NETWORK EMULATION WITH NETKIT

NETKIT

- Homepage
  - http://wiki.netkit.org/index.php/Main_Page
- Download
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  - http://wiki.netkit.org/index.php/Labs_Official

- For the NETKIT introduction we'll use the slides at the following URL:
  - http://wiki.netkit.org/netkit-labs/netkit_introduction/netkit-introduction.pdf

IP STATIC CONFIGURATION

IP configuration

- IP Networking control files
- NIC layer 2 configuration
  - `ip link`
- ARP configuration
  - `ip neigh`
- IP address configuration
  - `ip addr`
- IP routing/forwarding configuration
  - `ip route`

IP Networking Control Files

- Different Linux distributions put their networking configuration files in different places in the filesystem
- EX:
  - Debian: /etc/network/interfaces
  - Gentoo: /etc/conf.d/net
  - Slackware: /etc/rc.d/rc.inet1
- We'll refer to Debian based distros as the NETKIT virtual machines are Debian

Debian `interfaces`

- Complete doc: `man interfaces`

Essentials:

- `/etc/init.d/networking (start | restart | stop)`
- static:

```
auto eth0                       # bring the interface up automatically
iface eth0 inet static          # static configuration
address 192.168.1.5             # set ip address
netmask 255.255.255.0           # set netmask
gateway 192.168.1.254           # set default GW route
```

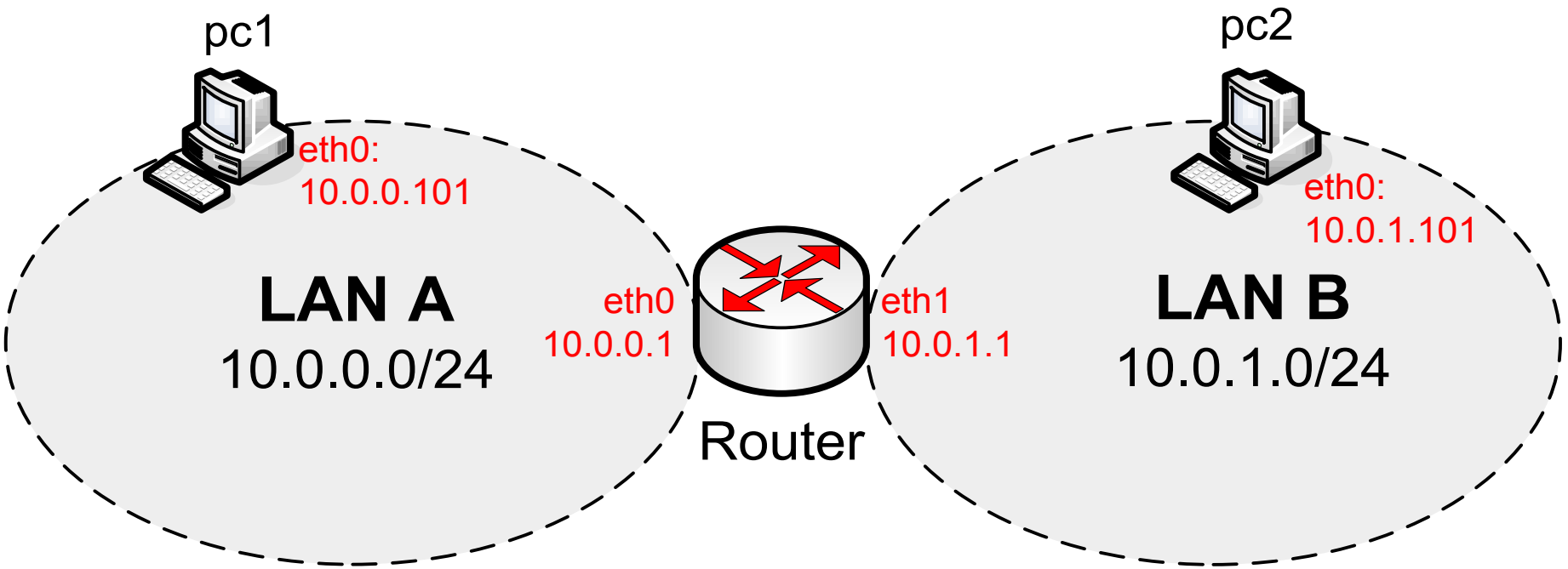
- dhcp:

```
iface eth0 inet dhcp            # use DHCP for IP configuration
```

