Network Station Manager
Version 2

Architectural Overview

IBM Network Computer Division
September 1999

Objective/Contents

- Network Station Hardware Components
- Network Station Software Components
- LAN Boot Logical Architecture
- LAN Boot Architecture - Workgroup < 50 users
- LAN Boot Architecture - Workgroup > 50 users
- LAN/WAN Boot Architecture - Enterprise > 500 users

Notes

The objective of this presentation is to introduce the IBM Network Station by taking a high level architectural perspective of it's operating environment.

We first take a brief look at the hardware components and software components of the Network Station.

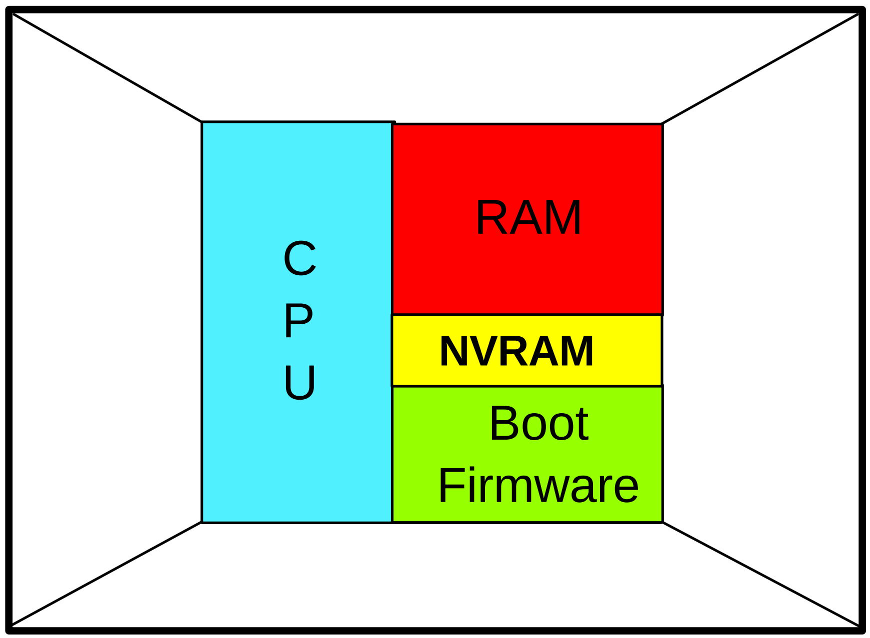
We then review the generic process of booting a station on a LAN to identify the different logical servers that are used and the type of information obtained from these servers.

Next, we repeat this boot process for three typical scenarios, that is for an environment with less than 50 users, with more than 50 users and for an enterprise with more than 500 users and a mix of LAN/WAN access.

We try to remain at a high level to concentrate on understanding the overall generic or architectural aspect of the boot process.

If you are hungry for additional details, the next presentation on Planning and Design takes these same steps a bit further by looking at much more of the underlying technical details and the choices that are available at each major step.

Network Station Hardware



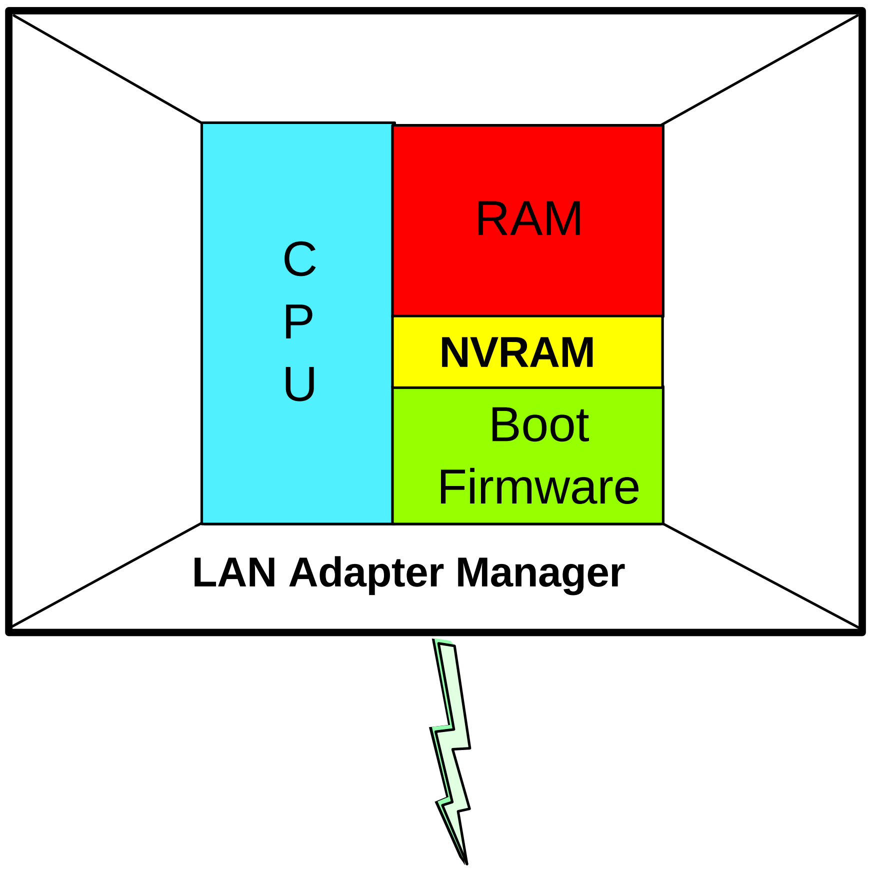
Notes

The first piece of the puzzle is the IBM Network Station so we first need to understand the components that make up an IBM Network Station or pretty well any network computer for that matter.

The core components are:

- A Central Processing Unit - With the currently available models of the Network Station, the processors range from a Power PC 403 33 MHz engine to an Intel MMX 266 MHz. This range allows a selection based on the type and number of applications that need to be executed on a particular station.
- Random Access Memory - Part of this memory is nonvolatile (NVRAM) to allow certain pieces of data to remain permanently between power off and power on of the station, and the rest is traditional RAM holding the operating system, applications and data, which must be reloaded after a power off. Note that this is a real memory system and that there is no paging into virtual memory on disk.
- Boot Firmware - This firmware is code that is given control after a power on and is responsible for performing power on self tests as well as initiating the sequence of events that are required for the station to contact a server on the network and download its operating system.

Network Interfaces



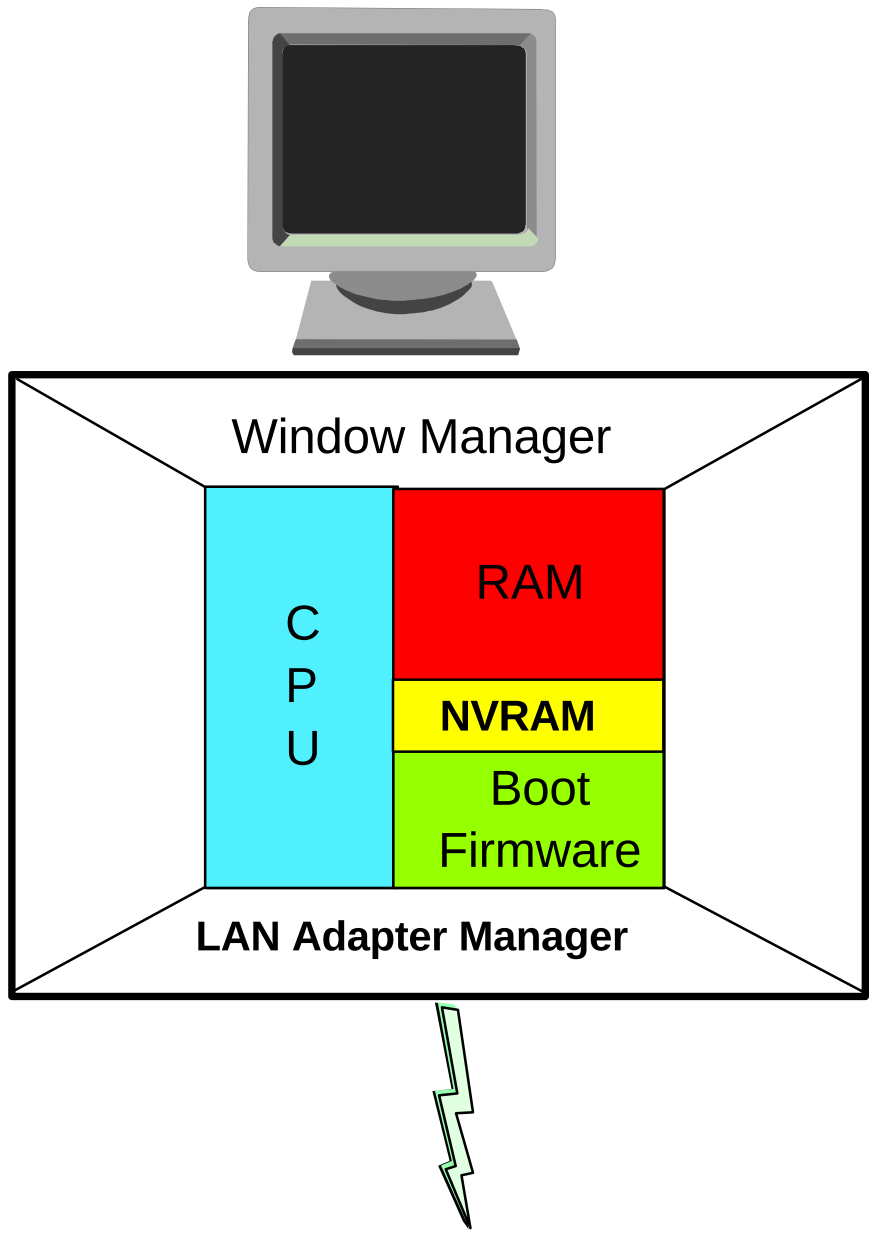
Notes

The next component required is a network interface card that allows the station to communicate with other hosts on the network, in particular with a server, in order to download its operational code.

This adapter can be either an Ethernet adapter or a Token Ring adapter.

During the power on sequence, as soon as the self diagnostics tests are completed, the adapter is opened in order for the station to be able to communicate on the network and contact one or more servers.

Monitor and Video Support

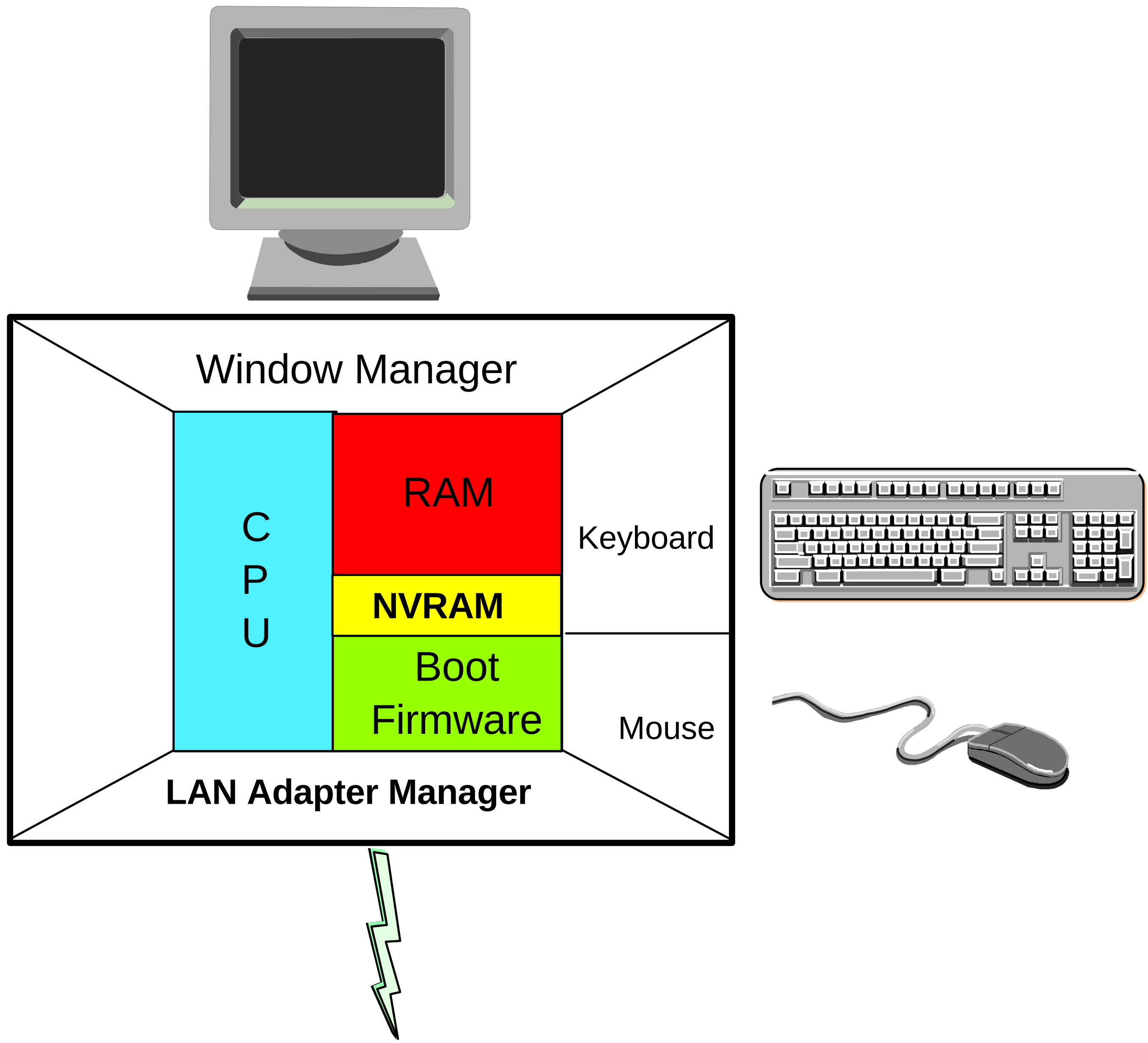


Notes

The next component is the display monitor.

A variety of monitors are supported in different video modes and resolutions and a window manager software component manages the windows displayed by the different applications operating on the Network Station.

