mixture of Macintosh computers. They've received funding to replace some of the older computers with state-of-the-art equipment.



Technology Objectives

- Support educational goals in various areas of instruction by providing students access to course content, research tools, and teachers.
- Ensure computer literacy by requiring computer use throughout the educational experience.
- Provide students with a state-of-the-art computing experience.
- Ensure that only authorized users log in to computers in the lab.
- Promote desktop security by protecting the computer and network resources from student tampering.

- Set up a network that is easy to maintain. All computers, whether new or old, need to be managed with the same network administration tools.
- Leverage the use of existing hardware and software. The school needs to get the most out of the past investments it made for client computers, servers, and software licenses.

Network strategy

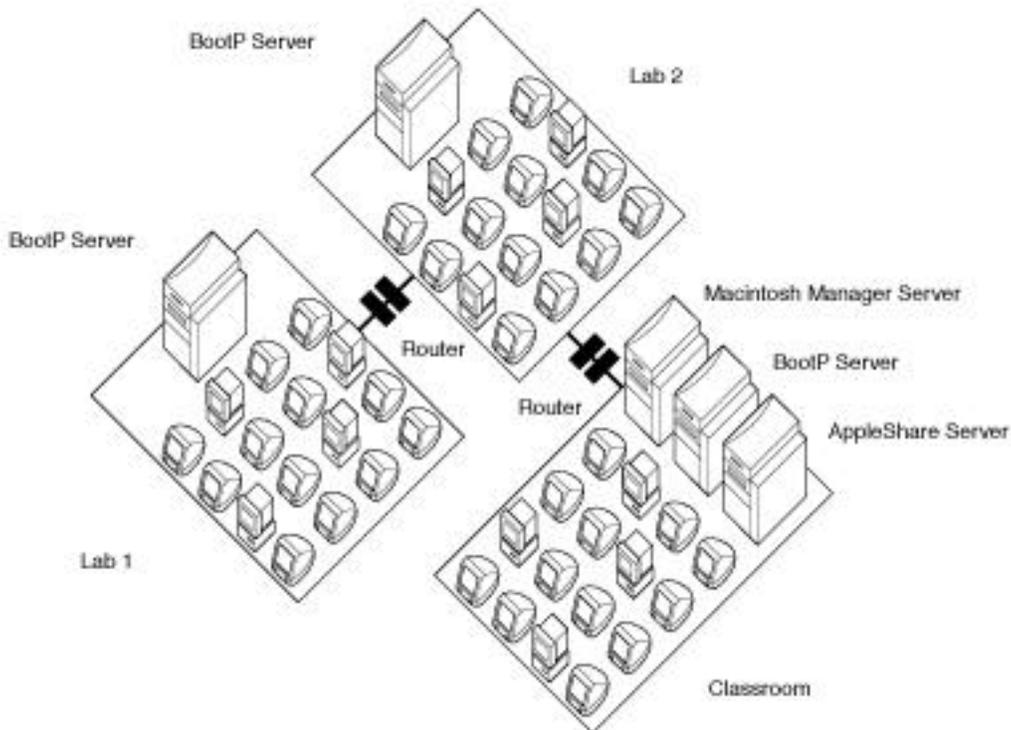
- Integrate network-startup computers into a lab that already has local-startup computers.
- Install Macintosh Manager client software on local-startup computers to allow easy management of existing computers along with the newer, network-startup computers.
- Use existing servers along with a NetBoot server to provide resources to the entire network. With several servers, it's possible to dedicate one computer as a startup server, one computer to manage Macintosh Manager user account information and user preferences, and the another computer to store user's documents and site-licensed applications.
- Set password options in Macintosh Manager to promote log-in security and to ensure that only authorized users can log in.
- Use Macintosh Manager Administration to set options that promote desktop security.
- Set up workgroup administrator accounts for teachers then show them how to use Macintosh Manager Administration to manage user accounts and workgroups.

Summary

A NetBoot server and network-startup computers can be integrated into an existing network so you don't need to abandon older technology. When a computing environment supports a large number of users, it's best to install several servers to distribute the load for network resources such as document storage and access to applications. It's possible to install the server programs that come with NetBoot on different servers. For example, you can install just the startup server software on one server, and the Macintosh Manager server software and user documents on one or more additional servers.

Integrating NetBoot Client Computers and Local-Startup Computers in Multiple Labs

A college has a classroom and two general-access computer labs located in different buildings. Students, faculty, and staff may log in to any computer on the campus to access their documents.



