LAN Setup Reflection

- After the LAN setup, ask yourself some questions:
  - Does your VM have the *correct IP*?
  - Are you able to *ping* some locations, internal and external?
  - Are you able to *log into* other VMs in the classroom?
  - What went *well*? What went *not so well*, and how did you *solve* it?
- **Remember:** Snapshots, Admin Logs

What is a *local area network* (LAN)?

- A group of devices (computers, etc.) that send and receive data traffic amongst themselves.
- A **`local area network`** will have a *network address* and a *subnet mask* that define the local address space.
- For example, the IT Lab LAN:
  - **Network Address:** **`10.0.0.0`**
  - **Subnet Mask:** **`255.255.255.0`**
  - **Address Space:** **`10.0.0.0`** to **`10.0.0.255`**

What is a *local area network* (LAN)?

- Technically, the **0** and **255** addresses have special meanings, so the actual address space would be **1** to **254**
- To connect *more than two* computers in a LAN, you at least need a **switch**.
- A switch sends and receives traffic between specific devices within a LAN.
- If you only needed communications *within* the LAN, the switch would be enough.

What is a *local area network* (LAN)?

- However, to send and receive communications outside the LAN, you will need a router.
- A **router** forwards traffic between two or more LANs
- On a LAN, the router usually serves as the *default gateway*.
  - Traffic to a destination IP in the *local* address space (as defined by the network address and subnet mask) can simply go directly to destination – via the switch.
  - If the destination IP is **not** local, then it goes to the default gateway, which decides how to *route* it from there

it20 is a ***router***

- ***it20*** is functioning as a **`router`**, so it is connected to two networks
  - **`cs.umb.edu`**
  - **`it.cs.umb.edu`**
- In order to do this, ***it20*** needs two Ethernet cards
- Each of these cards must be configured separately

Networking and the Boot Process

- When any machine boots, it knows nothing about the hardware or the network to which it is connected
- *On Linux machines it gets this information from scripts in a special directory*
- This directory is `init.d`
  - On **Ubuntu** the absolute path of this directory is `/etc/init.d`
  - On **Red Hat**, you will find it in `/etc/rc.d/init.d`

Networking and the Boot Process

- ***init.d*** contains shell scripts that can start, stop, and restart services
- Not all services are started automatically when you boot the machine, but all services come up, go down, or restart using scripts in ***/etc/init.d***
- To bring up the network, a Linux machine runs the script ***networking***, which is one of the many scripts in ***init.d***
- The networking script reads **configuration** information from text files in ***/etc/network***

Network Interface Controllers

- To connect to a network, a computer needs special hardware
- Usually, this hardware is an Ethernet card
- An Ethernet card is one example of a **network interface controller**, usually known by its acronym – NIC
- A **NIC** is a hardware device that connects a computer to a network

Configuring a NIC

- *When a Linux machine boots, it needs information to configure its network card*
- It gets this information in the text file ***interfaces*** – which, on Ubuntu, can be found in the ***/etc/network*** directory
- Its **absolute pathname** is **/etc/network/interfaces**
  - **All the information a Linux machine needs to connect to the network is found in *interfaces***
  - So if you want to change anything, you need to edit this file
  - However, only ***root*** can change this file, so you must use ***sudo*** to run a text editor on it

Configuring a NIC

- If you want to see how a machine is **configured** for the network, you can either:
  1. **Look at *interfaces*, or**
  2. **Run `ifconfig` utility with no arguments**
- If the computer has more than one network card, each one must be configured in *interfaces*
- The first network card is **`eth0`**, and the second one is **`eth1`**

/etc/network/interfaces on it20:

```
# This file describes the network interfaces available
on
# your system and how to activate them. For more
# information, see interfaces(5).

# The loopback network interface
auto lo
iface lo inet loopback

# The primary network interface
# The green ethernet cable into the motherboard jack.
auto eth1
iface eth1 inet dhcp
...
```