Keyboard and Mouse



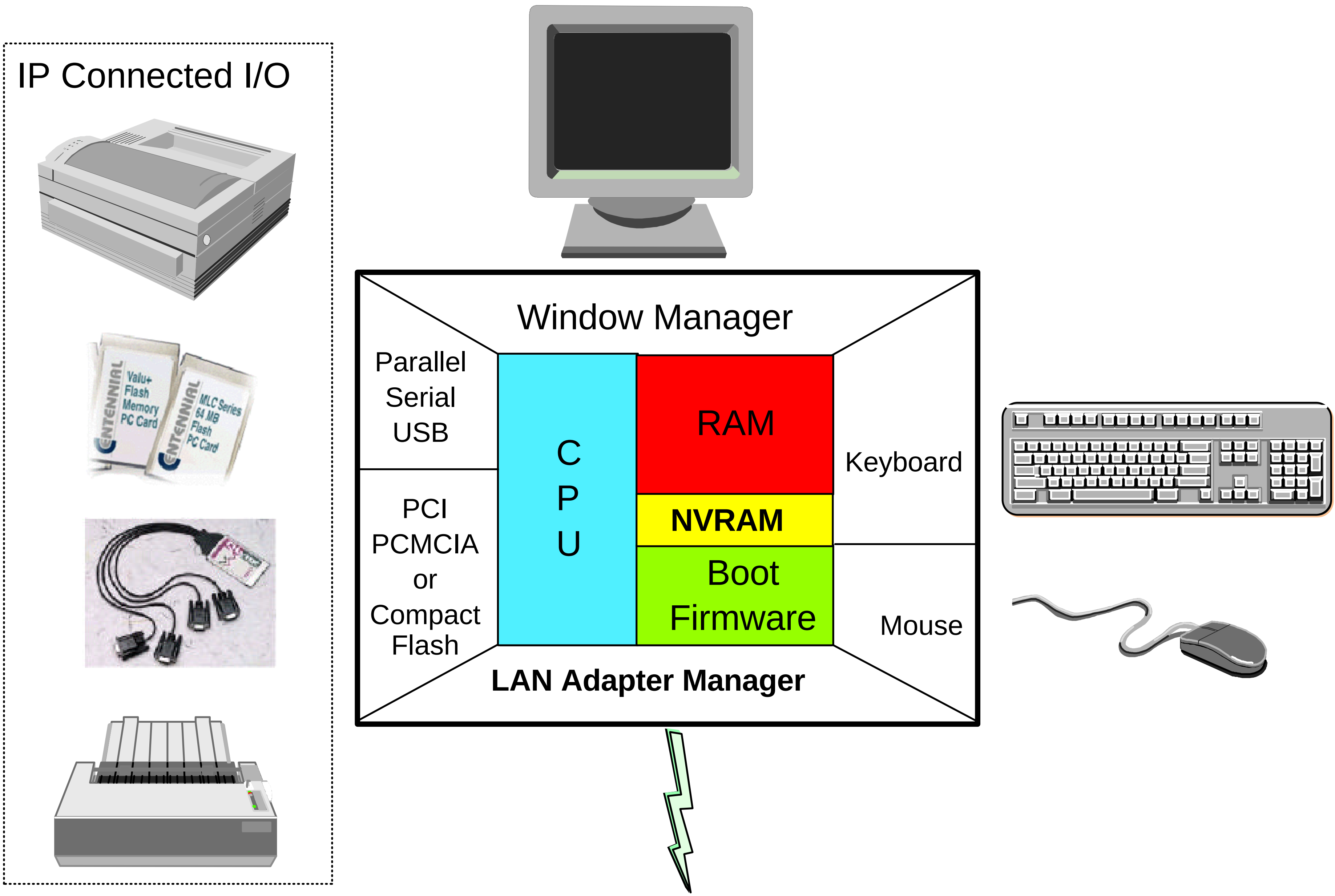
Notes

Next is the support for keyboard and mouse input.

The keyboard is a standard 102-key PC keyboard, available in different language configuration, and a 2-button mouse.

A 3-button mouse is supported, but not shipped with the Network Station.

Miscellaneous I/O Ports and Devices



Notes

Finally, there are a variety of I/O ports and devices available, dependent on the different models. For example:

- All models have some form of audio support, ranging from 8-bit mono integrated speaker to 16-bit stereo jack on the latest models
- All models have at a minimum one serial and one parallel port (except for the Series 2200). The serial port can be used to attach a serial printer, or communication device and the parallel port typically is used to attach a parallel printer.
- The earlier models a PCMCIA Type II adapter while the latest model (the 2800) supports PCI adapters.
- Some of the latest models also provide a USB port capability allowing for easy expansion of I/O devices connectivity.
- And all models also allow the use of Flash Memory Cards in order to provide a limited local storage capability, mostly for implementing local boot capabilities.

Network Station Software Components

Network Station Base Components

Base Code Firmware

POST Diagnostics, Base Network Support, Hardware Interfaces, Boot Strap, Setup Parms

Hardware

CPU, RAM, Boot Prom, NVRAM, Network Adapter, Monitor, Mouse, Keyboard, I/O

Notes

The base software components illustrated in this chart form the first layer above the hardware components.

These base components include the diagnostics routines, such as those performed during the Power On Self Tests when the user powers on the station. Most importantly, the base components include the firmware, which is code permanently resident on the station on a Programmable Read Only Memory (PROM) chip, that is given control after the POST completes and that then performs the steps necessary to boot the Network Station. This code is called the Boot Monitor.

The boot monitor is the component responsible for booting the Network Station; it determines how it is going to behave and how it is going to initiate the boot process by reading some of the configuration data that is permanently recorded in the Network Station's NVRAM.

With this information, the boot monitor is able to contact a boot server on the network and to download the operating system required by the particular model of the Network Station on which the boot monitor resides.

The boot monitor can be easily replaced, when new features or functions become available, by downloading a new version from a remote server and replacing the current one recorded in the PROM; this process is called reflashing the PROM.

Network Station Software Components

<u>Operating System Kernel</u>
Networking, Window / Task Mgmt. Hardware Interfaces

Network Station Base Components

<u>Base Code Firmware</u>
POST Diagnostics, Base Network Support, Hardware Interfaces, Boot Strap, Setup Parms

<u>Hardware</u>
CPU, RAM, Boot Prom, NVRAM, Network Adapter, Monitor, Mouse, Keyboard, I/O

Notes

The operating system is a NetBSD Unix software and it comes in two major flavors:

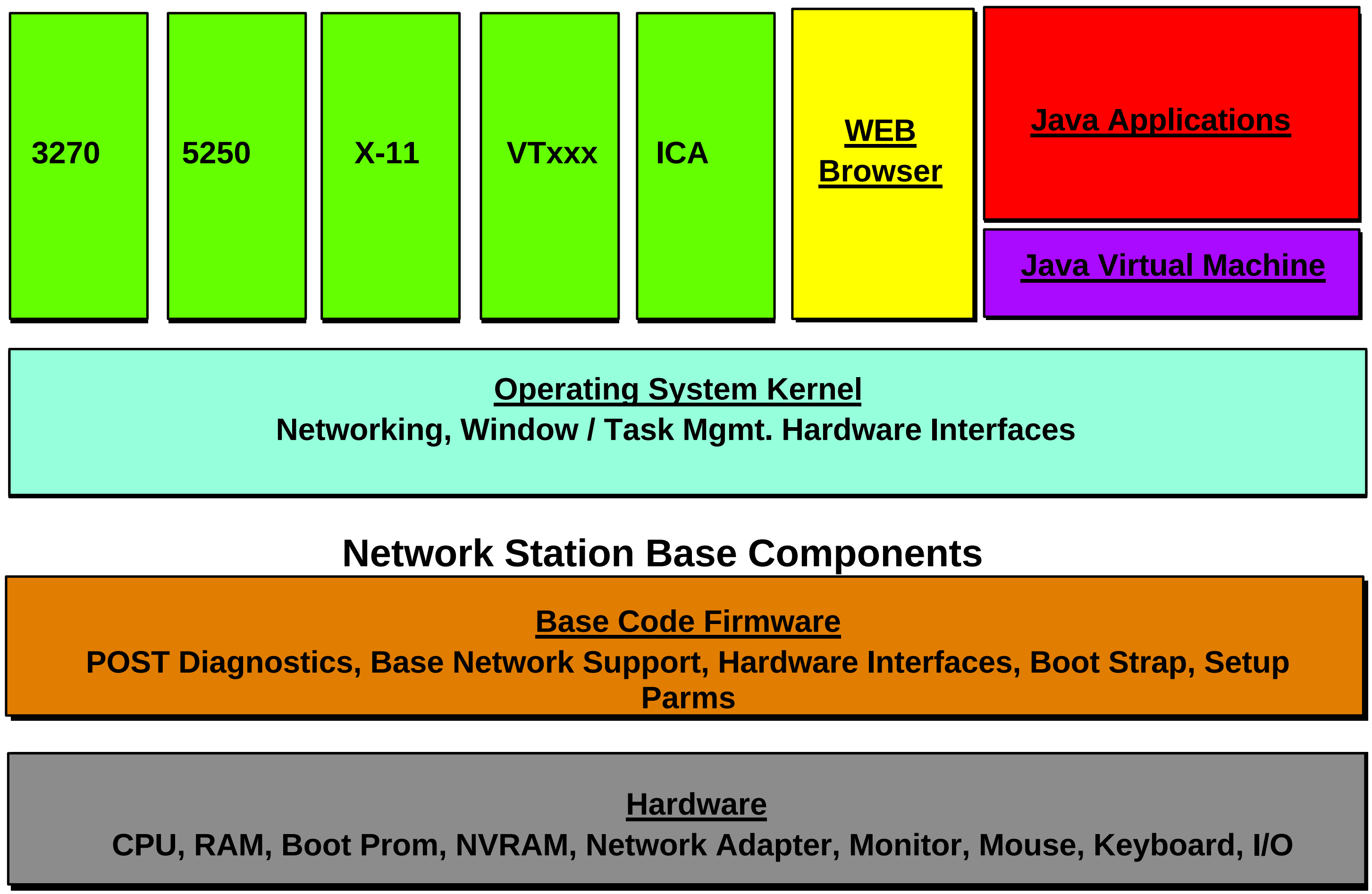
- Prior to V2R1, the kernel was supplied by NCDinc. and was designed to run on Power PC engines.
- With V2R1, the kernel is supplied by NCinc and is designed to operate on both a Power PC engine (except the Series 100) or on an Intel engine as available in the new Series 2800 and Series 2200.

It is important to remember that the kernel uses a linear memory model, which means that all applications use real memory and that there is no virtual memory or memory swapping. This is mainly because there is no local storage facility in the Netrwork Station that can be used to swap memory to.

Adding more memory to a Network Station increases the total number of local applications that can be run simultaneously, but not the performance. In low memory conditions, applications may not be loaded by the kernel and in critical low memory conditions, the kernel may close applications to free memory as a last resort.

Network Station Software Components

Applications loaded with desktop or on demand



Notes

Once the operating system is loaded and the user has logged in, applications can be started automatically or they can be loaded/started on request by the user.

The native applications available to the user are:

- A 3270 Emulator
- A 5250 Emulator
- An X windows terminal capability to access a AIX or Unix system as well as a multi-user Windows NT system using the X11 protocol
- A VTxxx emulator
- An ICA client to access a WinFrame or MetaFrame server (multi-user WIndows NT) using the ICA protocol.
- A Web browser based on Netscape's Navigator 4.5.
- Finally, any Java application or applet, either home grown or available on the market, can be executed on the Network Station's JVM.

In summary, note that once the Network Station is powered off, all software loaded in memory disappears, and must be reloaded after the next power on. Only the firmware necessary to reboot the Network Station remains.

One must remember that one of the main advantages of a thin client is that since the software resides only on the server, individual copies of the software do not need to be maintained and updated on every station. Every time a station loads either the kernel or an application, it is an opportunity to get a fresh updated copy of the software since it only needs to be updated on the server in order to be propagated to all stations.

IPL Considerations Summary

- **No local file storage**
  - **all software (including kernel) must be downloaded from a server !**
- **Network Station only supports TCP/IP**
  - **no NetBIOS, IPX, etc.**
- **Boot Monitor stored in flash memory**
  - **easy to update for new features/fixes**
- **Nonvolatile RAM (NVRAM)**
  - **contains information about the Network Station hardware and boot environment**
    - keyboard Language
    - screen resolution
    - selectable boot processes
- **Media Access Control (MAC) LAN address**

Notes

Here are a few reminders of some of the important boot considerations:

- There is no local file storage on the station; therefore all software (including kernel) must be downloaded from a server !
- The Network Station only supports the TCP/IP protocol and must therefore be attached to an IP network. NetBIOS, IPX/SPX, etc.. are not supported.
- The Boot Monitor is stored in flash memory and is easy to update for new features/fixes
- The Nonvolatile RAM (NVRAM) contains information about the Network Station hardware and boot environment such as keyboard Language, screen resolution and the selectable boot processes
- The MAC address is burned in to the adapter but can also be changed to an LAA type address.

Boot Monitor

- POST (power on self test)
  - Boot Monitor Version (boot code)
  - Video Memory Test
  - RAM Memory Test
  - Keyboard Controller
- BOS
  - Keyboard, Mouse, Display
  - Network Access
    - Ethernet, Token Ring
- Setup Utility
  - Set Network Parameters
  - Set Boot Parameters
  - Set Monitor Resolutions
  - Set Keyboard Language

Notes

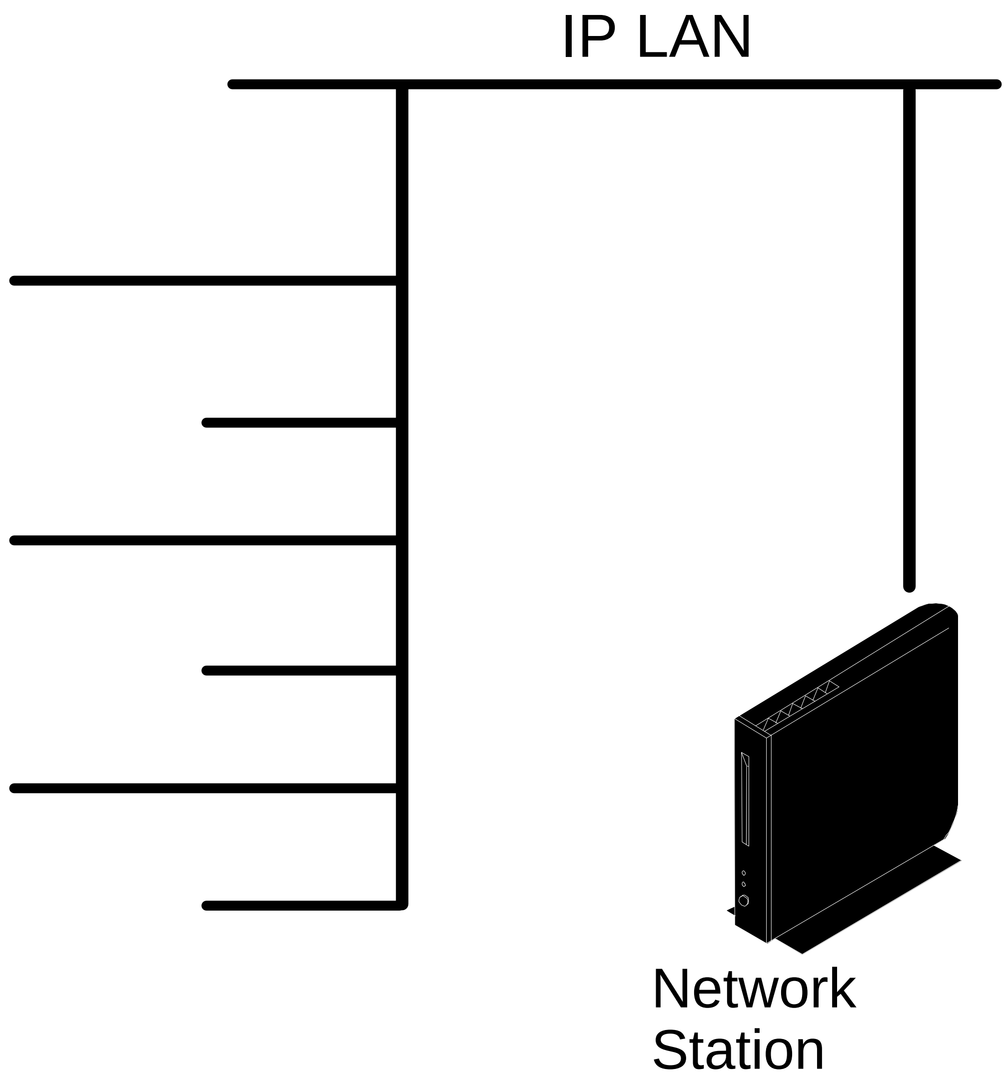
The boot monitor that resides in the PROM is responsible for:

- Executing the POST (power on self test) that verifies the boot Monitor Version (boot code), Video Memory, the RAM and Keyboard Controller
- BOS verifies the Keyboard, Mouse, and Display and the Network Access (Ethernet or Token Ring)

The boot monitor also offers a Setup Utility to allow the administrator to perform the following configuration tasks:

- Set Network Parameters, to specify the address of the station, the subnet mask, the gateway address and all such parameters that allows this station to function as an IP host
- Set Boot Parameters, that identifies the address of a boot server and the location of the operating system file that needs to be downloaded. There are other servers such as configuration servers and authentication servers that may need to be specified
- Set specific station characteristics such as Monitor Resolution and Keyboard Language

LAN Boot Logical Architecture



Notes

Lets us now get on to the next major and interesting topic, that of the boot process.