Technology objectives

- Enhance the college's position as a world-class institution by providing general-access-computing facilities to support instructional and research goals.
- Provide students, faculty, and staff access to the Internet as well as the most recent and most appropriate software applications across a number of academic disciplines.
- Provide students with a state-of-the-art computing experience.
- Ensure that only authorized users log in to computers in the lab.
- Promote desktop security by protecting the computer and network resources from student tampering.
- Set up a network that is easy to maintain. All computers, whether new or old, need to be managed with the same network administration tools.
- Leverage the use of existing hardware and software. The school needs to get the most out of the past investments it made for client computers, servers, and software licenses.

Network strategy

- Integrate network-startup computers into a lab that already has local-startup computers.

- Install Macintosh Manager client software on local-startup computers to allow easy management of existing computers along with the newer, network-startup computers.
- Use existing servers (such as an AppleShare server) along with NetBoot servers to provide resources to the entire network. With several servers, it's possible to dedicate one computer to act as the startup server and others as the Macintosh Manager server and to store users' documents and site-licensed applications.
- Use routers to allow networking between the two computer labs and the classroom.
- Set password options in Macintosh Manager to promote login security and to ensure that only authorized users can log in.
- Use Macintosh Manager Administration to set options that promote desktop security.
- Set up student workers as workgroup administrators to help with the daily management of user accounts and workgroups. You can give some students system access so they can help install and upgrade site-licensed application software that's used in the labs.

Summary

This is an example where NetBoot computers that are integrated into an existing network. When setting up a network that encompasses two or more subnets, a router to connect the subnets is necessary. BootP startup packets usually cannot cross a router, so you need to have one BootP startup server for each lab or classroom that you plan to have network-startup computers in.

Macintosh Manager can cross subnet boundaries, so it is possible to have one Macintosh Manager server for the entire college. (One Macintosh Manager server can handle up to 8000 user accounts.) A single Macintosh Manager server allows students to maintain their personal preferences, desktop, and access to server based documents on any NetBoot Macintosh on the network, regardless of location.

When a computing environment supports a large number of users, it's best to install several servers to distribute the load for network resources such as document storage and access to applications.

Macintosh Manager Administration software can be used by users with limited authority (workgroup administrators.) If you hire students to help manage the labs, you can easily set up workgroup administrator accounts that let them manage some network resources but not change global options for your network.

NetBoot Performance

A number of factors affect NetBoot client performance. You can adjust some factors to decrease NetBoot client startup time, improve client performance, and increase the number of clients supported. Other factors can be adjusted to increase network and server performance.

The combination of factors you adjust to optimize network performance depends on your particular set up. The best optimization strategy is to identify areas that can make the most impact, then change them first. You may find that implementing a few of the changes suggested below will improve greatly the user experience.

Network Performance Factors

You get the best performance from a 100 MB Ethernet network, where the server and the clients are on the same segment or hub. At a minimum, 10 MB “switched” Ethernet can be used for the client computers, provided that the server has a 100 MB connection to the 10 MB switched network. A Mac OS ROM file version 3.0 or newer is required to boot a client through an Ethernet switch. This Mac OS ROM file was supplied on the Mac OS X Server version 1.2 CDs with the Mac OS 9 NetBoot image. Mac OS ROM version 3.0 will ONLY work with Mac OS 9. Although NetBoot technology will operate on a 10 MB switched Ethernet network, 100MB connections offer optimum performance.

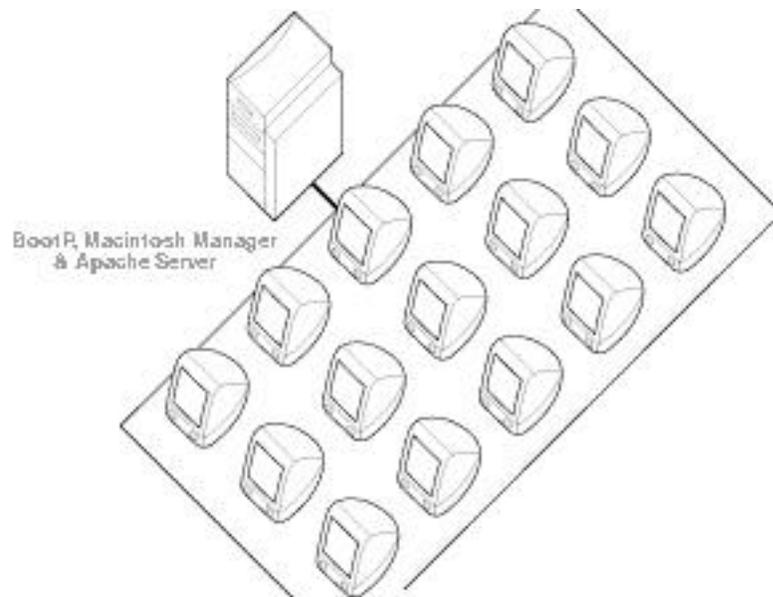
Analyze usage patterns before setting up a NetBoot network so you can determine how many client computers to connect to each segment or hub. If you expect heavy usage, you may need to split up tasks (such as Apple File Services and Macintosh Manager) among multiple servers.