- up and down scripts

```
up route add default gw 192.168.1.200
down route del default gw 192.168.1.200
(up|down) /etc/init.d/whatever-script.sh
```

Lab0-interfaces



Lab0-interfaces set-up

lab.conf:

```
router[0]=A
router[1]=B
router[mem]=64
pc1[0]=A
pc2[0]=B
```

To start the lab (on the host):

```
$ lstart
```

pc1/etc/network/interfaces

```
auto lo
iface lo inet loopback

auto eth0
iface eth0 inet static
    address 10.0.0.101
    netmask 255.255.255.0
    gateway 10.0.0.1
```

pc2/etc/network/interfaces

```
auto lo
iface lo inet loopback

auto eth0
iface eth0 inet static
    address 10.0.1.101
    netmask 255.255.255.0
    gateway 10.0.1.1
```

pc1.startup

```
/etc/init.d/networking start
```

pc2.startup

```
/etc/init.d/networking start
```

Lab0 set-up

router/etc/network/interfaces:

```
auto lo
    iface lo inet loopback

auto eth0
    iface eth0 inet static
    address 10.0.0.1
    netmask 255.255.255.0

auto eth1
    iface eth0 inet static
    address 10.0.1.1
    netmask 255.255.255.0
```

router.startup:

```
/etc/init.d/networking start
echo 1 > /proc/sys/net/ipv4/ip_forward
```

/proc/sys/net/ipv4

- The /proc filesystem acts as an interface to internal data structures in the kernel
- It can be used to obtain information about the system and to change certain kernel parameters at runtime
- Nice link:
  - http://www.linuxinsight.com/proc_filesystem.html
- The /proc/sys/net contains subdirectories concerning various networking topics
- In particular, /proc/sys/net/ipv4 contains sysctls which tune different parts of the IPv4 networking stack
  - EX: `ip_forward`, `ip_default_ttl`, `ip_echo_ignore_all`, `tcp_congestion_control`
- "`echo 1 > /proc/sys/net/ipv4/ip_forward`" means: "enable IP forwarding", i.e.: forward IP packets not addressed to us
- "`echo 1 > /proc/sys/net/ipv4/icmp_echo_ignore_all`" means: don't reply to ICMP echo request

How do I configure the IP stack at runtime?

- GNU Linux provides different tools for network configuration (`net-utils`)
  - `ifconfig, route, arp, netstat, etc...`
- `net-utils` have not been mantained since 2001
- `iproute2` is a collection of utilities that replaces `net-utils`

purpose	legacy "net-tools"	iproute2
Address and link configuration	`ifconfig`	`ip addr, ip link`
Routing tables	`route`	`ip route`
Neighbors	`arp`	`ip neigh`
VLAN	`vconfig`	`ip link`
Tunnels	`iptunnel`	`ip tunnel`
Multicast	`ipmaddr`	`ip maddr`
Statistics	`netstat`	`ss`

Essential `iproute2` commands

- For a complete doc → `man ip`
- Let's see the "must know" commands (assuming `eth0` interface available)
- Note: commands can be truncated. Ex: `ip r, ip n, ip addr`, etc…

- Show interfaces
  - `ip link show`
- Bringing interface up/down
  - `ip link set eth0 (up|down)`
- Set MAC address
  - `ip link set eth0 address 00:11:22:33:44:55`
- Set MTU
  - `ip link set eth0 mtu 1486`
- Enable/disable ARP
  - `ip link set eth0 arp (on|off)`

`iproute2` essentials cont.d…

- Show IP address
  - `ip address show [dev eth0]`
- Add/remove IP address
  - `ip address (add|del) 10.0.0.1/8 dev eth0`
- Flush all address
  - `ip address flush [dev eth0]`
- Q: what if you forget the “/network_prfx_len” suffix?