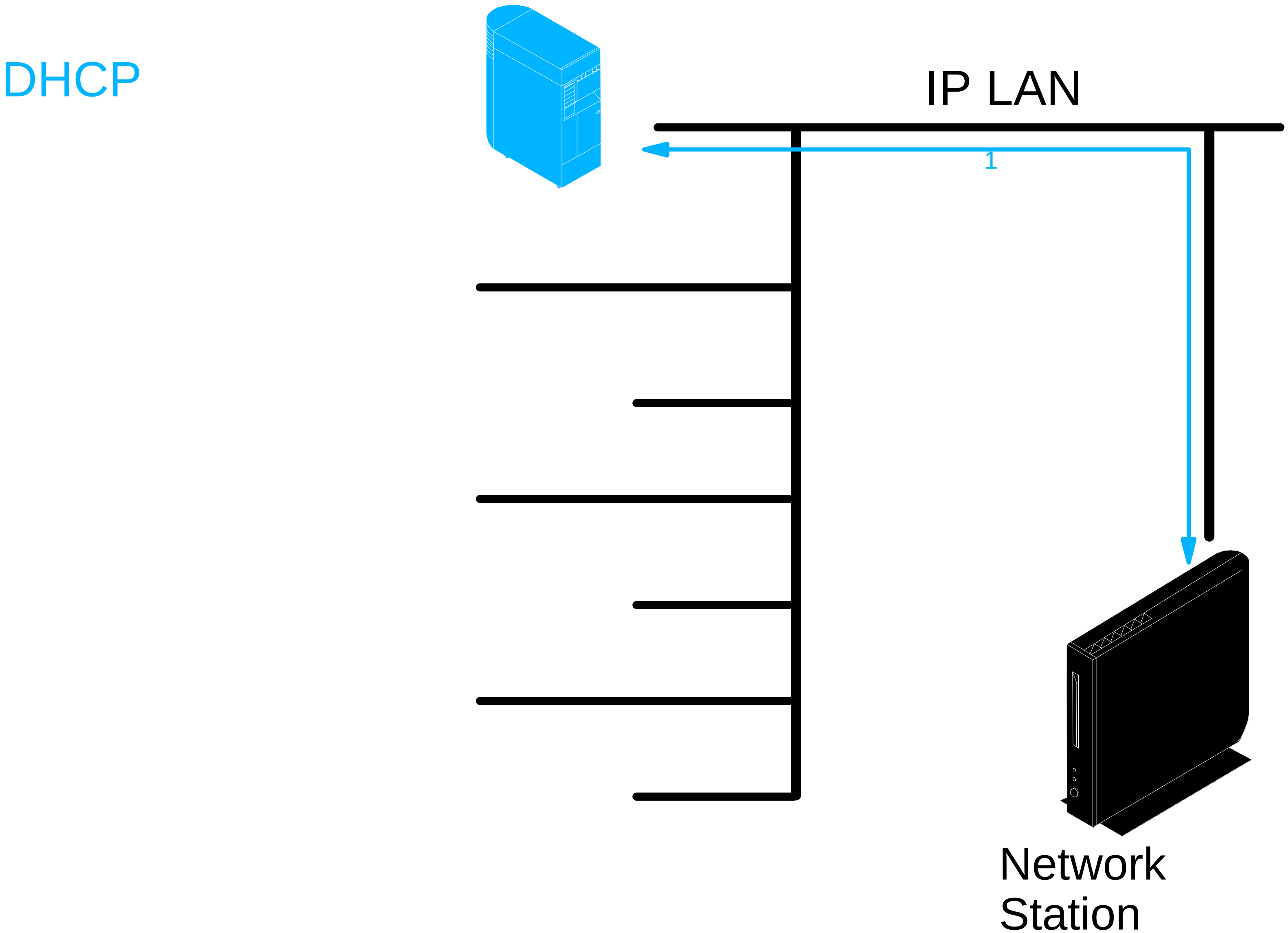
We define the boot process as all the activities that must take place between the time that the user powers on the Network Station and the time where the user is able to load an application to do some useful work.

When broken down into the individual events, there are quite a significant number of activities that must take place as part of the boot process, so we will use a step by step approach to identify each of the important steps, gradually building a diagram that summarizes all the major steps.

In this chart we first attach a Network Station to an IP LAN network. The important point to remember is that the Network Station only supports TCP/IP so it must be attached to an IP network.

After the station is powered on and has executed the POST tests, the boot monitor, stored in the station's PROM chip opens the network interface adapter to insert itself into the network.
It uses the Media Access Control (MAC) LAN address that was stored in the nonvolatile memory (NVRAM) along with data such as keyboard layout and screen resolution. From this point on, this station can uniquely identify itself on the network by using its MAC address.

LAN Boot Logical Architecture



Notes

The Network Station is an IP host, and therefore, in order to communicate with other IP hosts, it needs to have an IP address of its own. This IP address can be obtained either from NVRAM or from a BOOTP or DHCP server on the network.

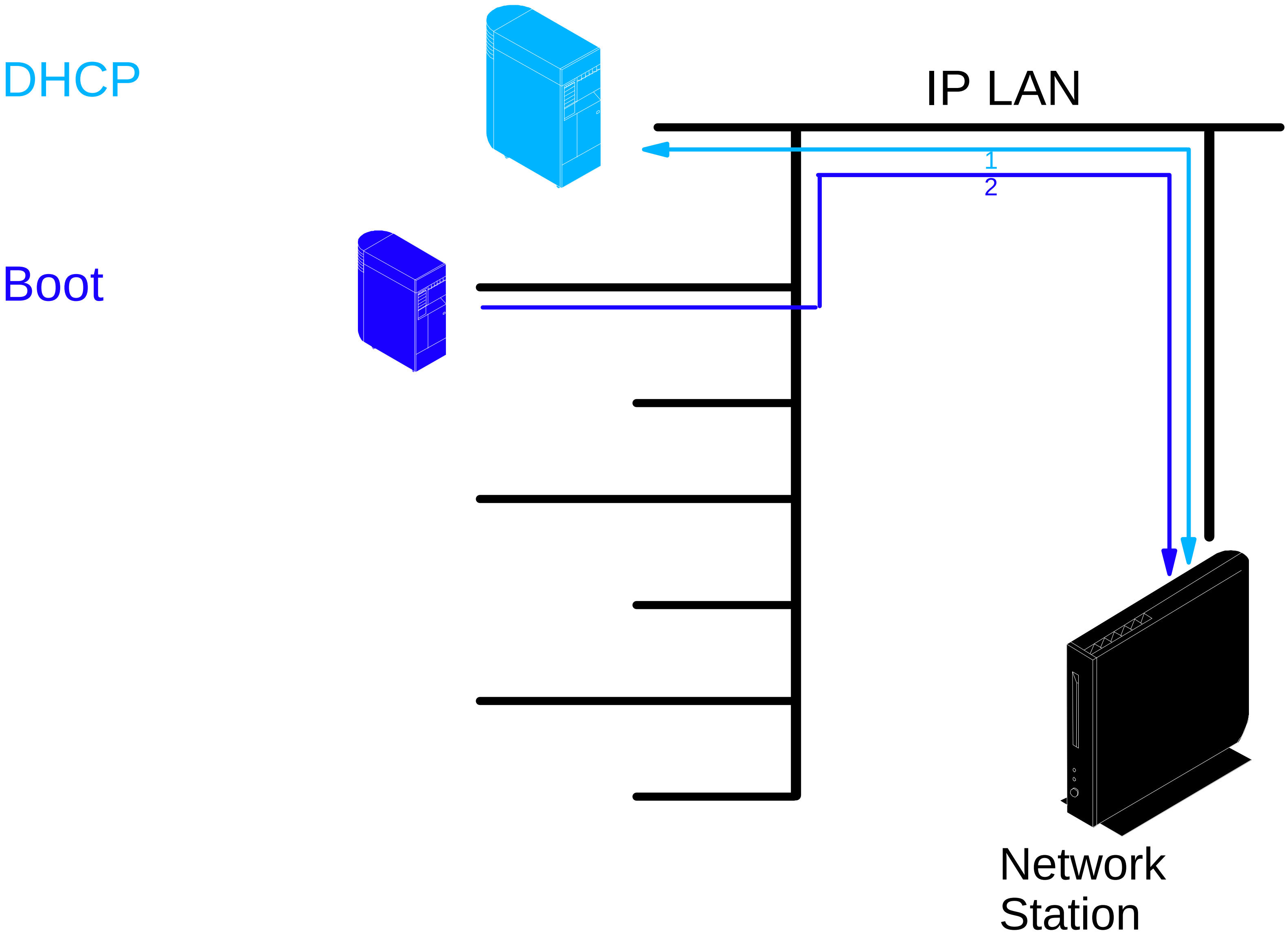
Here we use the DHCP server method, which is the recommended method. We discuss the advantages and disadvantages of each of these methods in the Planning and Design topic.

To obtain an IP address from a DHCP server, the station issues a broadcast (that's the only thing it can really do at this point since it does not yet have or own an IP address) on the network asking any DHCP server that is listening to respond by sending an IP address that it can use. Contained in this broadcast frame is the station's MAC address, which allows the station to uniquely identify itself to DHCP servers.

On receipt of this broadcast, one (or possibly more than one) DHCP server on the network responds by allocating an IP address that the station is allowed to use for a specified period of time. Note that the server can specifically recognize the station by its MAC address (if this MAC address has been specifically defined in the server) or it can choose to respond to requests originating from any MAC address.

Along with an IP address, the DHCP server can also send other vital pieces of information such as the address of a boot server that the station should contact to obtain its operating system, and the path to the directory where the operating system file can be found, and a few other pieces of configuration data which we will examine in more details later.

LAN Boot Logical Architecture



Notes

Now that the station has its own IP address, it is a recognized citizen on the network and has the ability to communicate directly with any other IP host on the network.
Its next important task is to obtain a copy of the operating system that it requires to operate.

There are two ways of obtaining its operating system:

- The station contacts a designated boot server on the network from which it downloads a copy of the operating system. This is the example we use here as this is the most common case.
- Or, if the station is equipped with a flash memory card, it can be configured to load its operating system directly from this local storage device. This is a special case that will be examined later.

Using the address of a boot server that was obtained from the DHCP server, the station contacts the designated boot server and downloads a copy of its operating system.

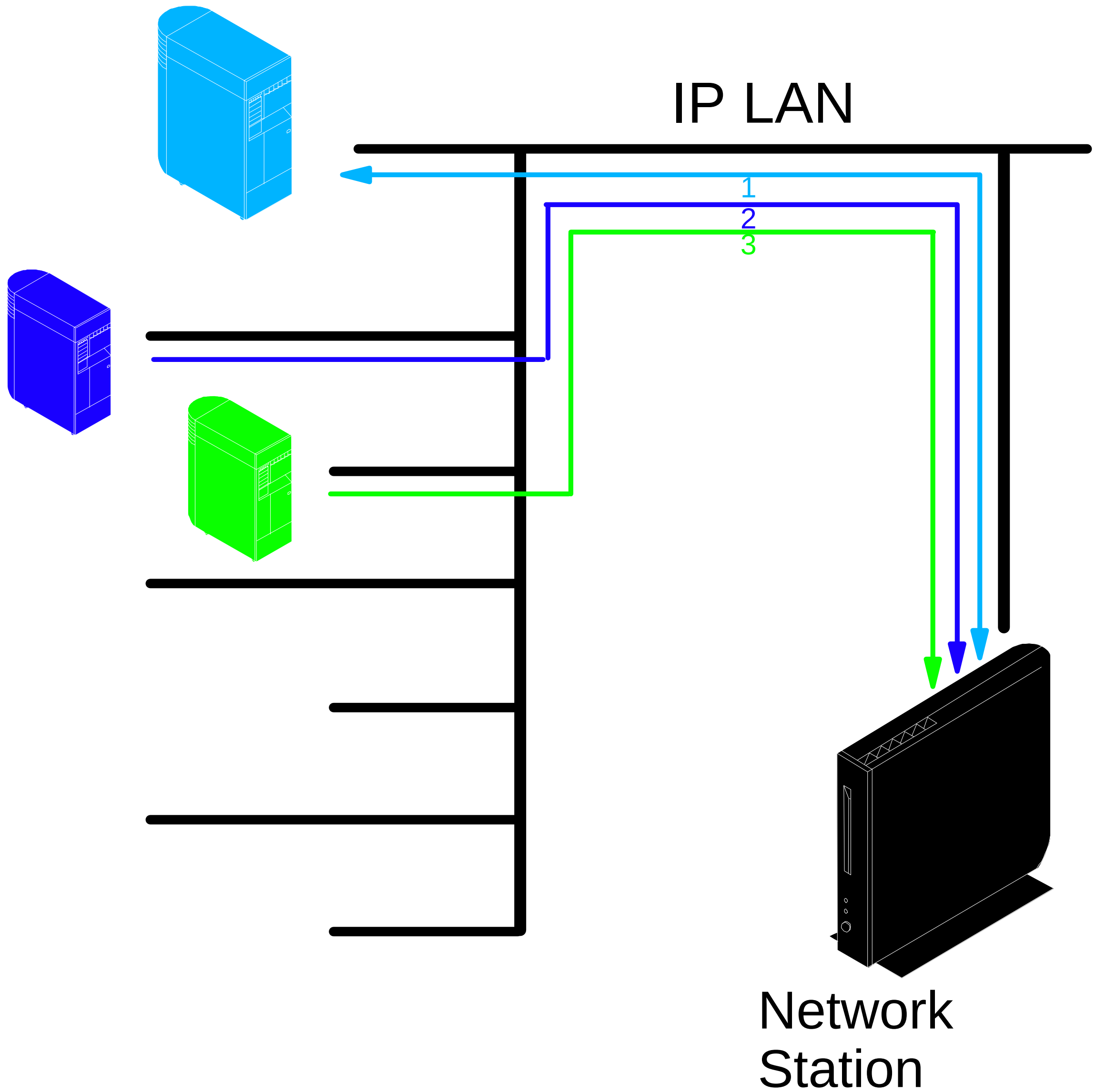
Typically, in the later releases, the operating system (which we will call the kernel from now on) is downloaded in compressed format in order to make the transfer faster and is uncompressed by the station after receipt.

LAN Boot Logical Architecture

DHCP

Boot

Configs



Notes

The next task in the boot process is to set up the operational environment for this particular station by obtaining some system configuration data from a configuration server.

