ECE4883 Lab 2 Fall 2003
Installation of a Linux Operating System Red Hat 8.0 host machine, VMware, a Red Hat 7.2 virtual machine, and an XP virtual machine

Version 9/5/2003
Assigned: August 26, 2003
Due: September 2, 2003

Read “Counter Hack” Chapter 1 Introduction and Chapter 2 Networking Overview.

Read about Bridged Networks for VMware at:

Turn in this lab with your answers. This lab will take approximately 2.5 hours to complete.

Working in “groups of 2” follow the attached lab and install Linux on your removable hard drive. During TA hours, you will need to obtain from the TA a removable hard drive, a key for the hard drive, Red Hat 8.0 installation CDs; VMware Installation CD, RedHat 7.2 CDs, and Windows XP installation CDs. You are to keep the hard drive and the key, you are to return all the CDs before you leave the lab. You will need to get the TA to enter a VMware license number, and later a Windows XP license number for you. Thus make sure you are working when a TA can assist you in those steps. You may work in the lab anytime the door is unlocked (see hours posted) however TA support hours are much more limited. The TA(s) usually hang out in the research lab COC331 when on duty and they are not needed in the student lab COC 311. Check off on Labs must be done during the TA's lab hours. CDs must be returned to the TAs before the TA hours end for that period.

Do not drop or roughly handle the Hard Drives. If you break it you will be asked to replace it and you will find they cost about $69. If you loose a Hard Drive frame key, it costs $19 because you have to buy an entire removable hard disk frame kit just to get the key.

To insert your hard drive into the machine:

Slide your drive into the docking bay. Push with your thumb to make sure the contacts are connected. Use your key to lock the drive into the bay. If the drive is not locked into the bay, you will not get power to your hard drive.

General Warning for the entire quarter:
Warnings on removing your hard disk from the machine while it is running Linux or turn the power off while the machine is running Linux:
Do not try to remove your hard drive from the linux machine while linux is running. Here is the procedure to shut down

In a text terminal:
shutdown -h now
after the machine halts use your key to remove the hard drive. DO NOT FORCE THE HANDLE UP WHEN REMOVING THE HARD DRIVE. IF YOU HAVE NOT UNLOCKED THE DRIVE AND YOU PULL HARD YOU CAN BREAK THE PLASTIC RELEASE HANDLE. Unix stores some file states in memory and this stuff needs to be written to the disk before the disk is removed otherwise you may corrupt your disk and have to reinstall LINUX.

In a graphical X window:
Click on the red-hat icon in the lower left of the screen. Select logout and then shutdown, yes.

Do not use cntl alt del to reboot the machine unless you have no choice. There is a chance you will corrupt your hard drive if you do it this way.

Installation of the host computer RedHat 8.0 Linux Operating System

The purpose of this section of the manual is to show how to install RedHat Linux 8.0. This installs linux kernel 2.4.18. Installation is a relatively simple procedure due to the windows-like GUI that RedHat provides.

Obtain the RedHat 8.0 Installation CDs from the TA. You do not need to get all the other CDs at this time.

*NOTE:* The convention of placing the key name in all caps between the ‘<’ and ‘>’ symbols will be used throughout this manual.

<UP ARROW>
This key allows the user to move up within a field.

<DOWN ARROW>
This key allows the user to move down within a field.

<TAB>
This key allows the user to move between fields.

<ENTER>
This key allows the user to select an option.
<SPACE>
This key allows the user to select an option.

The main focus of this section is to ensure you properly install RedHat Linux with the correct packages. The following section will go through the necessary steps of installing RedHat Linux 8.0.

To boot from the Red Hat 8.0 CD#1 of 3:
With no HD in the computer, turn on the power and insert a RH 8.0 CD #1 into the CD. Turn the power off. Put your HD in and then turn the power on. This will boot the computer from the CD. Do not add or remove a HD with power turned on. Just hit enter to get past the main menu.