- List/flush routing table
  - `ip route (list|flush)`
- Add/del route (next hop, default, direct forwarding)
  - `ip route (add|del) 100.0.0.0/8 via 10.0.0.1`
  - `ip route (add|del) default via 10.0.0.1`
  - `Ip route (add|del) 10.0.0.0/24 dev eth0`

iproute2 essentials cont.d…

- Show ARP cache
  - `ip neigh show [dev eth0]`
- Flush ARP cache
  - `ip neigh flush dev eth0`
- Add/del ARP cache entry
  - `ip neigh (add|del) to 10.0.0.2 lladdr 00:11:22:33:44:55 dev eth0 state “state_name”`

`(state_name: permanent, stale, noarp, reachable)`

`iproute2` advanced...

- IP policy based routing
  - `ip rule`
- IP xfrm framework configuration (eg: IPSEC)
  - `ip xfrm`
- Monitor IP events
  - `ip monitor`
- IP tunneling (IPinIP, IPinGRE, IPv6 tunneling)
  - `ip tunnel`

Exercise 1 (in class)

- Let's go back to Lab0-interfaces
- Remove `/etc/network/interfaces` files for all VMS and the networking script startup
- Reconfigure everything with `iproute2`
- Put the configuration commands in the startup scripts (e.g.: `router.startup`)

Solution (Lab0-manual)

pc1.startup:

```
ip link set eth0 up
ip address add 10.0.0.101/24 dev eth0
ip route add default via 10.0.0.1
```

pc2.startup:

```
ip link set eth0 up
ip address add 10.0.1.101/24 dev eth0
ip route add default via 10.0.1.1
```

router.startup:

```
ip link set eth0 up
ip link set eth1 up
ip address add 10.0.0.1/24 dev eth0
ip address add 10.0.1.1/24 dev eth1

echo 1 > /proc/sys/net/ipv4/ip_forward
```

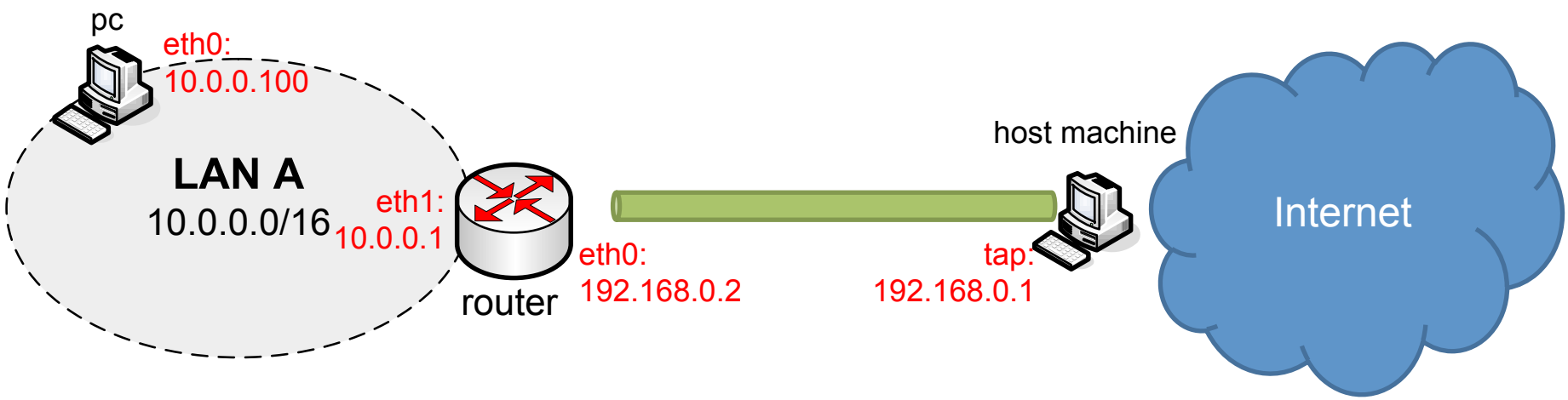
SOMETHING MORE ABOUT NETKIT

How to connect to the real world

- `/hosthome` directory in the VM is a link to the home of the user that launched the VM