System configuration data at this point are parameters such as:
- Does this specific station have a printer attached?
- What language is to be used during the boot sequence?

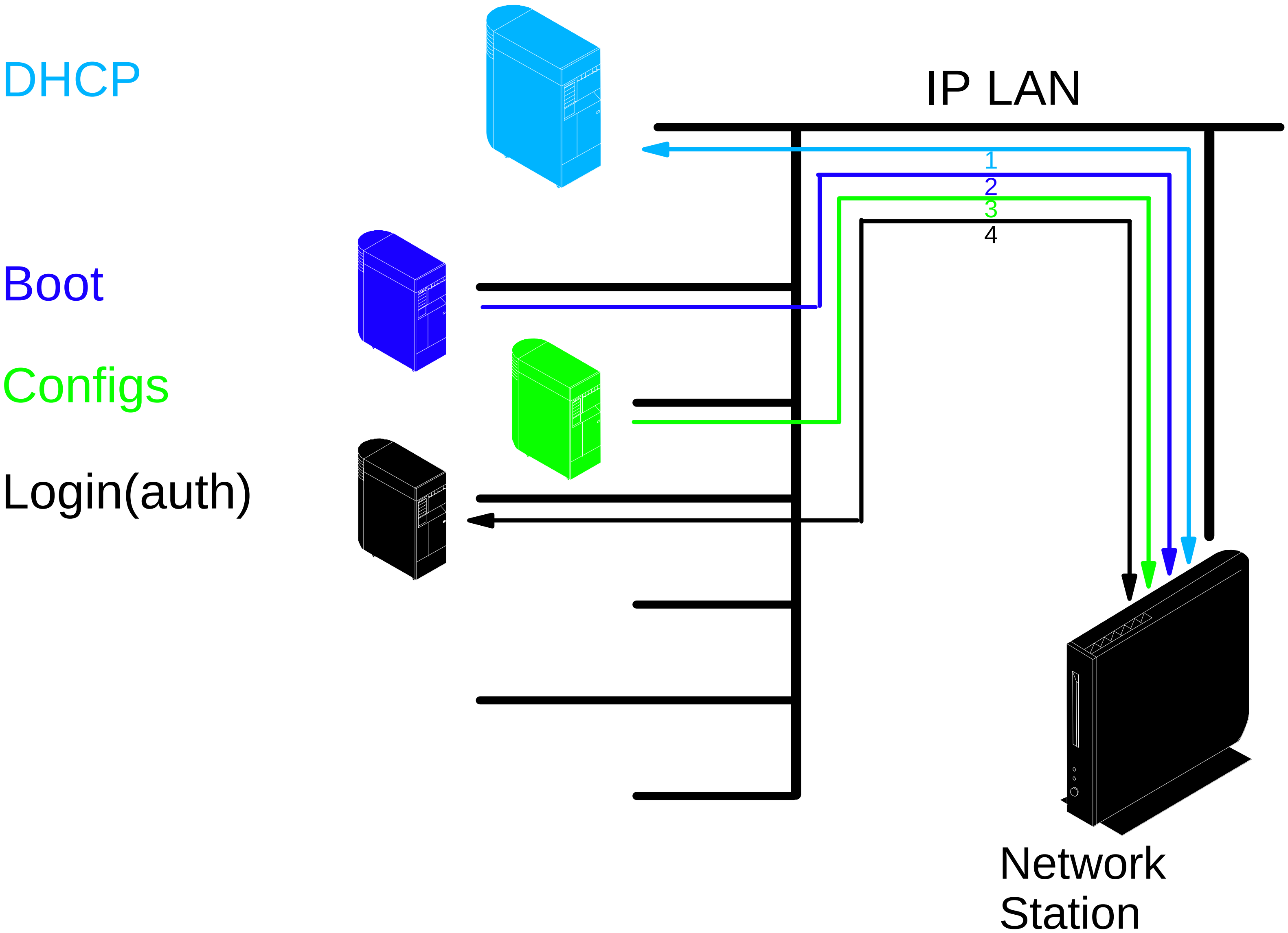
and system defaults such as :
- Is the mouse defined as right-handed or left-handed for all users?
- What is the background color of the screen?
- What is the screen saver background bitmap?

In this description, we are showing this configuration server to be a separate physical server, but it does not necessarily have to be. It could be on the same server as the boot server for example. However, because we are focusing more on the concepts here than on the actual implementation, we are using separate servers.

How does the kernel know the address of the configuration server where the configuration files are stored? This address is supplied to the Network Station either as one of the pieces of information returned by the DHCP server, or as a manually configured parameter in NVRAM.

The kernel contacts the designated configuration server and downloads the system configuration files. Some of the parameters considered as system defaults may be overridden later on by additional configuration files that are applicable to a group or a specific user.

LAN Boot Logical Architecture



Notes

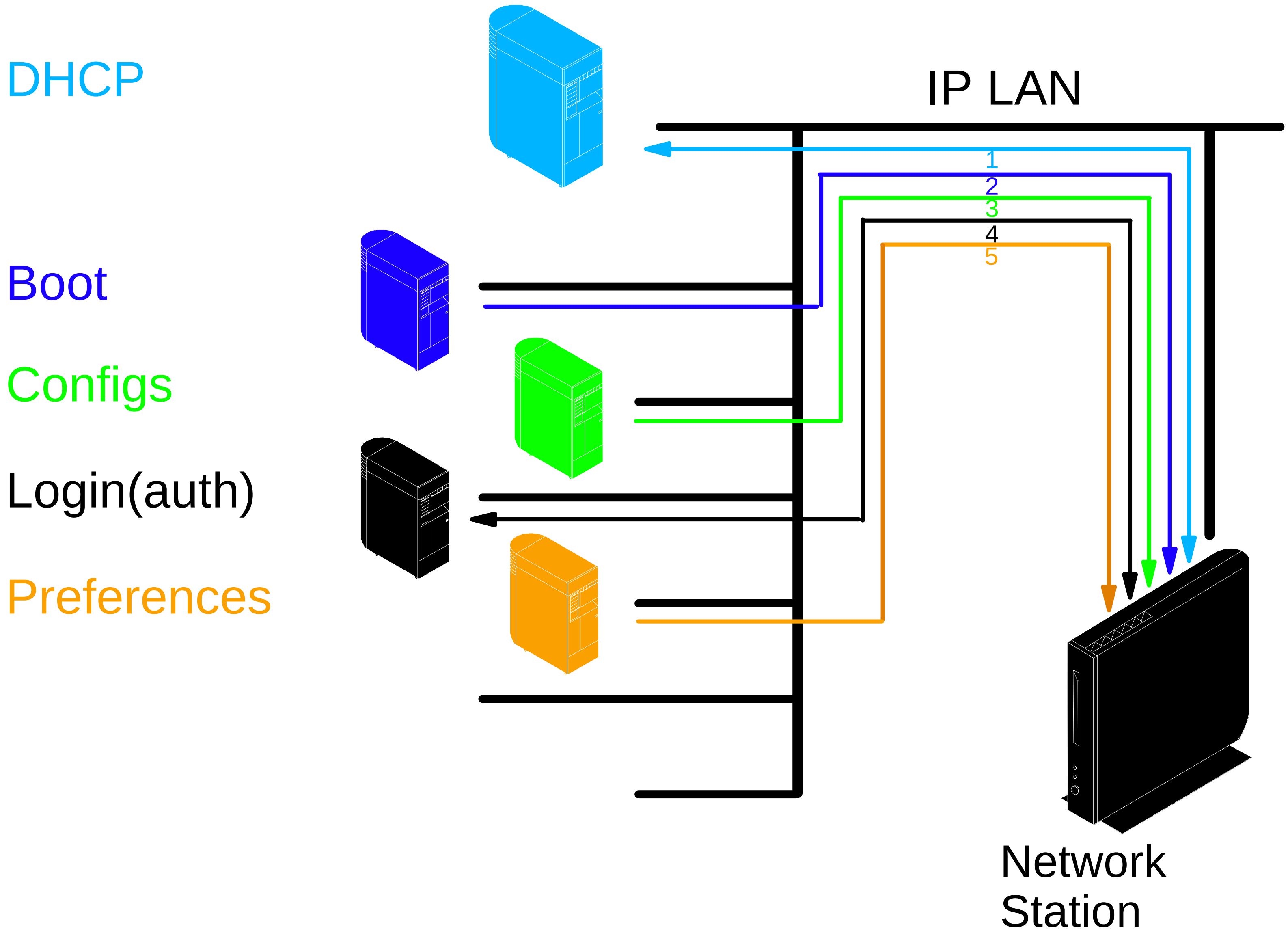
The next major step in the boot process is to identify the user that will be using the Network Station. The kernel gives control to a login client routine that displays a panel to the user asking for a user name and password.

The login client then contacts an authentication server to validate the identity of the user and that the correct password is used.

How does the login client know the address of the authentication server? There are three possibilities:

- Unless it is specifically identified, the default authentication server is the same server as the boot server
- The address of the authentication server has been specified in the DHCP data (or manually configured in NVRAM)
- The user has used the ROAM button on the login panel to manually enter the address of a specific authentication server. This is used in case where a user has traveled to a different location and needs to be authenticated by a server back home.

LAN Boot Logical Architecture



Notes

Once the user has been authenticated, the kernel now knows the user and the group it belongs to and is therefore in a position to download additional configuration files that are specific to this group and this user.

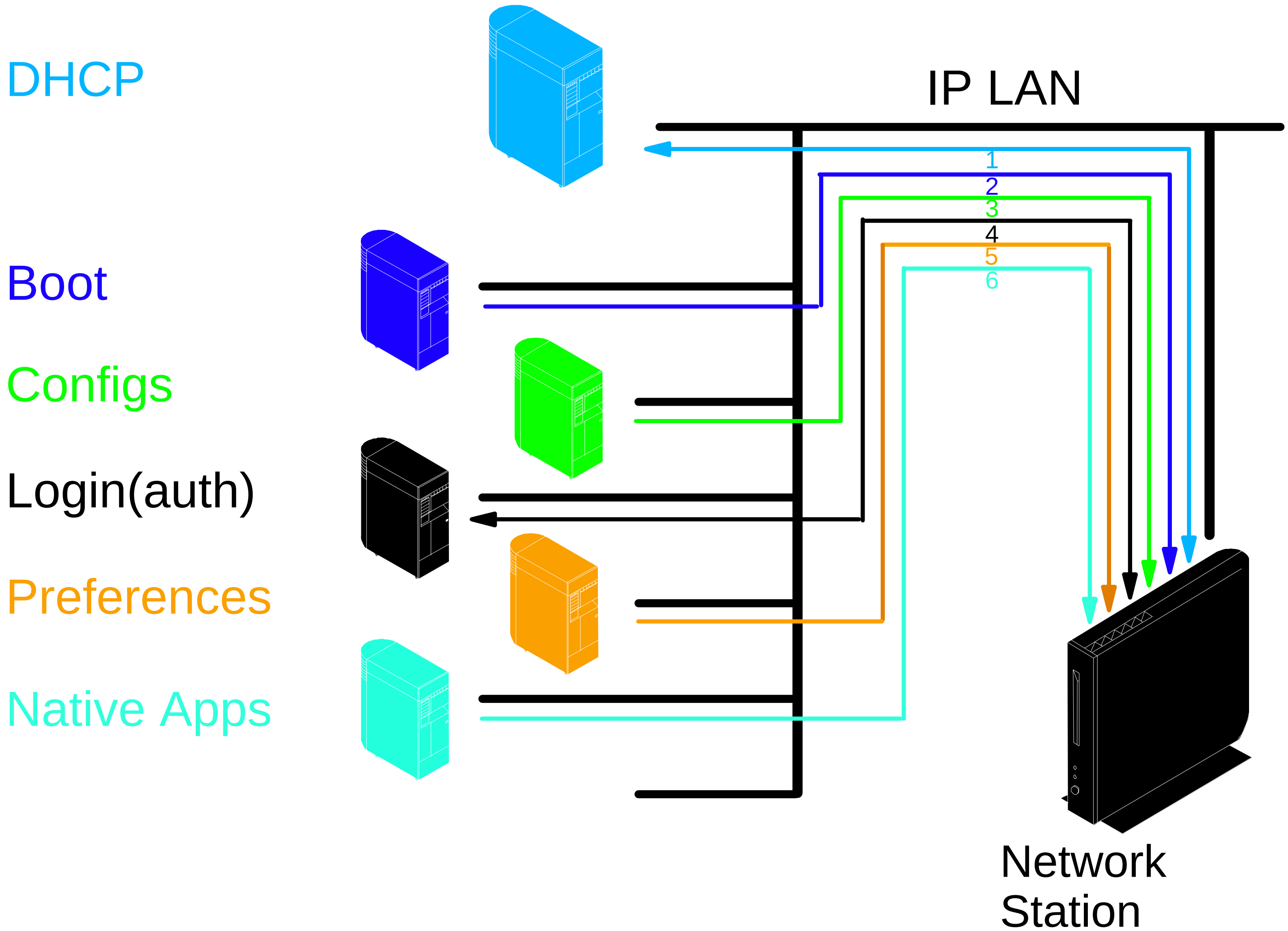
These configuration files are called the user preferences (configuration data) because they represent the specific user preferences, such as a left handed mouse when the system default is right handed, or a particular set of colors for the desktop, etc..

In the current versions of the product (V1R3 and V2R1), the preferences server is always the same as the authentication server, although there is a possibility to change this by a manual alteration of one of the configuration files.

The kernel fetches the preferences configuration files based on the user name and group name, and overrides the system defaults parameters for those parameters contained in the preferences files.

The preferences files also contain the information necessary to identify the applications that are to be autostarted based on the user profile, and also the setup of the desktop and the applications to be made available to the user.