/etc/network/interfaces on it20:

```
# The inside IT network
# The yellow  ethernet cable into the add-on PCI NIC.
auto eth0
iface eth0 inet static
   address 10.0.0.1
   netmask 255.255.255.0
   network 10.0.0.0
   broadcast 10.0.0.255
```

- The network card designated as ***eth0*** is connected to **it.cs.umb.edu** (*internal*)
- The network card designated as ***eth1*** is connected to **cs.umb.edu** (*external*)

The */etc/network/interfaces* File

- For each network interface in */etc/network/interfaces*, you see a line beginning with "auto" and followed by an interface name:

```
auto eth0
```

- *This line tells the operating system to automatically bring up this **NIC** every time the system is booted*
- Each network interface controller must have its own IP address, as well as some information

The */etc/network/interfaces* File

- There are two ways give the NIC its configuration information
  1. Put the information in the *interfaces* file
  2. Use **DHCP**
- Two types of IP addresses that can be assigned to a NIC
  - A **static** IP address
  - A **dynamic** IP address obtained from an address pool
- A *static* IP address never changes, hence the term "static"

The */etc/network/interfaces* File

- A *static* IP must be either:
  - Written into */etc/network/interfaces*, or
  - Specifically assigned to a machine via DHCP
- DHCP stands for **`Dynamic Host Configuration Protocol`**
- ***DHCP allows a machine to obtain all its network configuration information from another machine – the DHCP server***

The */etc/network/interfaces* File

- In the entry below, the first Ethernet card, *eth1* is configured to use DHCP

```
auto eth1
iface eth1 inet dhcp
```

- Like **eth0**, the operating system will bring it up automatically at startup, because we use "auto"
- The second Ethernet card is ***eth1*** because the first is ***eth0***

The */etc/network/interfaces* File

- The first Ethernet card is configured to use a **`static`** IP address

```
iface eth0 inet static
    address 10.0.0.1
    netmask 255.255.255.0
    network 10.0.0.0
    broadcast 10.0.0.255
```

- **Since this NIC is *not* using DHCP, it must get the other network configuration information it needs from */etc/network/interfaces***

The */etc/network/interfaces* File

- The **`netmask`** and network values tell *it20* which NIC to use to send an IP packet
- If the packet is addressed to the local network, **`it.cs.umb.edu`**, then it uses one card; *otherwise*, it uses the other
- *it20* (at IP address **`10.0.0.1`**) is the gateway for the IT Lab network
  - This information is often provided in **`/etc/network/interfaces`**
  - On *our* network, however, it is provided in another file: **`/etc/dhcp/dhcpd.conf`**

The */etc/network/interfaces* File

- ***eth1*** **talks to the *cs.umb.edu* network – as well as the greater Internet, to which it is connected!**
- The `broadcast address` is given by this line

```
broadcast 10.0.0.255
```

- A packet sent to this address is sent to every machine on the local IT Lab network
- You virtual machines need other two details for their NICs:
  1) *A gateway address. A gateway is a router that connects the local network to the Internet*
  2) *The address of a DNS server*

The Loopback Interface

- Every ***/etc/network/interfaces*** file has an entry for `loopback`
  - The loopback device is named ***lo***
  - It is **not** a physical device.
  - Rather, it is a software ***emulation*** of a network card
- *Any packets sent to the loopback device come right back to the machine, without ever going out on the network*
- The loopback device is used for testing, and some services depend on it

The /etc/hosts file

- *Every machine on the internet has an IP address*
  - But, you don't usually type the IP address itself *Instead you enter a **URL**, which is much easier to remember*
- Most of the time, your machine sends this name to a DNS server, which translates the name into an IP address, which you then uses to get the web page
- But, there is another way to turn a name into an IP address…

The `/etc/hosts` file

- Your machine can also look in the text file **`/etc/hosts`**
- Each line of this text file contain a *hostname* and an *IP address*
- Using this file (instead of DNS) is *fast* because you don't have to send a network message to get it
- Has anyone edited */etc/hosts* prior to this class?