- The language that will be used is English. Just select next.
- The keyboard being used are U.S. English. Just select next.
- 3 button mouse ps/2. Just select next.
- Click "NEXT" in the welcome to Red Hat Linux Screen.
- Select Custom Install
- Have the installer automatically partition for you
- Remove all partitions on this system
- Yes you are sure
- Select next on the partitioning screen
- Accept the default boot loader GRUB.
- In the network configuration window:
  For Network Devices, click Edit
  Select Activate on boot, but not Configure using DHCP
  Fill in IP address w.x.y.z. The IP addresses you will use depend upon which ECE4883 machine you use. Look at the monitor of the machine you are using. This is the base address you should use. This lab assumes a base address of w.x.y.z but do not use that, look at the monitor and use what it tells you! Each time you return to the lab you should change your IP addresses to use what your monitor says. If you come back to a different machine, you should change all your IP addresses for that new machine.

  Netmask: 255.255.255.0
  Click OK

For Hostname
  Manually should’ve been selected; type the Host name: group#-4883 ( # is your assigned group number). This gives everyone a unique name.

For Miscellaneous Settings
Gateway: use the gateway address the monitor has on it. This is the router’s address for that subnetwork your machine is on.
Primary DNS: use the DNS address the monitor has on it. (We do not have a Domain Name Server but use this address anyway, one has to be entered).
Click Next

• Choose no firewall and then next
• Select next on language screen
  ▪ Leave Eastern time selected
  ▪ Enter root password as “password” and confirm password is “password”
  ▪ Turn off (remove the default on) for MD5 and shadow passwords
  ▪ Now you must select what packages you will install:

In the package Group Selection Window many items are already selected. Add the following to what is already selected:
  Editors
  Server Configuration Tools
  Window File Server
  FTP Server
  Network Servers
  Development Tools
  Kernel Development
  Administration Tools

Click on select individual packages

Click on Next

Under the triangle by Applications
  Click on internet
    Add a check mark beside:
    ethereal
    ethereal-gnome
    mrtg
    nc
    ttcp
    xtraceroute

Click on system
  Add a check mark beside:
  iptraf
  nmap
  nmap-frontend

Click next to finish up selecting this extra stuff we have added to our install
• Select Install packages to satisfy dependencies. Click next

• About to Install Screen is next, select next
• Installation takes about 20 minutes and requires you to insert CD#2 and CD#3 at some point
• Select no I do not want a boot Floppy.

• Click Next at **Graphical Interface** (X) Configuration.
• The graphics card we are using is a NVIDIA GEFORCE 2 MX 32 Mb
• The correct monitor should have been automatically selected (it should be a SONY CPD-E400/E400E); click Next at Monitor Configuration.
• Asks if you want to test the graphical interface (Aside: You are using NVIDIA GEFORCE 2 MX 32 MB video cards just as an FYI).
  ▪ Remove any CD in the computer and select exit to reboot the machine.
  ▪ Some general configuration questions appear here, answer them.
  ▪ Logon as root and password is password

On your Red Hat 8.0 host, open a terminal window. By right click on the mouse and select new terminal.
In a terminal window type `ntsysv`
Turn off sendmail and also turn off syslog by pressing the space bar at those lines. (We do this to make it so the system boots faster, if we do not do this we need to wait up to 4 minutes sometimes for boot up to finish).
Turn on vsftpd by pressing the space bar at that line.
Tab to OK, press return bar when OK highlighted.

### Installing VMware on your RedHat 8.0 Host
Note: You will need a TA during this part to type in a VMware license number for you.

Next we need to install VMware. Obtain the VMware workstation 4.0.1 installation CD

When you insert the CD, it opens automatically. Drag the `VMware-workstation-4.0.1-5289.tar.gz` file to the root’s home to copy it to `/root`

After you close the CDROM window, right click on the CD image and select eject.