LAN Boot Logical Architecture



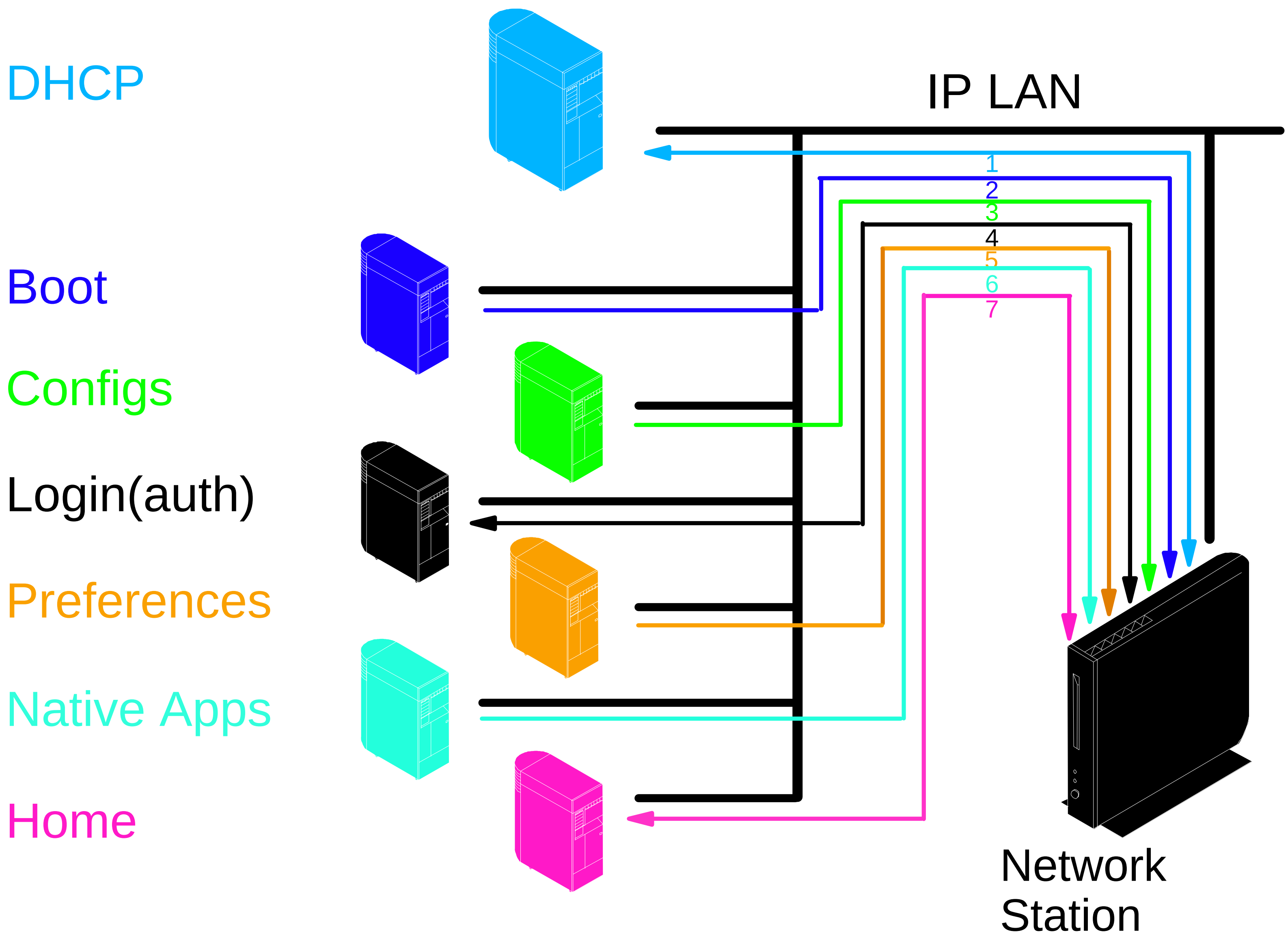
Notes

The next step is to load the applications that are specified as autostarted, or to load applications on request when the user click on a specific icon on the desktop to start an application.

The native applications, such as the emulators, or any Java application or applets, are modules that need to be downloaded from a server.

The native applications server is by default the same as the boot server and cannot be specified otherwise at this point in time.

LAN Boot Logical Architecture



Notes

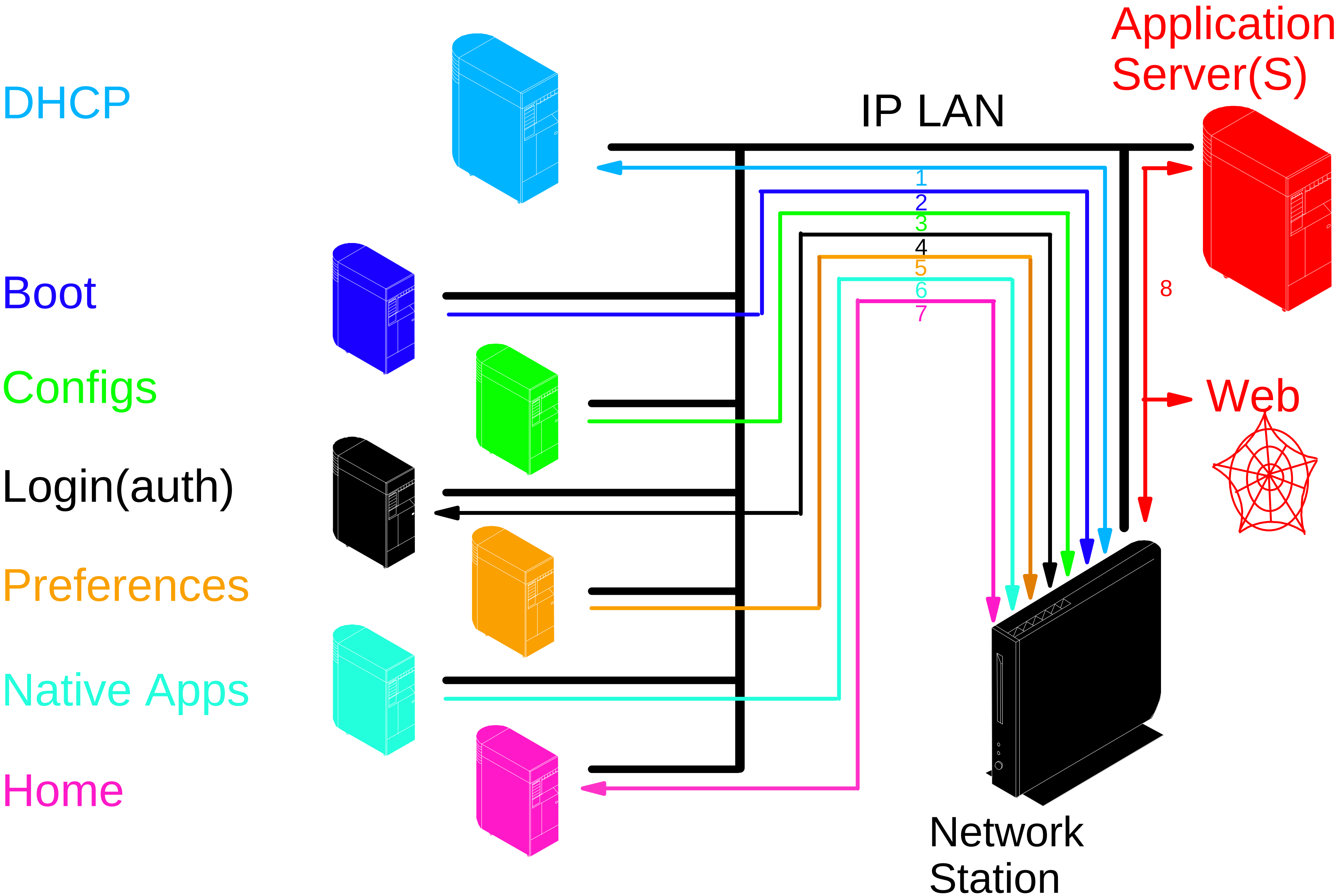
Some of the native applications allow the user to set applications preferences, such as emulator colors for example, or, in the case of a browser, to save some bookmarks.

Because there is no local storage on the Network Station where these application preferences can be stored, each user is given a home directory on a server where these can be stored. This server is called the home server and, at this point, is the same sever as the authentication server.

The home directory on the home server is automatically allocated to each user that logs on without the user having to take any specific steps for that to happen. If the user has some home grown local Java applications that he needs to use, and these applications require some local storage, the home server can serve as the target server for these files.

However, this is not mandatory because in fact any remote server can be designated as a file server and be accessed by local applications.

LAN Boot Logical Architecture



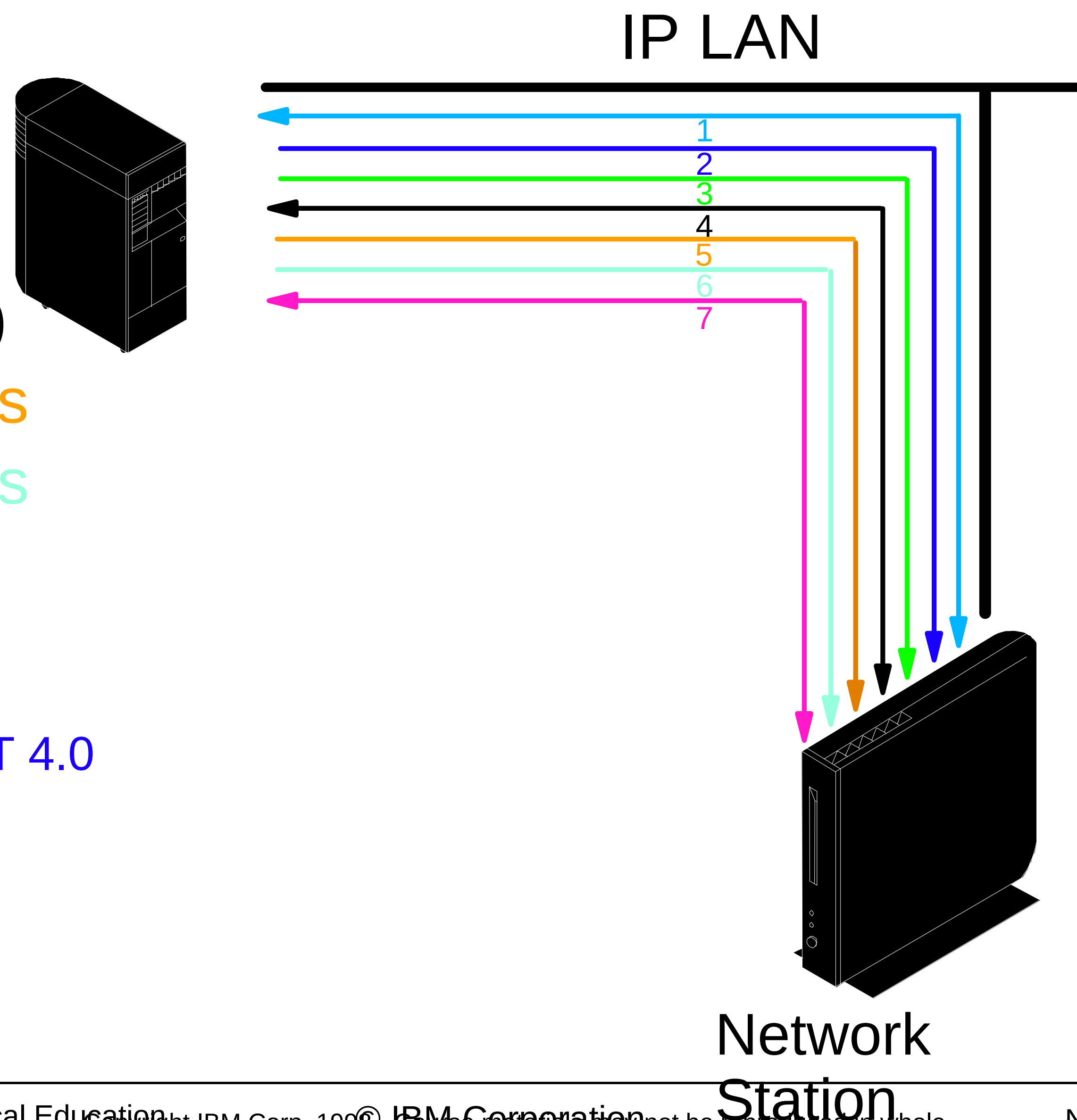
Notes

At this point, the boot process is essentially completed and the user has full control of his desktop.

As the user starts different applications, it is likely that he will access one or more application servers. For example, using a 3270 emulator will cause the user to contact a S/390 server, using a 5250 application means accessing an AS/400 server, using an ICA client means accessing a MetaFrame server, and using a Web Browser will give him access to the Web.

LAN Boot Architecture - Workgroup < 50 users

DHCP
Boot
Configs
Login(auth)
Preferences
Native Apps
Home
- AS/400
- RS/6000
- Windows NT 4.0



Notes

All the servers we looked at so far have been logically and physically separated in the diagram that we built. In practice however, some of these logical servers are actually combined and reside on one physical machine.

For example, here is an environment that would be typical for a small workgroup, say between 10 and 50 users. This case might be representative of a small AS/400 installation, or a small Microsoft Windows NT Terminal Server Edition installation, for example.

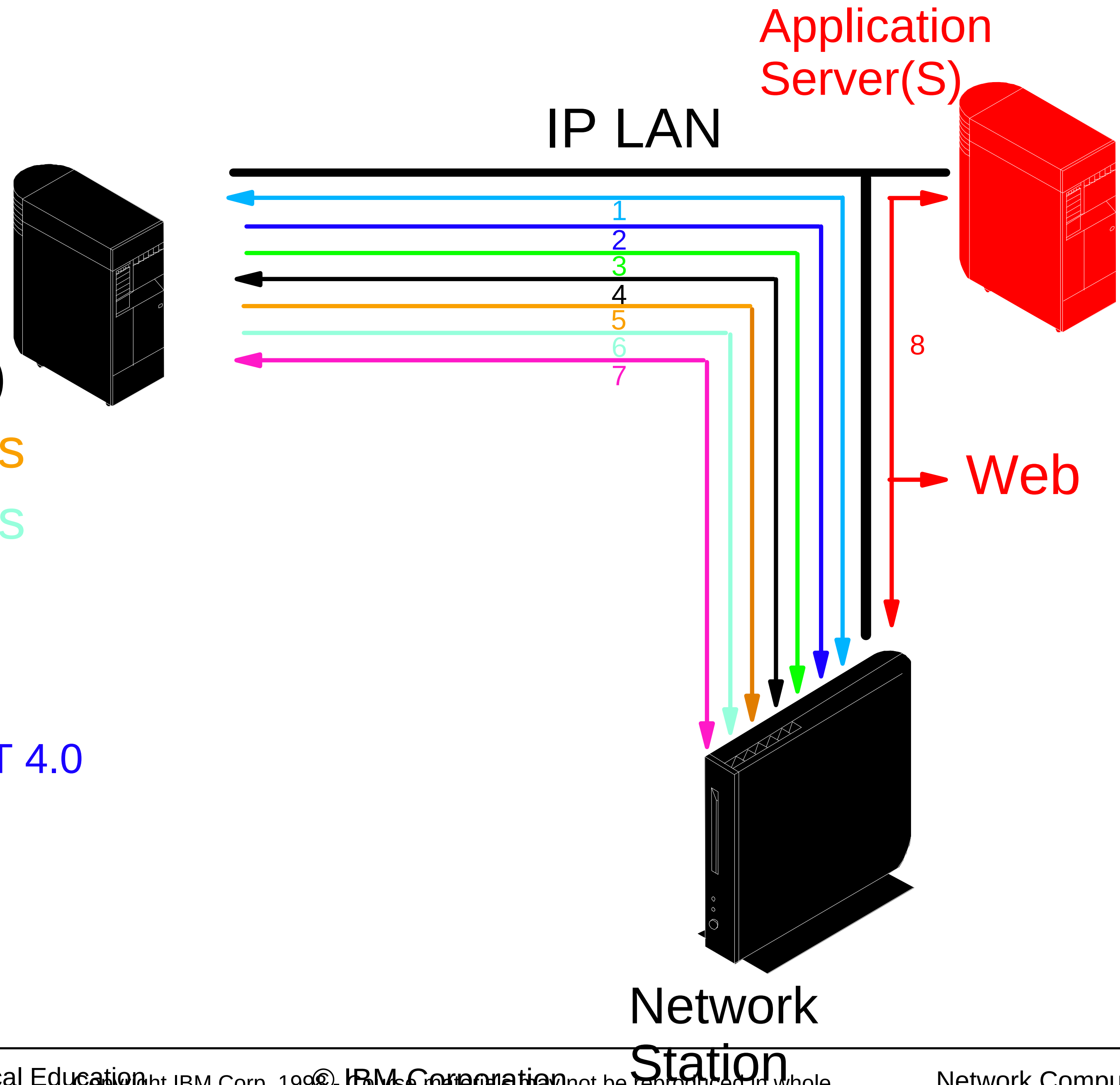
All the components are on a local LAN segment and the total number of users that can be handled is really dependent on the overall network traffic that they generate.

