

Linux Networking

- How Networking Works
- Configuring Networking in Linux
- Using system-config-network
- Network debugging
- Wireless networking
- IPv6



Networking

- Networking uses the TCP/IP protocol by default, but Linux can use other protocols to interact with other operating systems:

MS Networking (samba)

Novell Netware (ipx)

AppleShare (netatalk)



Networking References

- Much more info on TCP/IP available at:

Linux Network Administrator's Guide by Dawson, Bautts and Purdy (O'Reilly)

`https://www.redhat.com/docs/manuals/enterprise/RHEL-5-manual/Deployment_Guide-en-US/index.html`

`http://www.freeprogrammingresources.com/tcp.html`



Network Interfaces

- All interfaces treated as devices, found under */dev/devname*
- lo -- loopback device
Used for testing and accessing servers running on the local machine.
Named “localhost” with IP 127.0.0.1



Ethernet/wireless interfaces

- eth0, eth1, ...

Ethernet and wireless cards

Most common connections on campus

Drivers are usually loaded as a module during startup (using insmod) but some older drivers may have to be compiled into the Linux kernel to work correctly. Usually detected at installation unless you add the card later.



PPP interfaces

- ppp0, ppp1, ...

Point-to-point protocol, usually telephone modem

Appears when you invoke the PPP client daemon, usually by running something like wvdial or kdial, to connect to an Internet service provider



Other interfaces

- tk0, tk1... Token ring interfaces
- sl0, sl1... SLIP (serial, usually modem, outdated and replaced by PPP)
- plip0... Parallel-Line Interface Protocol
(parallel port, like LapLink)
- cipebc0... Crypto IP Encapsulation (IP tunnel)
- isdn0... ISDN modems
- ax0, ax1... AX.25 (for amateur radio buffs)



Naming of Parts

- **NIC:** Network Interface Card, the hardware that connects the machine to the network (might be built in to motherboard, might be a PCI or ISA or PCCard addon)
- **MAC Address:** hardware address of the NIC, assigned by the card manufacturer when the card is made
Ex: 00:0a:95:a7:62:d8
- **IP Address:** 32-bit address relating machine to its "physical" location on the network (also called IP number)



IP Packet

- Contains the data to be transferred plus MAC addresses and IP addresses for both source and destination

Header info	IP Addresses	Actual data to be transferred
-------------	--------------	-------------------------------

Header info includes packet identifier, packet type, protocol to be used, time to live and checksum

- This string of bytes is "yelled" on to the subnet, and the router forwards it where it's supposed to go.



IP Numbers

- Each interface must have a unique 32-bit IP number (at least, on its subnet)
- Usually written as four 8-bit numbers
129.186.142.36
- First three numbers determine the subnet
- Each subnet has a router that transfers packets to and from the subnet



Where does the IP Number Come From?

- localhost is always 127.0.0.1
- PPP connections are assigned an IP when they connect
- Ethernet, wireless and similar connections get an IP number in one of two ways:
 - Static IP number
 - Dynamic addressing (DHCP or BOOTP)



Static IP Number

- Assigned by the network administrator
- At ISU, primarily used for machines that must be at predictable locations (server or remote access desktop)
- At ISU, log in to <http://asw.iastate.edu> and go to Request for Services > Domain Name Service > IP Request to request a static IP number
- Also used on private networks (isolated behind a router with no DHCP, or in a location with no Internet connection)



Dynamic IP Numbers

- A machine connecting to the net requests an address and a DHCP server gives it one
 - Most of campus buildings (including residence)
 - Most DSL routers and cable modems
 - Many Linux-based router projects
 - Microsoft's Internet Connection Sharing (Windows 98+)



Private Networks

- Private network IP addresses fall in the following ranges:

10.0.0.0 through 10.255.255.255

172.16.0.0 through 172.31.0.0

192.168.0.0 through 192.168.255.0

As long as your network is isolated or connected to the Internet by a router, you can use IP numbers in this range. Assign one to each machine and keep track of what you use. Just don't use them on campus!