On your Red Hat 8.0 host, open a terminal window. By right click on the mouse and select new terminal.

```
[root@localhost cdrom]# cd /root
[root@localhost root]# tar -zxvf VMware-workstation-4.0.1-5289.tar.gz
[root@localhost root]# cd vmware-distrib
[root@localhost vmware-distrib]# ./vmware-install.pl
```
(Danger: Do not EVER run the command ./vmware-install.pl again, if you do you will have to redo this entire lab!!!!!!)

... Hit enter or change directory for bin files and answer other questions. Make sure you run the vmware-config.pl script by answering yes to that question (or run it after installation) This script sets up networking for the VM machine and will ask some questions.

Use the following answers:
Do you want networking for your virtual machines? YES
Do you want this program to probe for an unused private subnet? NO
What will be the address of your host on the private network? w.x.y.z+1 (One more than the base address on your monitor)
What will be the netmask of your private network? 255.255.255.0
Do you want to be able to use host-only networking in your virtual machines? NO
Do you want this program to automatically configure your system to allow your virtual machines to access the host’s filesystem? NO

What this has done is set up a bridged network on /dev/vmnet0, a Host-Only Network on /dev/vmnet8 which we can ignore, and NAT on /dev/vmnet8. We are only going to use the bridged network which will act like a hub for all virtual machines that we wish to put on top of our linux host. Each of these virtual machines will be just like plugging another machine into a hub. We need to remove the vmnet8 stuff. We do this by running vmware-config.pl again

Would you like to skip networking setup and keep your old settings as they are? NO
Do you want networking for your virtual machines? YES
Would you prefer to modify your existing network configuration using the wizard or the editor? EDITOR
Do you wish to make any changes to the current virtual networks settings? YES
Which Virtual network do you wish to configure? 8
The network vmnet8 has been reserved for NAT network. Are you sure you want to modify it? YES
What type of virtual network do you wish to set vmnet8? NONE
Do you wish to make additional changes to the current virtual network settings? NO
Do you want this program to automatically configure your system to allow your virtual machines to access the host’s filesystem? NO

cd /etc/init.d
./vmware stop
./network stop
./network start
./vmware start
Now if you do an ifconfig all you see is eth0 set to the host machines IP of w.x.y.z and the lo loopback interface. This is what we want.

Now when you start vmware with the command vmware we have the networking we want. If you type ifconfig you can see the result of setting up the networking in the VMware host.

Launch vmware (type 'vmware') and goto Help, Enter Serial Number. Have the TA come in and enter a serial number for your VMware license.

/************************************************************/
DO NOT DO THESE STEPS AT THIS POINT IN TIME. THEY NEED TO BE DONE WHEN YOU RETURN TO THE LAB AND HAVE TO CHANGE YOUR IP ADDRESSES

Note: Each time you return to the lab, if you sit at a different monitor, you will need to change the base address and all the virtual machine address (later in the lab you set up virtual machines with their IP addresses).

**Here are the specific steps you need to take to change the base address of the host and the IP addresses of the virtual machines:**

In RedHat 8.0 with no VMware running
In a terminal window type
setup
network configuration
yes
IP address w.x.y.z (see your monitor)
Default Gateway: see your monitor
Primary Name Server: see your monitor
Tab to OK
Tab to quit
/etc/init.d/network stop
/etc/init.d/network start
ifconfig
you should see your new a.b.c.d address for eth0 now

Now to change your Vmware set up
Still in the terminal window of your 8.0 host

[root@localhost cdrom]# cd /root
[root@localhost root]# cd vmware-distrib/bin
[root@localhost vmware-distrib]# ./vmware-config.pl
Would you like to skip networking? NO
Do you want networking for your virtual machines? YES
Would you prefer to modify your existing network configuration using the wizard or the editor? EDITOR
Do you wish to make any changes to the current virtual networks settings? YES
Which Virtual network do you wish to configure? 0
The network vmnet0 has been reserved for bridge. Are you sure you want to modify it? YES
What type of virtual network do you wish to set? NONE
Do you wish to make additional changes to the current virtual network settings? NO
Do you want this program to automatically configure your system to allow your virtual machines to access the host’s filesystem? NO
Do you want networking for your virtual machines? YES
Do you want this program to probe for an unused private subnet? NO
What will be the address of your host on the private network? w.x.y.z+1 (One more than the base address on your monitor)
What will be the netmask of your private network? 255.255.255.0
Do you want to be able to use host-only networking in your virtual machines? NO
Do you want this program to automatically configure your system to allow your virtual machines to access the host’s filesystem? NO