NetBooting and AirPort

The use of AirPort wireless technology is NOT recommended or supported by Apple for NetBoot clients.

How many clients can be supported per server?

The illustration below shows one server that supports clients on the same network. In this example, the server is running the BootP, Macintosh Manager, AppleFileServices and Apache processes. Further, we expect these client computers to start up simultaneously, and to launch applications at the same time after the startup has completed.



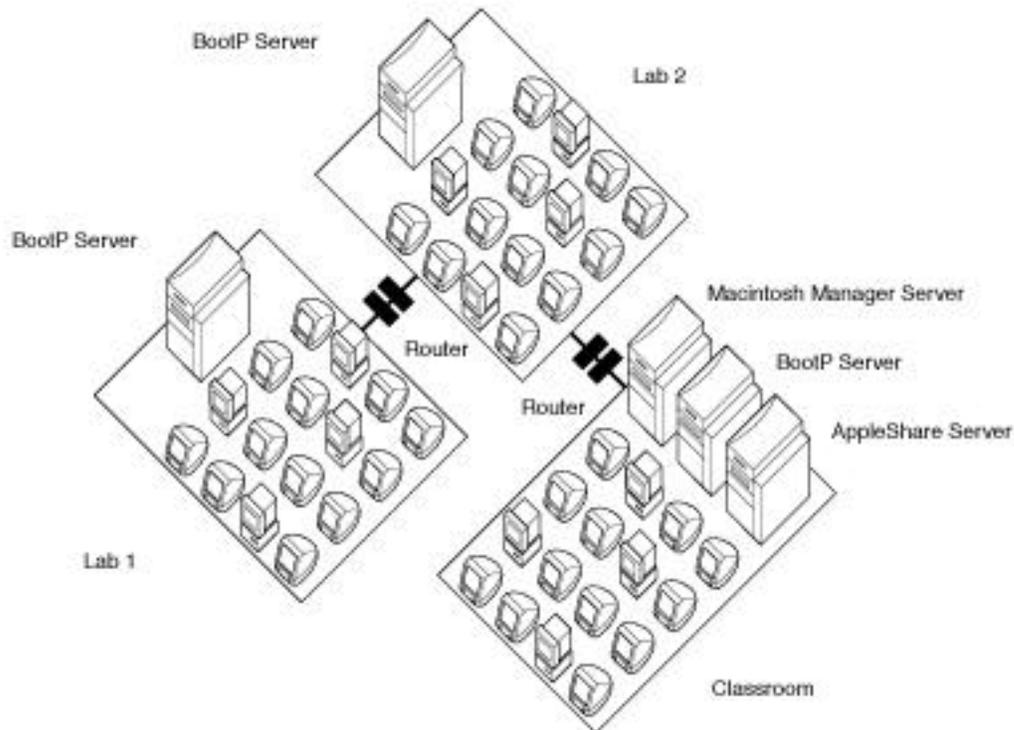
In this example, a maximum of 15 clients per server is recommended.

If users start up clients computers and launch applications at random times, the load on the server's disk subsystem and the network will be spread more evenly over time. In this case, you can place more clients on each network segment, up to 25 in some cases.

The example below illustrates the concept of splitting responsibilities of the NetBoot server processes over several servers. In this example, clients are starting up and launching applications randomly.

Macintosh Manager packets can travel through routers. If you have a large number of users, you can manage them with one Macintosh Manager server. Further, you can integrate Mac OS X Server running only Apple File Services, or Mac OS based AppleShare IP servers, to store files.

BootP packets, which are used to load the operating system into a Net Boot client computer, cannot usually travel through routers. You will need one BootP server on each individual segment or hub to start up the NetBoot client computers.