The servers used could be AS/400, or RS/600 or PC servers and it is possible to have a mix of servers although that would probably be unusual in such a small environment because of the skills required to maintain multiple platforms.

In this case, all logical servers are actually combined into one physical machine.

LAN Boot Architecture - Workgroup < 50 users

DHCP
Boot
Configs
Login(auth)
Preferences
Native Apps
Home
- AS/400
- RS/6000
- Windows NT 4.0

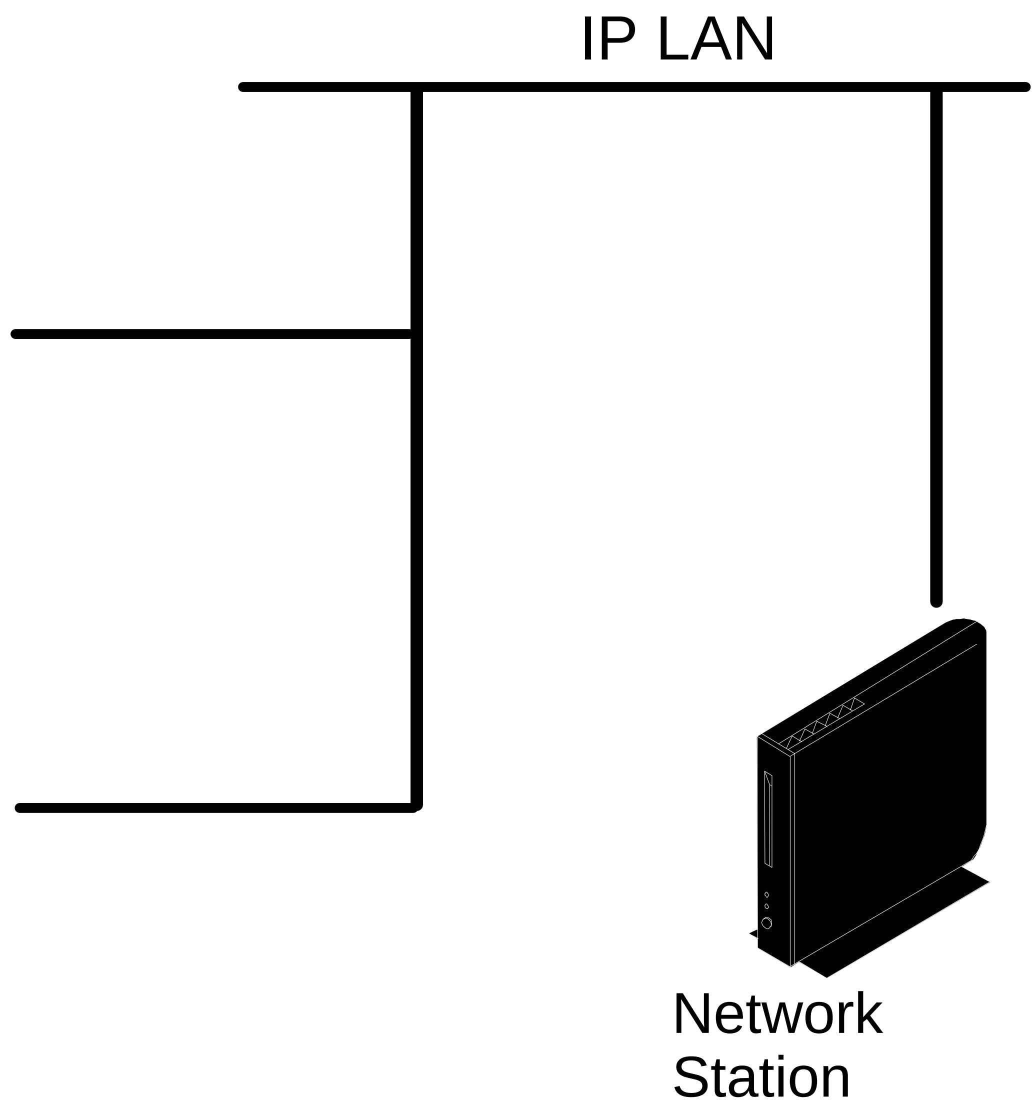


Notes

Once a station has completed its boot process by accessing this one server for all the logical server functions it requires, it can then access any application server it needs for the user applications.

In this case, we have shown a DHCP server but if there were a small enough number of stations, NVRAM might be considered.

LAN Boot Architecture - Workgroup > 50 users



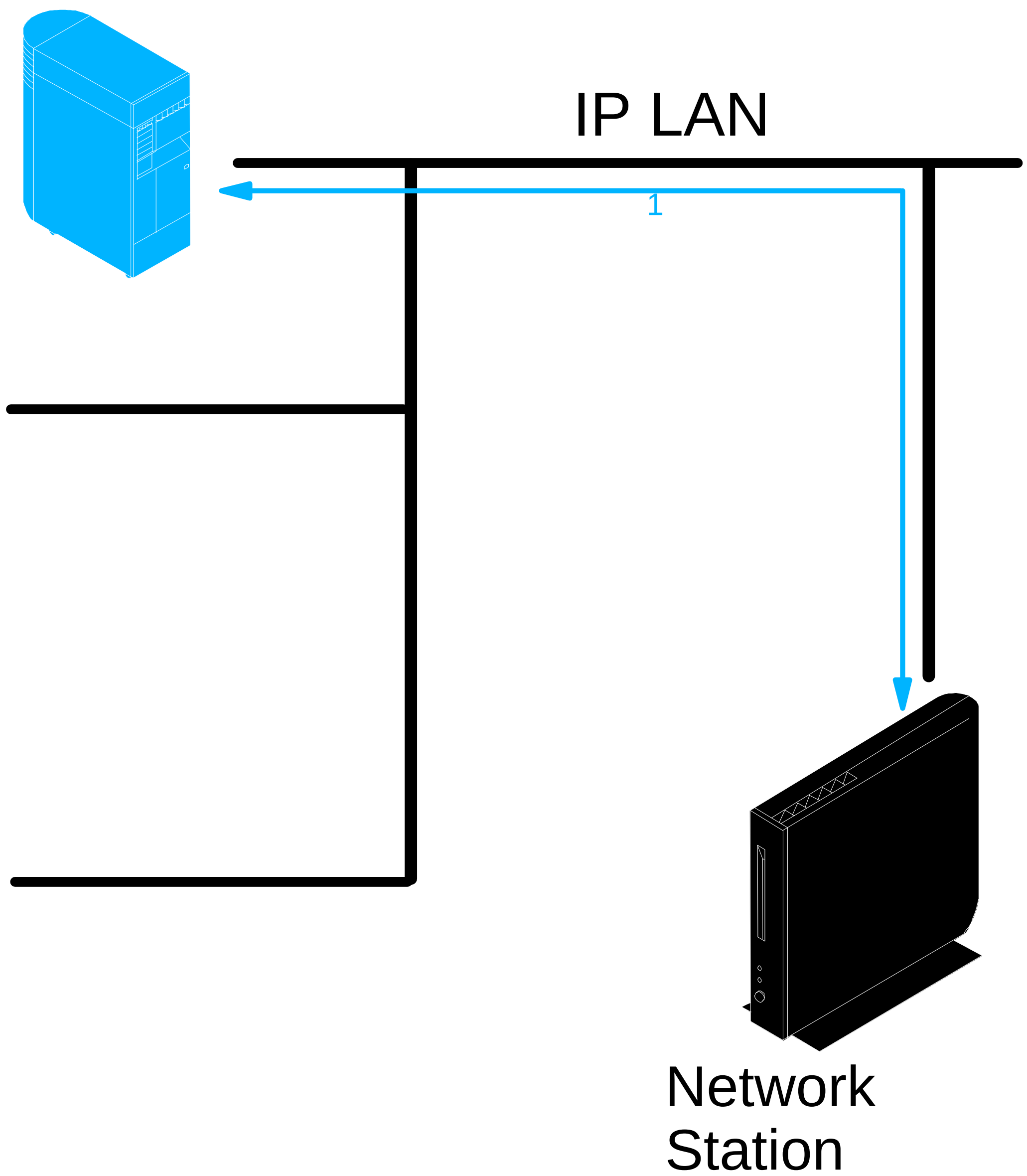
Notes

As we stay within a local LAN environment but move to a larger workgroup where the number of users is above 50, there are a few more considerations that come into play, such as the need to use multiple boot servers to maintain a reasonable performance, the need to monitor the capacity of the LAN, and a greater need to plan for a worst case scenario and for backup mechanisms.

In this case, it starts to make sense to separate the server functions.

LAN Boot Architecture - Workgroup > 50 users

DHCP



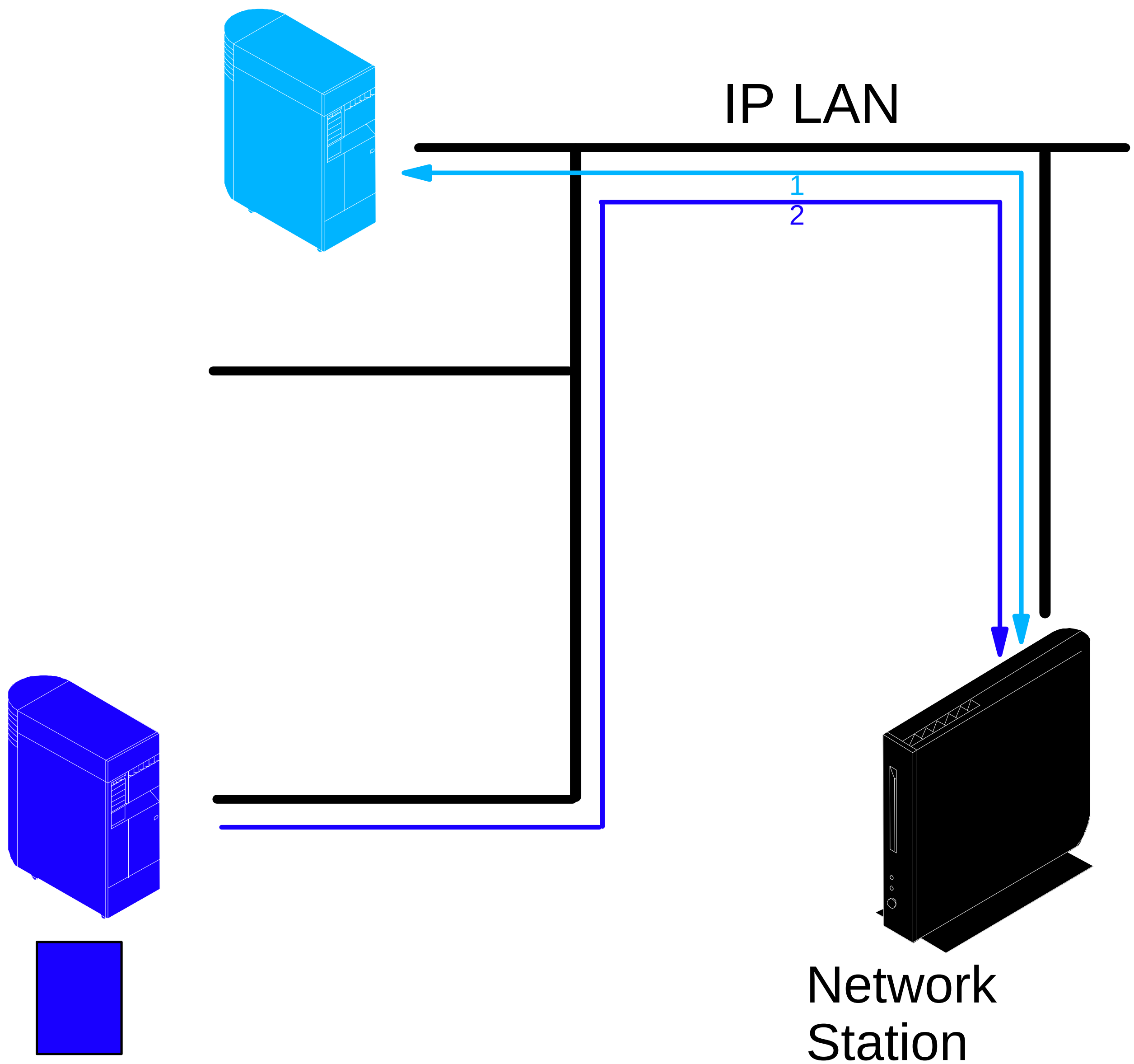
Notes

Because of the larger number of users, a DHCP server should now be used to facilitate the management of IP addresses and to have the flexibility to easily reassign where the stations boot from, as an example, in cases where we want to start use load balancing on in emergency situations.

Whether to use multiple DHCP servers and where to locate these servers becomes a question of overall network planning and design, as well as network policies within the organization. See the next Planning and design topic for a few additional details on this issue.

LAN Boot Architecture - Workgroup > 50 users

DHCP



Boot
- AS/400
- RS/6000
- Windows NT 4.0
- Flash Card

Notes

In this case, we need more than one boot server to satisfy the needs of all the stations and we might install a boot server on each LAN segment, if there are multiple segments, or allocate a boot server to IP subnets and manage this through the DHCP server.

All of this is highly dependent on the actual topology of the network and traffic volumes and patterns.

Another possibility for a booting Network Stations is to use a flash card boot. A flash card is like a local storage device on which can be recorded the files that are needed for booting a station, such as the kernel, the fonts and the application modules.

The card is inserted into the Network Station and the boot monitor is directed to read these files from the local card instead of from a server on the network.