What this has done is set up a bridged network on /dev/vmnet0, a Host-Only Network on /dev/vmnet8 which we can ignore, and NAT on /dev/vmnet8. We are only going to use the bridged network which will act like a hub for all virtual machines that we wish to put on top of our linux host. Each of these virtual machines will be just like plugging another machine into a hub. We need to remove the vmnet8 stuff. We do this by running vmware-config.pl again

Would you like to skip networking setup and keep your old settings as they are? NO
Do you want networking for your virtual machines? YES
Would you prefer to modify your existing network configuration using the wizard or the editor? EDITOR
Do you wish to make any changes to the current virtual networks settings? YES
Which Virtual network do you wish to configure? 8
The network vmnet8 has been reserved for NAT network. Are you sure you want to modify it? YES
What type of virtual network do you wish to set vmnet8? NONE
Do you wish to make additional changes to the current virtual network settings? NO
Do you want this program to automatically configure your system to allow your virtual machines to access the host’s filesystem? NO

Next you need to change the IP address of the RedHat 7.2 virtual machine.
Start the RedHat 7.2 machine
In a terminal window type
setup
network configuration
yes
IP address a.b.c.d (see your monitor)
Default Gateway: see your monitor
Primary Name Server: See your monitor
Tab to OK
Tab to quit
Use the Red stop button in Vmware to shut off the 7.2 virtual machine
Restart the 7.2 Virtual machine
ifconfig
you should see your new a.b.c.d address for eth0 now

For the XP machine:

Start
Control Panel
Network and Internet Connections
Network Connections
Right Click on local area connections
Properties
Select TCP/IP
Properties
Make your changes and click OK
Use Vmware to stop ans then restart XP

You are now ready to work on the new monitor (and new network associated with that monitor)

END. DO NOT DO THESE STEPS YOUR FIRST TIME THROUGH THE LAB
/*************************************************************************/

Installing RedHat 7.2 Operating System as your first virtual operating system.
Obtain the RedHat 7.2 Installation CDs from the TA. You will also need the VMware
installation CD later to install some tools after installing RedHat 7.2

After booting up a VMware installed computer and opening a terminal window (right
mouse, select new terminal) and starting vmware with the command vmware, select File,
New Virtual Machine. Select typical configuration, on the next screen select Linux, then
make the linux virtual machine name RedHat7.2, use the default location. Select Use
Bridged Network. Select Finish.
On the main VMware screen select the RedHat7.2 virtual machine.
Insert the RedHat 7.2 install CD #1 in the CDROM, answer NO to do you wish to run /mnt/cdrom/autorun. Close the cdrom window that opened.
Click on Start this virtual Machine.
Hit enter at the Welcome to Red Hat Linux 7.2 window.

- The language that will be used is **English**. Just select next.
- The keyboards being used are **generic 105**. Just select next.
- 3 button mouse ps/2. Just select next.
- Click ”NEXT” in the welcome to Red Hat Linux Screen.
- Select Custom Install
- Have the installer automatically partition for you
- Yes you would like to initialize the drive
- Remove all partitions on this system
- Yes you are sure
- Select next on the partitions screen
- Use GRUB. All defaults on this screen are OK as is.
- Do not enter a grub password, just select next