- A VM can be set with a TAP interface
  - a TAP interface is a network interface connecting the VM and the host machine
  - If the host machine is connected to the internet the VM can use the host machine as the default GW to the internet
  - With vstart:
    - vstart vm --eth0=tap,10.0.0.1,10.0.0.2
    - “vm” is whatever name
    - The first IP address is the TAP address on the host machine
    - The second IP address is the address of eth0 on the VM machine
    - The IP addresses can be whatever IP addresses as long as they are in different subnet with respect to any other interfaces
  - With lstart:
    - vm[0]=tap,10.0.0.1,10.0.0.2
  - To delete a “zombie” TAP (you may need to bring it down first…)
    - `tunctl -d “tap_name”`

TAP interface example



Lab0-tap

lab.conf

```
router[0]=tap,192.168.0.1,192.168.0.2
router[1]=A
pc[0]=A
```

router.startup

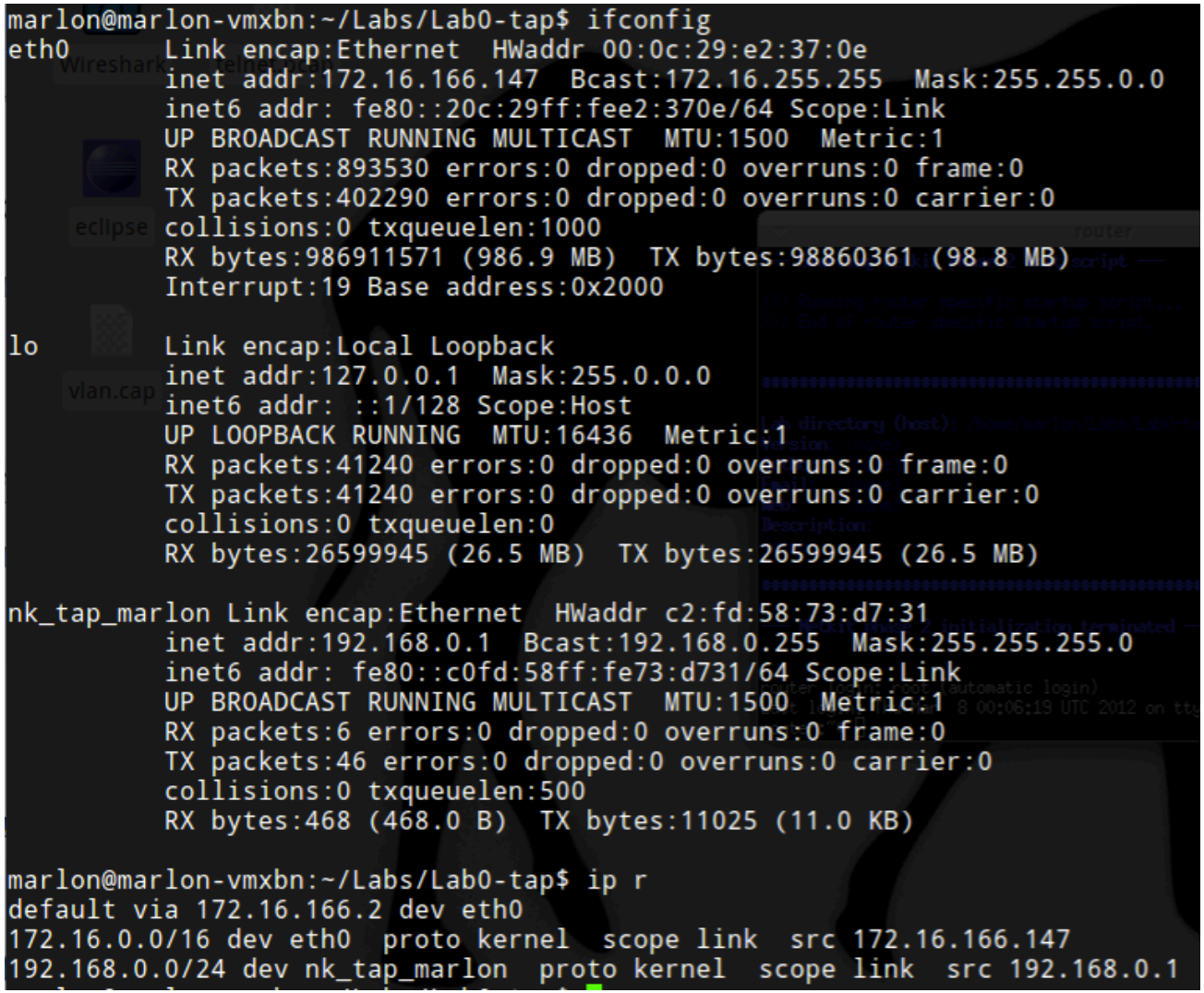
```
ip link set eth1 up
ip address add 10.0.0.1/16 dev eth1
iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
```