Splitting responsibility for different services between multiple servers can increase the number of clients that can be supported per network segment or hub, up to 50 clients in some cases.

Using routers can also isolate network traffic and provide connectivity over longer distances.

Every environment is different. You may need to adjust other factors to realize acceptable performance, which are discussed in Client Performance Factors and Server Performance Factors.

Server Performance Factors

In a single server network, each client is using the same server to startup, implement virtual memory and provide the application and file storage needs of your clients. This puts great demands on the disk subsystem of the server and on the network.

Increasing the physical RAM available on the server to at least 256 MB can help cut down on Mac OS X Server's access to its disk subsystem.

As the Macintosh Manager server process dynamically distributes shadow images over your entire disk subsystem, adding another hard drive is a viable option to improve performance.

Storing and saving user documents on another AFP compatible server can further reduce the workload on your disk subsystem. Use the Macintosh Manager administration utility to set this up.

You may be tempted to rearrange the "shadow images" and other "system" files. However, doing this incorrectly may result in an unusable server. Rearranging system files is NOT recommended.

The clock rate of the CPU is also of importance, especially in a single server network. Always pick the fastest supported machine available to be your server.

Client Performance Factors

Perhaps the number one variable that can have a positive impact on performance is increasing the physical RAM in each client. This cuts down on the need to "page" (the technique which implements virtual memory) and can provide crisper performance by allowing more caching in memory. For best results, it is highly recommended that each client has a least 64 MB of physical RAM, and that the cache size be increased to at least 2 MB.

The second most important variable relating to client performance is the client's Virtual Memory setup. NetBoot clients "page" over the network by default. Consider setting up "local paging" instead. Local paging sends virtual memory traffic to the clients' local hard drive instead of using the network to access the system disk on the server. This can reduce network traffic and the load on the server's disk subsystem quite a bit, and offers better client performance, especially in launching applications. This is done using the NetBoot Desktop Admin to change the clients' system image on the server. Once you have enabled your NetBoot client to make persistent changes to the system image, open the Memory control panel and select the local hard disk in the Virtual Memory panel. You will also need to insure that all of the NetBoot client's local hard drives have the same name.

If you have a large amount of physical RAM in the client, you may want to consider turning Virtual Memory off, eliminating paging entirely. Note, however, that in Mac OS 8 and 9, VM is on by default and is generally recommended. In any case, if you have changed the Virtual

Memory settings, don't forget to make the new system image "shareable" by running NetBoot Desktop Admin again.

The Macintosh Manager allows you to create a virtual desktop environment by saving preferences files on a per user basis. These are stored on the server. The more preferences you save, the longer it will take for your client machines to load them after a user logs in. If you are encountering long delays between the login and getting to the Finder, restricted Finder, or Panels environment, consider reducing the number of preferences you are saving using the Macintosh Manager.

Most importantly, do not save a user's web browser cache. Browser caches can grow quickly in an environment where Internet browsing is one of the primary applications you use. Setting Macintosh Manager not to save the browser cache will eliminate the transfer of these large files between the server and the client, thus reducing startup times after login dramatically.

Performance Summary

For best performance, follow these tips:

- Always use a least a 100 MB Ethernet connection from the server to the network where the NetBoot clients reside.
- The minimum recommended connection for a client to the network is a switched full duplex 10 MB Ethernet connection. A Mac OS ROM file version 3.0 or newer is required to boot a client through Ethernet switches. This Mac OS ROM file was supplied on the Mac OS X Server version 1.2 CDs, and only works with Mac OS 9 NetBoot images. A 100 MB Ethernet full or half duplex connection is preferable. Ethernet switches should be configured to support automatic negotiation of the duplex mode.
- Choose a server, network and client configuration that supports the usage patterns of your users.
- Add more servers to your network, and consider splitting functionality (BootP, Macintosh Manager, Apple File Services).
- Increase the physical RAM on the server to reduce the load on the disk subsystem.
- Add hard disks to your server to enhance the performance of the disk subsystem.

- Use the fastest computer available as the server, especially in a single server network.
- Add more physical RAM to the NetBoot clients and increase the client disk cache size to reduce virtual memory paging and network traffic
- Implement “local paging” to the hard drive on NetBoot clients
- Reduce the number of preferences Macintosh Manager is saving for your users.
- Do not save browser caches.

Performance Guidelines

Apple ran some tests to determine which networking topologies worked best for NetBoot performance. Due to the number of variables that affect performance, Apple Computer does not guarantee you will achieve the same results.