- In the network configuration window:
  Activate on Boot is already selected, remove check on configure using DHCP.
  Fill in:
  IP address: Use w.x.y.z+1 (one more than the base address of the RedHat 8.0 host system, since now you are adding a second computer to your subnet).
  Netmask: 255.255.255.0
  Network: w.x.y.0 (see your monitor for w.x.y)
  Broadcast: w.x.y.255
  Host name: redhat7.2
  Gateway: see your monitor
  Primary DNS: same as Gateway
  Next

- Choose no firewall and then next
- Select next on language screen
- Leave Eastern time selected
- Enter root password as “password” and confirm password is “password”
- Turn off (remove the default on) for MD5 and shadow passwords
- Now you must select what packages you will install:

In the package Group Selection Window many items are already selected. Add the following to what is already selected:
Emacs

Software development (we will need gcc compiler later this semester)
Kernel development
Click on select individual packages
Click on Next

  Click on the triangle by Applications
  Click on internet
  Add a check mark beside:
    ethereal
    ethereal-gnome
    mrtg
    mtr
    mtr-gtk
    nc
    netscape-navigator
    tcpdump
    ttcp
    xtraceroute

Click on system
Add a check mark beside:
  iptraf
  linuxconf

Click next to finish up selecting this extra stuff we have added to our install

  • Click next on unresolved dependencies screen to automatically fix the unresolved dependencies we created
  
  • Select NVIDIA GEFORCE 2 MX GENERIC 32 MB memory

• About to Install Screen is Next, select next
• Installation takes about 15 minutes and requires you to insert CD#2 at some point; you will see a failure message that says the CDROM failed to eject. At that point insert the CD#2 and then after doing that select OK. Then OK again on please insert CD#2.
  ▪ Skip Boot Disk creation.

• Select Sony CPD E400 from the list and click Next.

• Select 800x600

• Remove the CD when the CDROM failure message appears, click OK.
Logon as root and password
(Note: your x windows will not work yet. We need to install some Vmware tools later and then X windows will work. You start x windows typically with “startx”).

In a window type ntsysv
Turn off sendmail and also turn off syslog by pressing the space bar at those lines.
Tab to OK, press return bar when OK highlighted.

To test if your new virtual RedHat 7.2 machine is on the bridged network ping your host machine that the virtual machine is on:

ping 192.168.1.1 or whatever the address is of the host machine your virtual machine is on top of.
control c to stop it

Installing the VMWare tools on your new virtual machine.

You may need to hit CTRL and ALT at the same time to release the cursor from your virtual machine and allow you to select the following:

While running the new RedHat 7.2 virtual machine, select File “Install VMware Tools….”
This should create a virtual cdrom directory from which you can copy the tools file.

While still inside this Red Hat 7.2 virtual machine type the following

mount /dev/cdrom
cd /tmp
cp /mnt/cdrom/vmware-linux-tools.tar.gz .
umount /dev/cdrom
tar zxf vmware-linux-tools.tar.gz
cd vmware-tools-distrib
./vmware-install.pl
select default directory to install
select default daemon file directory
select default for library
yes to create new path
default on documentation directory
yes on path
default on rc directory
default on scripts
yes on invoke tools now
Now that you are done, type this next line exactly as it appears:
shutdown –h now
in the Red Hat 7.2 Virtual machine.
Installing Windows XP as another Virtual machine (at the same level as the Red Hat 7.2 virtual operating system, not inside the Red Hat 7.2 virtual system).

Obtain the Windows XP installation CDs from the TA. Note later you will need the TA to type in the license number. (You do not need a VMware installation CD)

After booting up a VMware installed computer and opening a terminal window (right mouse, select new terminal) and starting vmware with the command vmware, select File, New Virtual Machine. Select typical configuration, on the next screen select windows XP professional, then make the XP virtual machine name winXPPro, use the default location. Select Use Bridging Network. Select Finish.