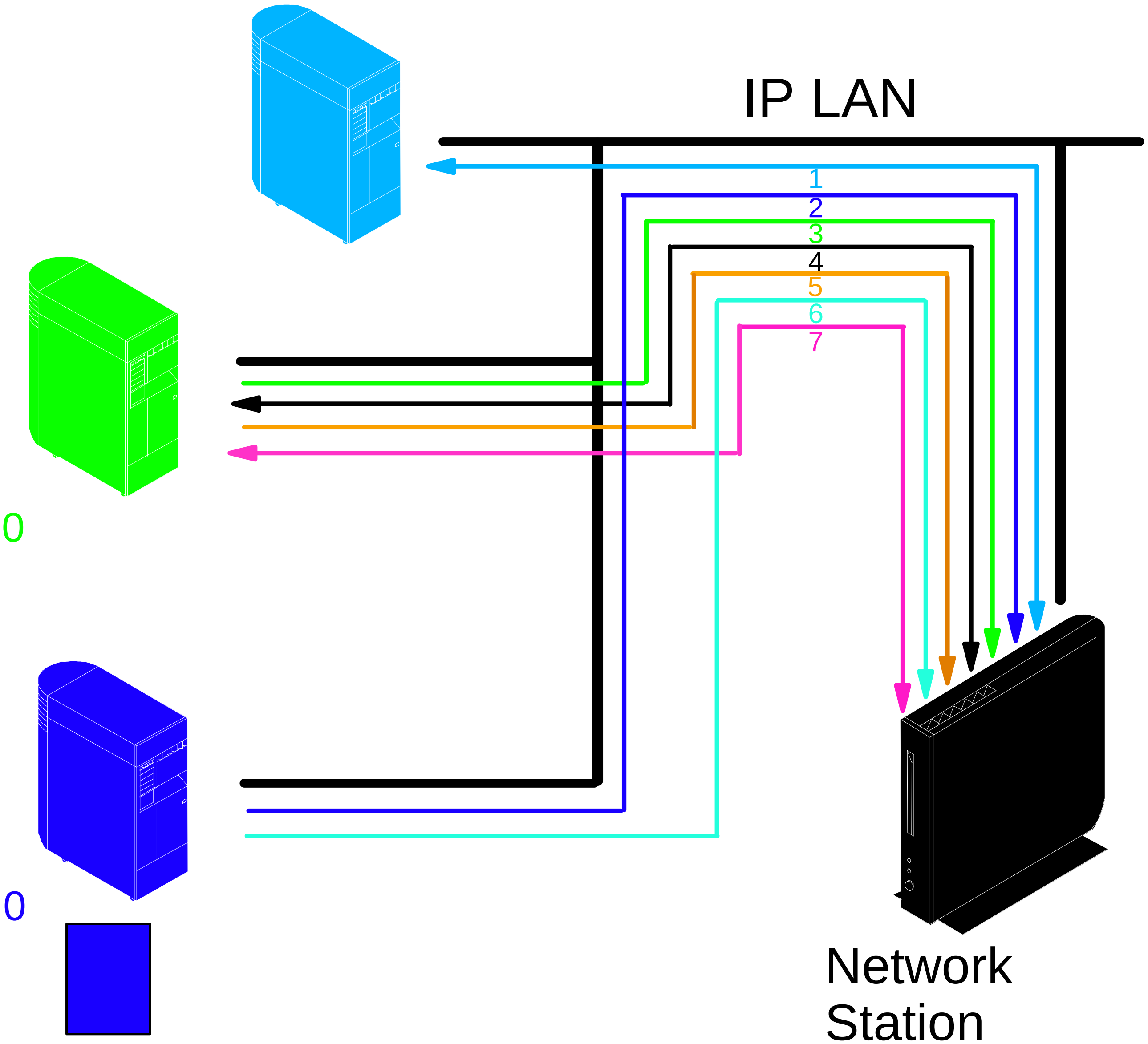
This can be advantageous where there are a small number of users in a remote office connected through a low bandwidth link and where a boot server in such as small location becomes hard to justify. Other Network Stations (from 10 to 15 stations) can also boot from another Network Station which has a boot flash card in a process called peer booting.

LAN Boot Architecture - Workgroup > 50 users

DHCP

Home
Preferences
Login(auth)
Configs
- AS/400
- RS/6000
- Windows NT 4.0

Native Apps
Boot
- AS/400
- RS/6000
- Windows NT 4.0
- Flash Card



Notes

All the other servers, such as the Configuration, Authentication, Preferences and Home servers are combined on the same physical machine, where we also have the Network Station Manager application that can be used to manage the configuration files for system and user definitions.

Typically, these configuration files are small, compared to the kernel and application modules, and therefore the load on such a server is much less than on a boot server.

From an administrative point of view, it is much easier to combine all of the configuration data and user accounts on one server rather than have to manage multiple sets of configuration files on multiple servers.

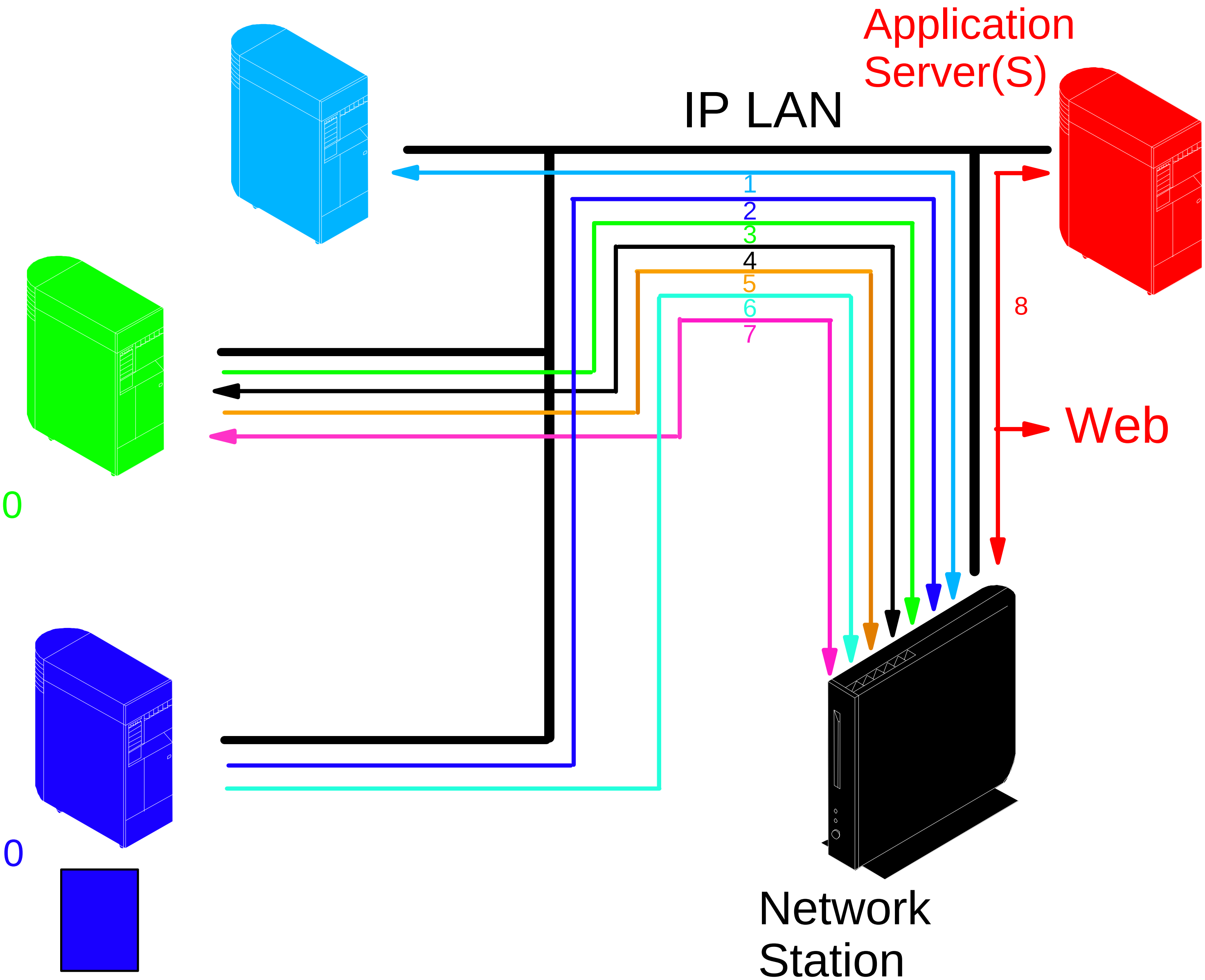
In a Windows NT environment, even though this server could potentially reside on the same machine than a backup domain controller, an analysis would be required first to determine whether this can negatively impact the performance of the BDC. Typically, PDC and BDC are machines that should be dedicated to these functions.

LAN Boot Architecture - Workgroup > 50 users

DHCP

Home
Preferences
Login(auth)
Configs
- AS/400
- RS/6000
- Windows NT 4.0

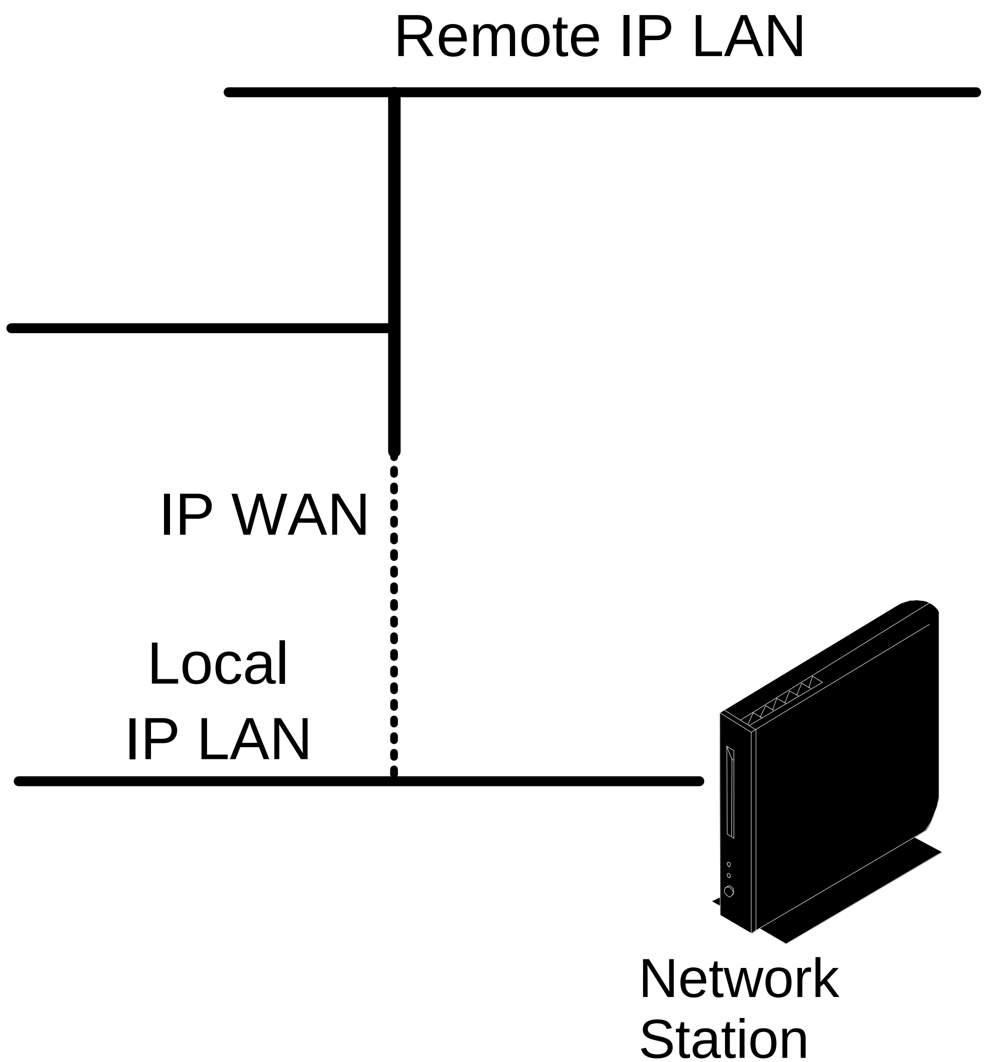
Native Apps
Boot
- AS/400
- RS/6000
- Windows NT 4.0
- Flash Card



Notes

Once again, our Network Stations are up and operational from using these three separate servers and they can then access their multiple applications servers just like any other hosts.

LAN/WAN Boot Architecture - Enterprise > 500 users



Notes

Here is a large enterprise environment example, based on a real customer with upwards of 5000 users in 65 remote branches.

This customers uses a centralized management approach at the headquarters location and uses network management tools such as Tivoli's IT Director and others to manage the remote servers and the Network Stations.

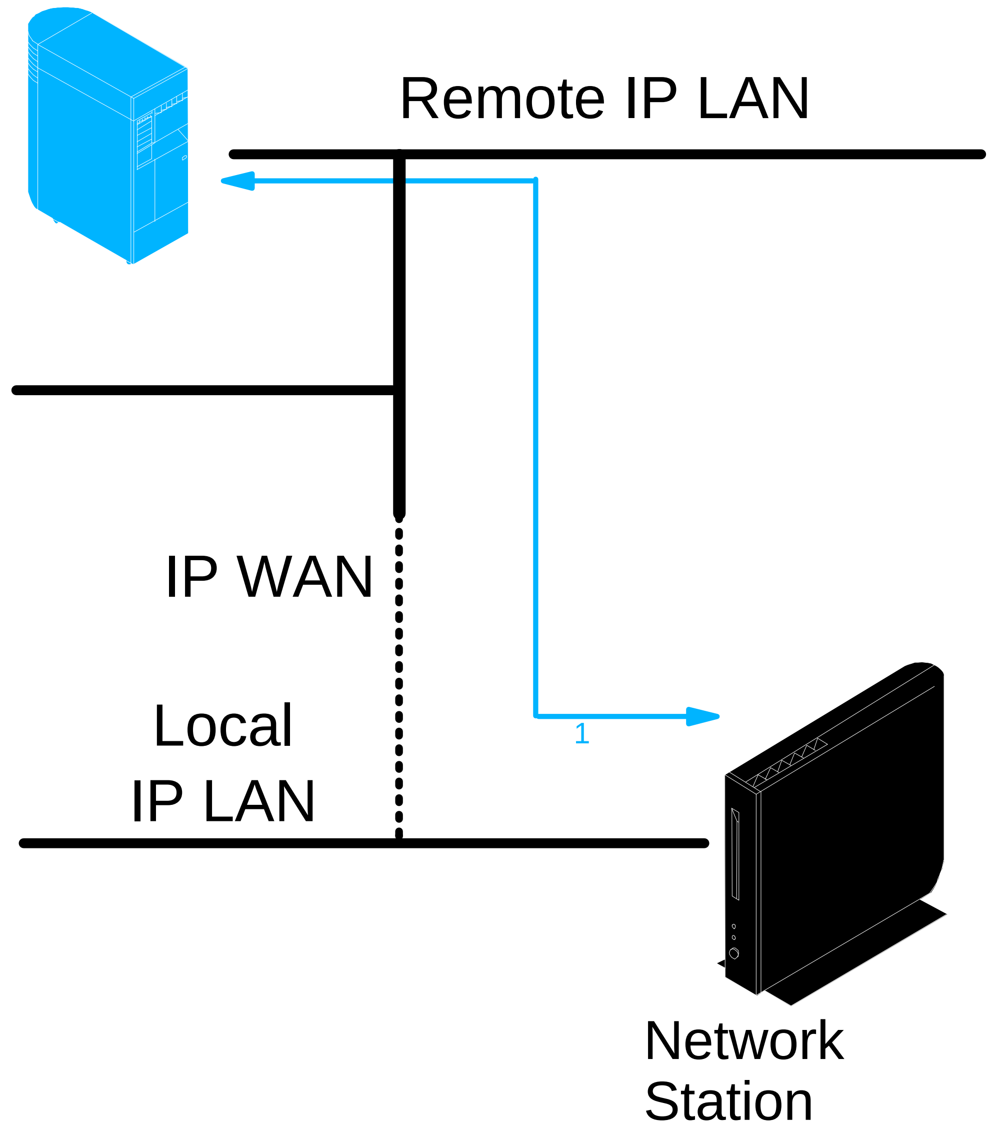
The Network Stations have SNMP MIB capabilities (read only) and can be rebooted remotely from a central location.

The branch offices have no local Information Technology staff because the actual Network Stations are very easy to install and maintain; they can be installed and plugged in right out of the box without any other intervention.

The local branch offices all have local LANs which are connected to the corporate central LAN through a variety of Wide Area Network links.