The server used in the testing was a 400MHz G3 PowerMacintosh with 250MB of RAM and three 9GB drives. All three drives were used in the test. The software used was Mac OS X Server 1.0-1 with version 1.0 of the NetBoot server, version 1.0.1 of Macintosh Manager, version 1.1 of the NetBoot extension, version 1.1 of NetBoot Desktop Admin, and version 1.0.1 of the Macintosh Manager client.

The clients all had 32MB of memory, VM was set to use the local disk, and AppleShare client 3.8.2 was used on all the clients.

Two network configurations were tested. One using all 4 Ethernet ports on the Apple 4 port Ethernet card operating at 100 MB using hubs, with 12-13 clients on each segment for a total of 50. A second test was run using only 2 ports of the Apple 4 port Ethernet card operating at 100 MB using hubs, with 25 clients on each segment.

The clients performed all operations simultaneously, which places the greatest load on the server and the network. The results showed no dramatic difference in performance between the two topologies.

In both topologies, 50 clients booted simultaneously should take about 3 minutes to start up and display a login screen.

If all log in at the same time, and have 570KB of data in preferences to transfer, all 50 should display the desktop in 3 minutes. If your preferences are larger, the rule of thumb is to add an additional minute for every MB of preferences transferred when clients are logging in at the same time.

Simultaneous applications launches of 50 clients should take a little over a minute.

The logout procedure can also be time consuming, as all changed preferences must be written back to the server. If all 50 clients log out simultaneously, expect to wait approximately one minute per MB of preferences saved.

This should be a worst case scenario using a 100MB Ethernet network. In practice, most of the clients will not be performing the same operation at the same time. NetBooting performs best when machines start up and perform operations at different times.

The first time a machine NetBoots, booting and logging in will take longer than at any other time. The reason is that the NetBoot server must set up the client and save various parameters in the client's firmware as well as the server. Subsequent startups and logins of the clients will be faster.

Reducing the amount of data transferred in the login and logout process is critical to good performance. Internet browser caches are especially prone to causing delays at log in and log out. It is highly recommended that you do NOT save internet browser caches unless absolutely necessary.

Applications Suitability Factors

Although the concept of NetBoot technology is simply to relocate the storage activity of the client from the local hard disk to the server, some applications may have problems operating in a NetBoot network.

NetBooting is designed to allow applications to save user information in the Preferences folder of the server's client image. If the application in question does this, you should not experience problems using it with a NetBoot network. However, not all applications operate this way. Some applications create their own folders and save customization parameters or temporary work files elsewhere. Applications that do this may complain about writing to a locked volume.

If you can discover what folder or file the application needs access to, do the following:

- Unlock the NetBoot image with NetBoot Desktop Admin
- Move or copy the file or folder to the Preferences folder of the client's boot image (NetBoot HD), and delete the original. Note its location before deleting, you will need that for the next step.
- Create an alias to the file or folder, and then drag it back to the location of the original
- Edit the name of the alias to remove the word "alias"
- Lock the NetBoot images with NetBoot Desktop Admin

This should allow the application read/write access to that file or folder.

Some applications require that a CD be locally available. In this case, you will need a CD for every client that chooses to use this application mounted in the local drive. Sometimes you can use an alias to access a CD image shared over the network. You will have to experiment to see if you can get your application to operate this way.

Other applications use "keys" or "dongles" to enable their usage. Keys must be available on a local storage medium (the local hard drive), and dongles must be serially accessible by the client computer to operate.

The best way to make configuration changes

Sometimes entries must be made in a variety of places to implement changes. The best way to change things is to rerun the NetBoot Setup Assistant, which will do the right thing to make your changes successful.

Where to get software updates and more information

Refer to Apple's support pages on the World Wide Web for software updates for Mac OS X Server and NetBoot. These pages are located at <http://www.apple.com/support>.

Apple's Technical Information Library contains articles, which have the latest information on Mac OS X and NetBoot. These articles are generated by Apple's technical support organization based on customer questions, and contain tips and tricks, with step by step instructions accomplish a variety of tasks on your server. The TIL is located at <http://til.info.apple.com>.

To generate a complete list of Mac OS X Server and NetBoot related TIL articles quickly, click on "Advanced Search", in Section 4 of the first page. On the Advanced Search page enter "Mac OS X Server" in Section 1 and click on the "Search" button in Section 6 to see a list of the latest articles on Mac OS X Server and NetBoot. Double click on the title to display the article.