1) Insert the XP CD #1 into the machine and select start this virtual machine.
2) At the “Welcome to Setup” screen, press ENTER
3) Press F8 (“I agree”) to the license agreement
4) Delete all partitions on the drive. For each partition, highlight the partition, and then press D. Then press ENTER. On the next screen, press L. Repeat these steps for each partition until all you have is one unpartitioned space.
5) Select the unpartitioned space and press ENTER
6) Format the partition using the NTFS file system
7) Once the disk is formatted, the installer will copy files for installation and then reboot.
8) Once the software installs, select Regional and Language Options and press Next
9) Type in your name and “Georgia Tech” for the organization field, and click Next
10) Obtain the product key from the TA, type that in the field, and click Next
11) Set the computer name to “XP” and type in an administrator password of password. Click Next.
12) Set the Date and Time, and click Next
13) At the Network Settings screen, select “Custom Settings” and click on Next.
14) Select Internet Protocol (TCP/IP), and then click on properties.
15) Select “Use the following IP address” and use the following settings:
   IP Address: use one IP address higher than your Linux installed virtual operating system. For example if you used 138.210.231.101, now use 138.210.231.102
   Netmask: 255.255.255.0
   Default Gateway: leave blank
   DNS server: leave blank
16) Click OK and then click Next
17) On the next screen, click the first option that says you want this computer to be part of a workgroup (i.e. it is not part of a domain). Keep the workgroup name as WORKGROUP. Click Next.
18) At the “Welcome to Microsoft Windows” screen, click Next
19) For network connectivity, select LAN and click Next
20) Make sure that the option “Obtain IP automatically” as well as the option “Obtain DNS automatically” are not selected and use the following settings:
   IP Address: see IP address above for example w.x.y.z+2
   Netmask: 255.255.255.0
   Default Gateway: see sign on your monitor
Preferred DNS: see sign on your monitor
21) At the registration screen, choose the option not to register at this time
22) Enter the username “user1” in the “Your name” field and click Next
23) Click on Finish

Windows XP should now be successfully installed on your system.

Open up a command window and ping your host machine’s IP address.

**Installing the VMware tools package inside the XP virtual machine**
Start the XP virtual machine
Click OK on the warning that VMware tools are not installed.
Select File Install Vmware tools
Select install
Simply follow the on screen instructions

If you are unable to open both the Red Hat 7.2 virtual machine and simultaneously the XP virtual machine, you may need to change the amount of memory the XP machine uses to 128 Mb.

To do this (if necessary) in host Vmware workstation (RedHat 8.0) select windows XP but do not start it.
Select EDIT
Select virtual machine settings
Select guest memory size (MB) 128
Select OK

Summary:
At this point you have set up your RedHat 8.0 host machine with a base address, a RedHat 7.2 virtual machine, and an XP virtual machine. You now have three computers in one box all connected together in a bridged network which can communicate through the single network interface card out to any network you connect you host machines physical interface card to.

Draw a picture here of three machines connected together by a hub or a switch and put names on the machines as well as IP addresses on each of the three machines network connections:
Show Your Hand Drawn Diagram to the TA and also demo ping to each of the other two machines simultaneously from your Host machine RedHat 8.0. Have the TA sign his name and enter the date here:

______________________________  Date: ______________________

What corrections and or improvements do you suggest for this lab? Please be very specific and if you add new material give the exact wording and instructions you would give to future students in the new lab handout. You may cross out and edit the text of the lab on previous pages to make corrections/suggestions.

How long did it take you to complete this lab? Was it an appropriate length lab?
Appendix: MAC addresses and VMware

From:
http://www.vmware.com/support/kb/enduser/std_adp.php?p_sid=9Dx_YkSg&p_lva=351&p_faqid=219&p_created=1023555156&p_sp=cF9ncmlkc29vdD0mcF9yb3dfY250PTUmcF9zZWFyY2hfdGV4dD1NQUMmcF9zZWFyY2hfdHlwZT03JnB ieHJvZmlldXVwPXM5bW9naW46U0FTRDE0MjU1MjIyNzA1MTg1NzYyMDM0MjQyMzU3NzUyNDQ0Nzc3MzEwMTI4MDE='

VMware ESX Server automatically generates MAC addresses for the virtual network adapters in each virtual machine. In most cases, these MAC addresses are appropriate. However, there may be times when you need to set a virtual network adapter's MAC address manually - for example:

You have more than 256 virtual network adapters on a single physical server. Virtual network adapters on different physical servers share the same subnet and are assigned the same MAC address, causing a conflict.
You want to ensure that a virtual network adapter always has the same MAC address.