pc.startup

```
ip link set eth0 up
ip address add 10.0.0.100/16 dev eth0
ip route add default via 10.0.0.1
```

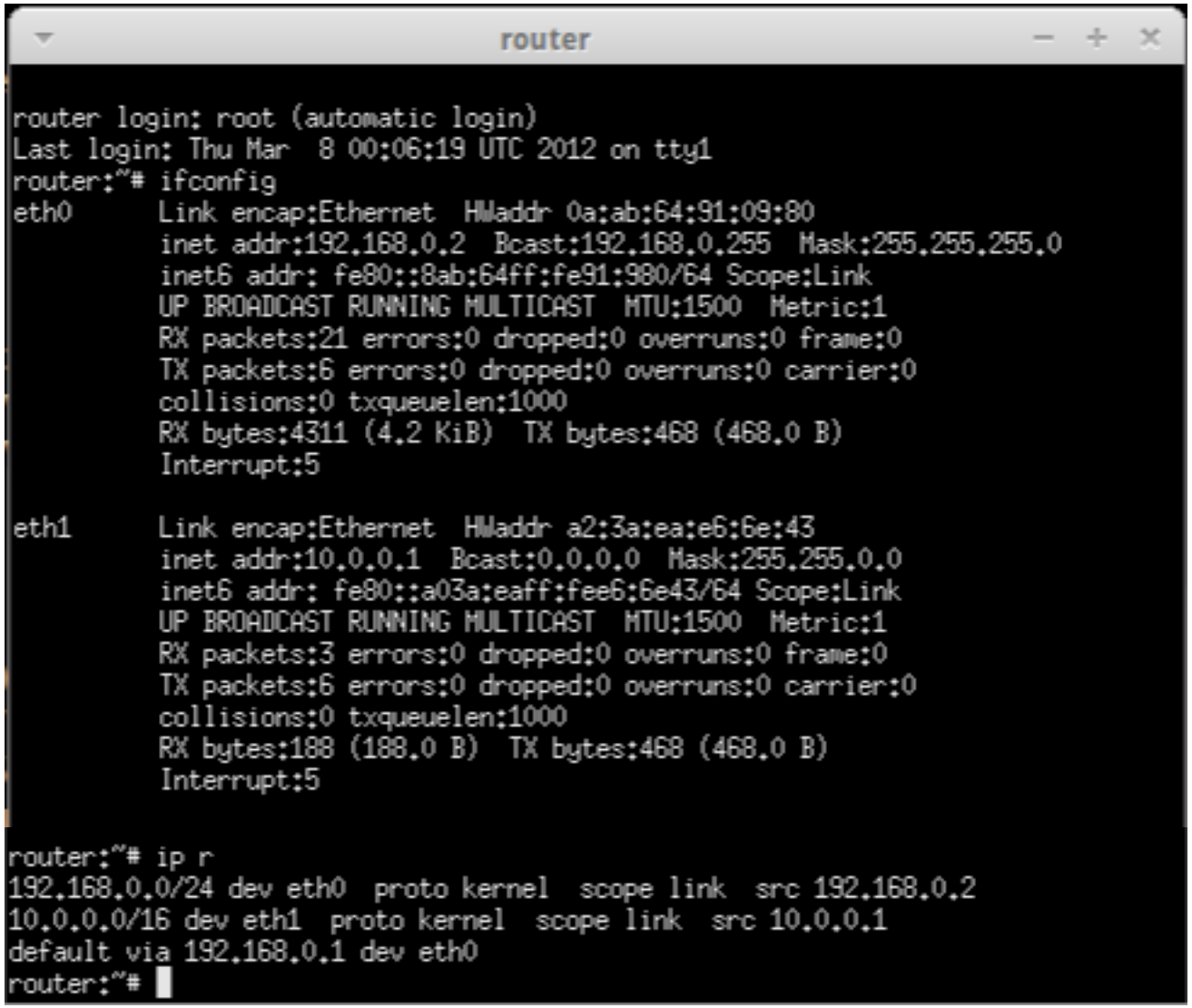
Lab0-tap

host machine



Lab0-tap

router virtual machine



How to permanently write the netkit FS

Two ways:

1. Launch the VM with the "`-W`" option

```
vstart vm -W
```

1. Mount the FS file in loop

```
mount -o loop,offset=32768 \
$NETKIT_HOME/fs/netkit-fs /mnt/nkfs
```

How can I permanently add packages to the VM?

- The “TAP way”
  1. Start a VM with a tap and with the -W option
  2. Connect the Host machine to the internet.
  3. configure a name server inside the vm /etc/resolv.conf
  4. Run apt-get on the VM (perhaps you will need to run apt-get update first)

- The “chroot way”
  1. Bind the proc/ and dev/ in the netkit FS
  2. chroot inside the FS mounted as in the previous slide
  3. configure a name server inside the chrooted /etc/resolv.conf
  4. Run apt-get update and install