Private IP Addresses

- Inside a network, only one machine can have a given **private IP address**
- *But every local network can assign its machines addresses from certain IP address blocks*
- For IPv4 these blocks are:
  - ***10.0.0.0*** - ***10.255.255.255***
  - ***172.16.0.0*** - ***172.31.255.255***
  - ***192.168.0.0*** - ***192.168.255.255***
- These blocks are for *private* IP addresses!

Private IP Addresses

- Public IP addresses are visible to the world at large, and you have to get them from your regional Internet registry
- Both IPv***4*** and IPv***6*** provide for private addressing
- *Private addresses are only visible inside a network*
  - Only *one* machine can have a given public IPv4 or IPv6 address
  - Two different machines can both have the same private address, say ***10.0.0.1***, as long as they are on different local networks

Private IP Addresses

- *Because private IP addresses are invisible outside the network, they offer security from the dangers of the Internet*
- They also make life easier for system administrators

Translation: Makes life easier for YOU! :-)

- Every machine that is on the public internet needs a public IP address which can only be obtained from a registry
- *But a system administrator can assign machines private address without having to get permission from anyone*
- This gives you another measure of control over the networking process

Configuring DHCP

- The configuration file for DHCP is `/etc/dhcp/dhcpd.conf`
- This file has many entries, each
  - starting with the ***name*** of thing that is being configured
  - followed by an open curly brace **{**
  - followed by a number of lines, each of which ends with a semi-colon **;**
  - and ending with a closing curly brace **}**

Configuring DHCP

Ex.: For our ***it.cs.umb.edu*** network

```
subnet 10.0.0.0 netmask 255.255.255.0 {
    allow unknown-clients;
    range 10.0.0.20 10.0.0.89;
    option domain-name-servers 10.0.0.251,10.0.0.252;
    option domain-name-servers
    10.0.0.1,192.168.104.12;
    option routers 10.0.0.1;
    default-lease-time  600;
    max-lease-time      7200;
}
```

Configuring DHCP

- The line

```
range 10.0.0.20 10.0.0.89;
```

  specifies the ***range*** of private IP addresses.

- *The DHCP server picks an address from this range each time a machine on our network asks for one*
- We use static IP addresses for the virtual machines in this lab, but they will get that static IP address from *DHCP*
- DHCP can provide all the information necessary, for a machine to connect to the network

Configuring DHCP

- The lines

```
option domain-name-servers 10.0.0.251,10.0.0.252;

option domain-name-servers
10.0.0.1,192.168.104.12;
```

specify the value(s) that DHCP will give your virtual machine to use for *DNS services*

- The line

```
option routers 10.0.0.1;
```

specifies the *router* address DHCP gives your virtual machine. This is the "*gateway*" to which we referred, earlier.

Configuring DHCP

- The line

```
default-lease-time   600;
```

specifies, in minutes, how long you can use this this address

- When DHCP gives a machine an IP address, it is said to give that machine a **lease** on the address
- After the lease expires, a machine that uses the IP address from DHCP will ask for an extension of the lease

Configuring DHCP

- The line

```
max-lease-time   7200;
```

specifies the maximum minutes a machine can hold its lease

- After the lease *expires*, a machine asks for a new lease
- Each virtual machine will be assigned a specific static IP address, which it will get from an entry in ***/etc/dhcp/dhcpd.conf***

Configuring DHCP

- The entry in question looks like this:

```
host itvm2x-yz.it.cs.umb.edu {
hardware ethernet 00:0c:29:c5:37:f1;
    fixed-address 10.0.0.151;
}
```

- The series of *hexadecimal* numbers is the **MAC address** of the virtual machine that gets this static IP address

Doing without DHCP

- DHCP is not the only way to give your virtual machine an IP address
- **You can give your machine a static IP address, by entering it in your *`/etc/network/interfaces`* file**
- One way or another, each NIC on a machine must get the following information:
  - Network address
  - IP address
  - Gateway address
  - Broadcast address
  - Netmask
  - DNS Nameserver addresses
- It can get this from a DHCP server **or** from ***`/etc/network/interfaces`***