LAN/WAN Boot Architecture - Enterprise > 500 users

DHCP



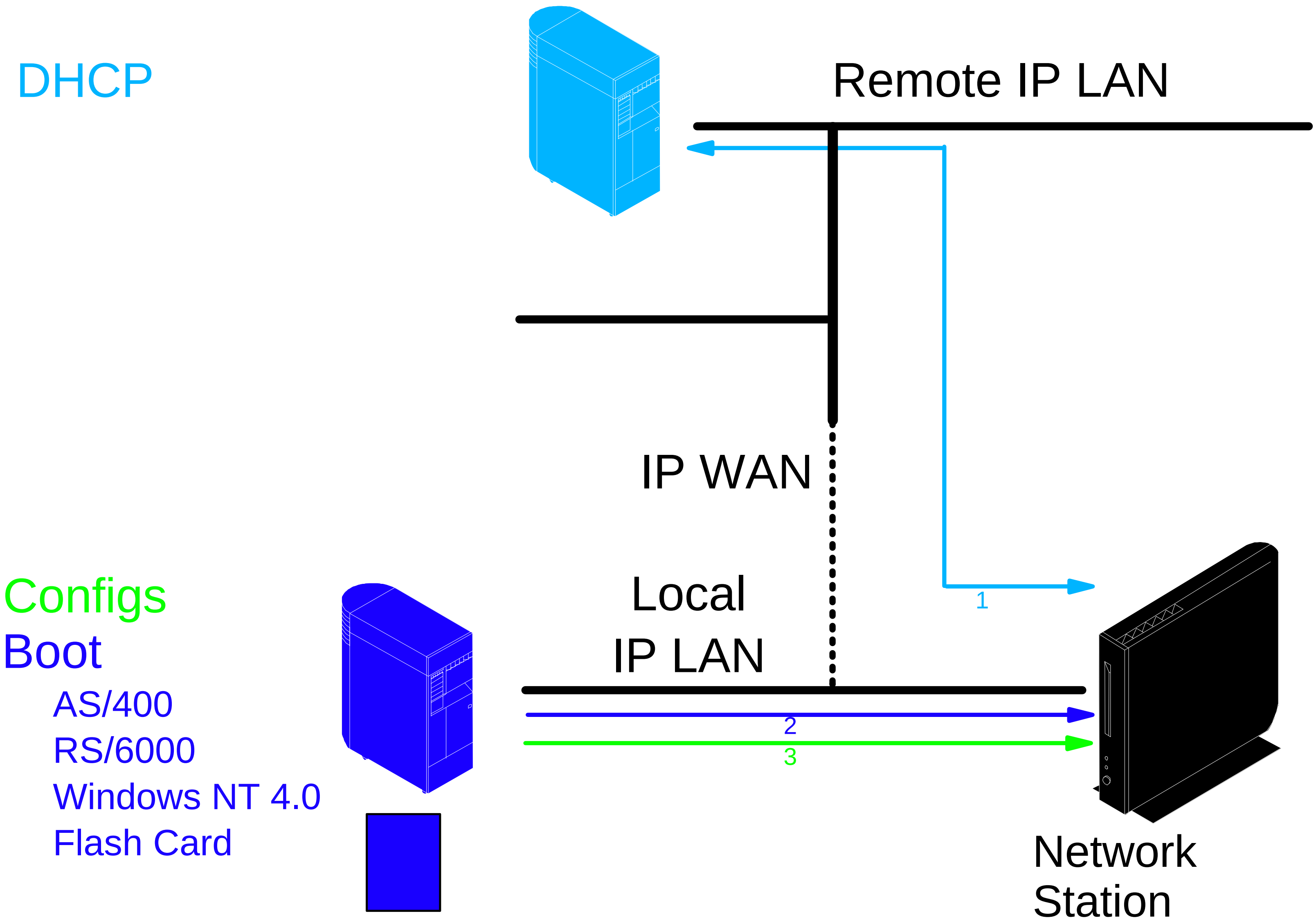
Notes

The management of IP addresses is centralized and controlled through the corporate DHCP server.

This allows the corporate network administrators to easily change the configuration data for each an every Network Station in the network and direct them to boot from selected boot servers, all without any intervention at the local branch office.

Access to the corporate DHCP server is through the WAN links, but the amount of information that needs to be transmitted is minimal at this point.

LAN/WAN Boot Architecture - Enterprise > 500 users



Notes

Because of the amount of data that needs to be downloaded from the boot servers, these are located on the local LAN and can be a mix a different servers.

Note that in this case, we have also located the terminal configuration files on the boot server. These files typically do not change very often and can therefore be managed at a central location and copied to the boot servers for operational purposes.

LAN/WAN Boot Architecture - Enterprise > 500 users

DHCP

Login(auth)
- AS/400
- RS/6000
- Windows NT 4.0

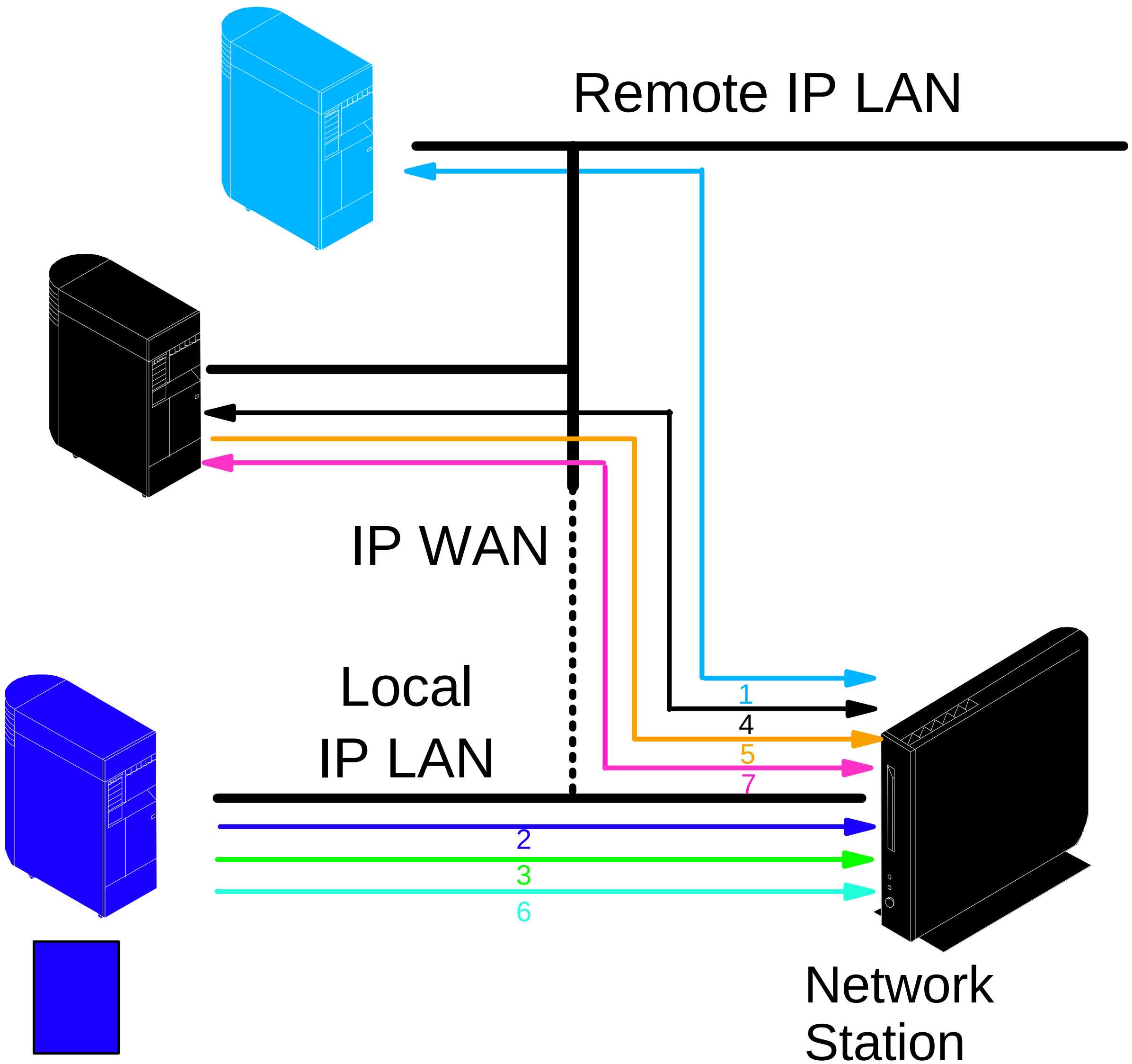
Preferences

Home

Native Apps

Configs

Boot
- AS/400
- RS/6000
- Windows NT 4.0
- Flash Card



Notes

The Authentication and Preferences servers are also centralized, located on the corporate LAN, and allows management and control of all user configuration data in a single location.

A user from any branch can therefore easily roam from branch to branch and still always have his user preferences stay the same.

The native applications are obtained form the local boot server but the home directories are located on the home server at the central site, thereby facilitating the management and backup of these files.

LAN/WAN Boot Architecture - Enterprise > 500 users

DHCP

Login(auth)
- AS/400
- RS/6000
- Windows NT 4.0

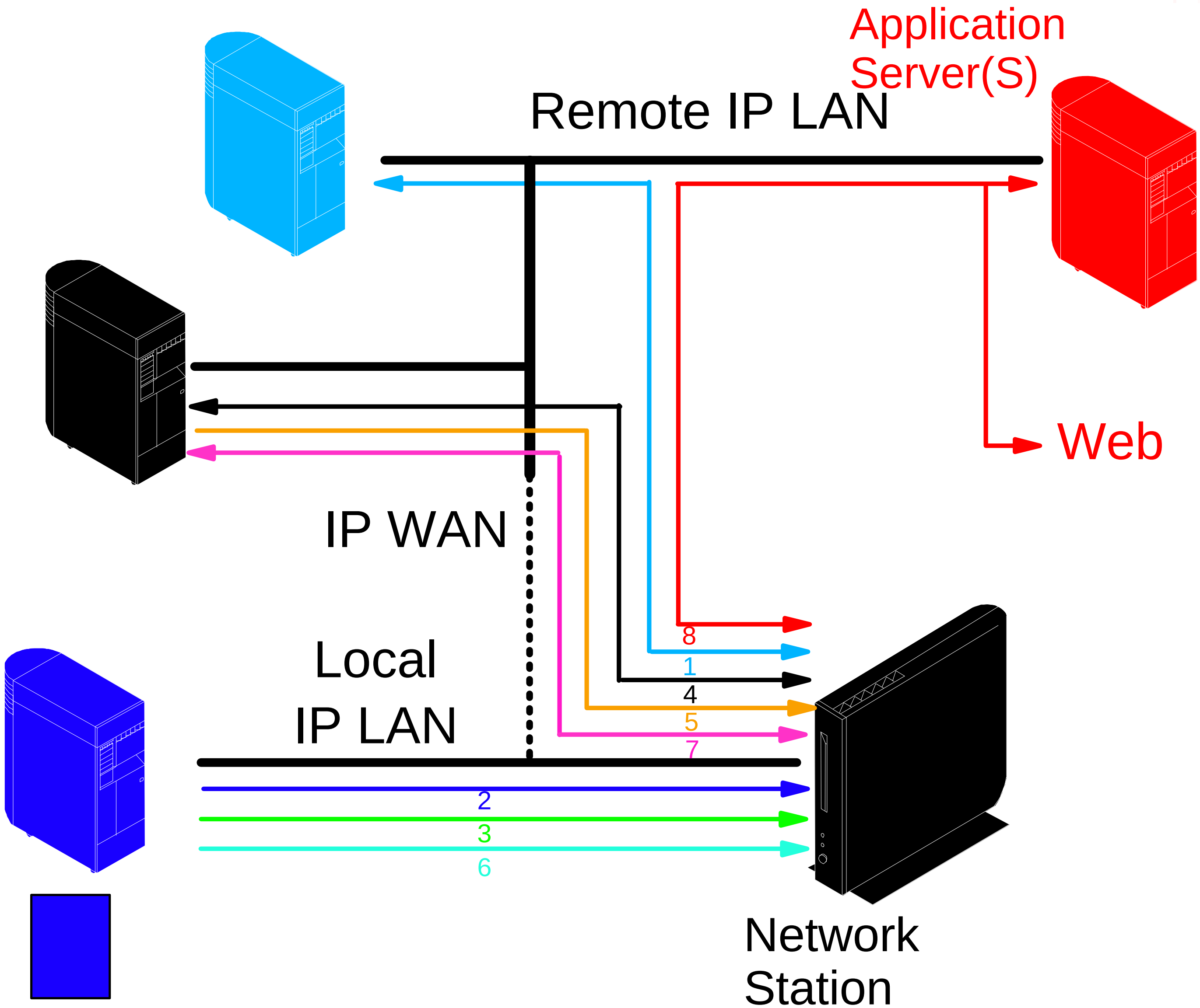
Preferences

Home

Native Apps

Configs

Boot
- AS/400
- RS/6000
- Windows NT 4.0
- Flash Card



Notes

Finally, all application servers are accessed on the corporate LAN.

Recap - Boot Process

- Power On Self Test (POST)
  - Displays logo, counts memory, checks keyboard and mouse connections, LAN connections
- Network Station broadcasts its MAC address and boot version to the network (or data taken from NVRAM)
- BootP or DHCP server returns the TCP/IP address of the host and the Network Station (or data taken from NVRAM)
  - Also fully qualified path to the operating system kernel
- TFTP or NFS is used to download the kernel
- NFS or RFS (AS/400) loads the configuration files
- The User Logs on and is Authenticated
- NFS or RFS (AS/400) loads the user preference files
- NFS or RFS (AS/400) loads the local applications
- NFS or RFS (AS/400) mounts the server's file system

Notes

As a review, here are the key phases of the boot process.

- The Power On Self Test (POST) displays the logo, counts the memory, checks the presence of the keyboard and mouse.
- The LAN adapter is opened and the station inserts itself into the network.
- The station retrieves from NVRAM the information is needs to contact a boot server:
- If using a Network boot (recommended method):
  - A DHCPDISCOVER frame is broadcasted on the network. The frame contains the MAC address of the station.
  - A DHCP server returns the IP address that the station should use, the boot server address and the path to the kernel file.
- If using an NVRAM boot (For small networks or test cases):
  - The station loads the station IP address, the boot server address and the path to the kernel file from the local NVRAM.
- TFTP or NFS is used to download the operating system
- NFS (or RFS for AS/400) is used to download the configuration files
- The user logs on and gets authenticated
- NFS (or RFS for AS/400) loads the user preferences files
- NFS loads the application modules
- NFS mounts the server's file system
- The station is ready for the user to start applications

Summary

- **Installing Network Stations is easy**
- **Installation planning is the hard part**
  - **Understand the LAN environment of the installation**
    - LAN/WAN capacity needs to be well understood
    - Customer existing administration procedures and desires
    - Security and policies
    - Distribution of IT skills
  - **What service requirements are expected**
    - This can be the main driver to the boot server plan
- **Network Stations depend on the network for a successful installation/operation**

Notes

In summary, the actual installation of IBM Network Stations is easy, and installing the actual server or servers can also be an easy task once all the planning decisions regarding the type of server(s) to use, their location and their role have been done. However, it is the overall installation and network planning that is the hard part.

Essentially, because the Network Stations are highly dependent on the network for their operation, the network design and planning is the most essential and the most critical factor in the successful implementation of Network Stations.

The key is to:

- Well understand the LAN environment of the installation. That is, the LAN/WAN capacity needs to be well understood, the existing customer administration procedures and desires must be known, the security issues and policies of the organizations must be taken into account as well as the distribution of IT skills.
- Understand the service level that are expected or that are part of the organization policies.

The next topic focuses on the planning and design by attempting to identify all the important planning elements that must be considered and by providing as many details as possible on each of these elements. The objective is not necessarily to provide the answers but to provide all the questions that should be asked and provide some insight into the impact of some of the key decisions that are to be made.