DYNAMIC CONFIGURATION WITH DHCP

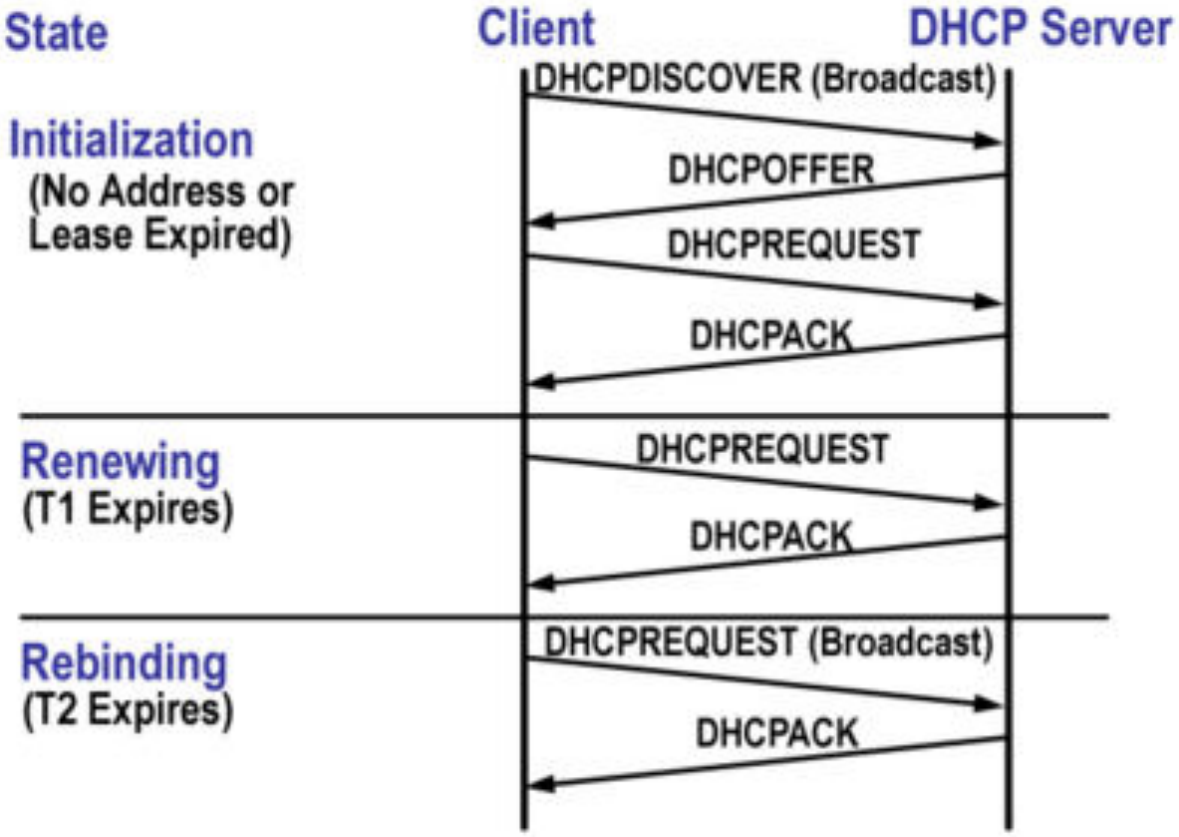
DHCP

- Dynamic Host Configuration Protocol (DHCP) is a network configuration protocol for hosts on IP networks
- A DHCP client obtains from a DHCP server a set of configuration parameters, typically:
  - IP address/netmask (for a given lease time)
  - Default GW
  - DNS server
  - Domain name
  - Search name list
  - NetBIOS name server
  - SMTP server

DHCP basics

- 4 way handshake
  - Discover, Offer, Request, ACK
- Works with multiple DHCP servers on the same LAN (DHCP Release message)
- The Client broadcast (typically at startup) the discover and receive one or more offer from the Server(s) – (then the protocol continues, but we don't care for now…)
- The Client can Renew (/Rebind) a lease for a previously assigned IP address
- 1 DHCP server for each LAN
  - DHCP-Relays allow DHCP communication through routers

DHCP handshakes



DHCP in Linux

- ISC DHCP is the most used opensource DHCP implementation
  - http://www.isc.org/software/dhc
- Provides:
  - DHCP Client (`dhclient`), Server (`dhcp3-server`), Relay (`dhcrelay`)
- ISC DHCP client and sever are already in the NETKIT VM filesystem
  - DHCP relay can be installed with `apt-get`

NETKIT lab with DHCP

Lab0-dhcp

Same topology as in Lab0-interfaces.

Differences:

1) In `router.startup` add the following command:

```
/etc/init.d/dhcp3-server start
```

2) In `pc{1,2}/etc/network/interfaces` remove the static configuration and add:

```
auto eth0
iface eth0 inet dhcp
```

3) Create the DHCP server configuration file in `router/etc/dhcp3/dhcpd.conf` (see the next slide)

4) Router has also a tap to the outside world:

```
router[2]=tap,192.168.0.1,192.168.0.2
```

5) lab.dep to start router first

DCHP server configuration

```
default-lease-time 3600;
option domain-name-servers 8.8.8.8;
option domain-name "lab0-dhcp.org";
option domain-search "lab0-dhcp.org";

subnet 10.0.0.0 netmask 255.255.255.0 {
    range 10.0.0.100 10.0.0.254;
    option routers 10.0.0.1;
}

subnet 10.0.1.0 netmask 255.255.255.0 {
    range 10.0.1.100 10.0.1.254;
    option routers 10.0.1.1;
}
```