This document explains how VMware ESX Server generates MAC addresses and how you can set the MAC address for a virtual network adapter manually.

How VMware ESX Server Generates MAC Addresses
Each virtual network adapter in a virtual machine gets its own unique MAC address. ESX Server attempts to ensure that the network adapters for each virtual machine that are on the same subnet have unique MAC addresses. The algorithm used by ESX Server puts a limit on how many virtual machines can be running and suspended at once on a given machine. It also does not handle all cases when virtual machines on distinct physical machines share a subnet.

A MAC address is a six-byte number. Each network adapter manufacturer gets a unique three-byte prefix called an OUI - organizationally unique identifier - that it can use to generate unique MAC addresses. VMware has two OUIs - one for automatically generated MAC addresses and one for manually set addresses.

The VMware OUI for automatically generated MAC addresses is 00:05:69. Thus the first three bytes of the MAC address that is automatically generated for each virtual network adapter have this value. ESX Server then uses a MAC address generation algorithm to produce the other three bytes. The algorithm guarantees unique MAC addresses within a machine and attempts to provide unique MAC addresses between ESX Server machines.

The algorithm that ESX Server uses is the following:

When the algorithm generates the last 24 bits of the MAC address, the first 16 bits are set to the same values as the last 16 bits of the console operating system's primary IP address.

The final eight bits of the MAC address are set to a hash value based on the name of the virtual machine's configuration file.
ESX Server keeps track of all MAC addresses that have been assigned to network adapters of running and suspended virtual machines on a given physical machine. ESX Server ensures that the virtual network adapters of all of these virtual machines have unique MAC addresses.

The MAC address of a powered-off virtual machine is not remembered. Thus it is possible that when a virtual machine is powered on again it can get a different MAC address.

For example, if a machine had IP address 192.34.14.81 (or in hex, 0xc0220e51) and the configuration file hashed to the value 95, the MAC address would have the following value:

00:05:69:0e:51:95

Since there are only eight bits that can vary for each MAC address on an ESX Server machine, this puts a limit of 256 unique MAC addresses per ESX Server machine. This in turn limits the total number of virtual network adapters in all powered-on and suspended virtual machines to 256. This limitation can be eliminated by using the method described in the next section entitled "Setting MAC Addresses Manually".

Note: The use of parts of the console operating system's IP address as part of the MAC address is an attempt to generate MAC addresses that are unique across different ESX Server machines. However, there is no guarantee that different ESX machines with physical network adapters that share a subnet always generate mutually exclusive MAC addresses.

Setting MAC Addresses Manually
In order to work around both the limit of 256 virtual network adapters per physical machine and possible MAC address conflicts between virtual machines, the MAC addresses can be assigned manually by system administrators. VMware uses a different OUI for manually generated addresses: 00:50:56. The addresses can be set by adding the following line to a virtual machine's configuration file:

```
ethernet0.address = 00:50:56:XX:YY:ZZ
```

where XX is a valid hex number between 00 and 3F and YY and ZZ are valid hex numbers between 00 and FF. The value for XX must not be greater than 3F in order to avoid conflict with MAC addresses that are generated by the VMware Workstation and VMware GSX Server products. Thus the maximum value for a manually generated MAC address is

```
ethernet0.address = 00:50:56:3F:FF:FF
```
VMware ESX Server virtual machines do not support arbitrary MAC addresses, hence the above format must be used. So long as you choose XX:YY:ZZ so it is unique among your hard-coded addresses, conflicts between the automatically assigned MAC addresses and the manually assigned ones should never occur.