Configuring Networking

- Basic networking (first Ethernet card) is configured during installation
- Networking changes can be done in two ways:
 - Edit configuration files, restart interface with `ifdown iface` and `ifup iface` (or “`ifconfig iface down`” and “`ifconfig iface up`”)
 - Use the Network Administration Tool
`system-config-network`



Network Configuration Files

- **`/etc/sysconfig/network`**

Basic information about the computer; whether or not networking is on and the hostname

- **`/etc/sysconfig/network-scripts/ifcfg-iface`**

Configuration information for interface *iface*, plus ifup and ifdown scripts

- **`/etc/hosts`**

IP numbers for “special” machines

- **`/etc/resolv.conf`**

Info on domain name servers and search domains



/etc/sysconfig/network

- Sets whether or not networking is on, the hostname and (optionally) the gateway device and IP.

NETWORKING=yes

HOSTNAME=hostname.subdomain.iastate.edu

GATEWAYDEV=eth0

GATEWAY=129.186.144.254

- When using DHCP, the DHCP client will create this file for you.
- The hostname should also be in /etc/hostname for compatibility.



/etc/sysconfig/network-scripts

- Configurations for the different network interfaces are located in `/etc/sysconfig/network-scripts/ifcfg-iface`
- The scripts `ifup` and `ifdown` can be used to start and stop interfaces:

```
ifup interface
```

```
ifdown interface
```

- Changes to configurations can be done manually or with the Network Configuration tool (`system-config-network`)
--- we'll show you both before we're done.



ifcfg-eth0, static IP on isolated network

```
DEVICE=eth0
# static IP, do not use a boot protocol
BOOTPROTO=none
# activate interface at startup
ONBOOT=yes
NETWORK=192.168.1.0
NETMASK=255.255.255.0
IPADDR=192.168.1.27
# do not allow users to enable and disable
USERCTL=no
```



ifcfg-eth0, dynamic IP with DHCP

```
DEVICE=eth0  
# use DHCP for configuration information  
BOOTPROTO=dhcp  
# activate on startup  
ONBOOT=yes
```



PPP connections

- For the most part you don't need to modify `ifcfg-pppn`; if you use `wvdial`, `Kppp` or a similar tool to make your connections, it will manage that file for you.
- You may need to modify `ifcfg-pppn` and/or dialing scripts manually if your PPP service has strange requirements (ISU's doesn't) or you have a cranky modem



Typical ifcfg-ppp0 (page 1 of 2)

```
DEVICE=ppp0
NAME=test
# Name in WVDIAL's configuration list
WVDIALSECT=test
# Modem device and serial port speed
MODEMPORT=/dev/modem
LINESPEED=115200
# name used for PAP authentication at dialup
PAPNAME=jbalvanz
# User can activate and deactivate PPP
USERCTL=true
# Do not activate on startup
ONBOOT=no
```



ifcfg-ppp0 (p. 2 of 2)

```
# do not force reconnect if connection drops
PERSIST=no
# use this interface as the default route
DEFROUTE=yes
# modify /etc/resolv.conf with host's DNS info
PEERDNS=yes
# do not automatically open PPP on demand
DEMAND=no
# hang up after 10 minutes inactivity
IDLETIMEOUT=600
```



Domain Names

- Used so you can remember easy names (like www.iastate.edu) instead of 129.186.1.122
- When it doesn't know, your machine asks the domain name server (DNS) what IP number corresponds to the name it has.
- Controlled by two files in Red Hat Linux:
 /etc/hosts
 /etc/resolv.conf



/etc/hosts

- Normally used only on isolated networks without domain name servers, or for those machines you have to be able to connect to even if the DNS isn't available. On a typical isolated network:

127.0.0.1 localhost.localdomain localhost

192.168.0.1 pavillion

192.168.0.2 jeffs486

192.168.0.10duron fileserv

- Second names are called aliases



/etc/resolv.conf

- Tells Linux what machines to ask for DNS info if the name given isn't in /etc/hosts
- You may not have to make this if using DHCP or PPP; those clients can create “/etc/resolv.conf” on connection
- Typical /etc/resolv.conf for Iowa State's network:

search ait.iastate.edu

nameserver 129.186.142.200

nameserver 129.186.140.200

nameserver 129.186.1.200



Networking Commands

- Most of network configuration can be done with a small number of text-mode commands:

```
hostname  
ifconfig  
route
```

- From a GUI, you can use the Network Administration Tool (system-network-config)



hostname

- Sets the hostname in `/etc/sysconfig/network` and `/etc/hostname`

`hostname machinename`

- This is normally done during startup by the script `/etc/rc.d/sysinit`; you shouldn't need to do it manually.
- Use the shorthand name (emperor) instead of the fully-justified domain name (emperor.ait.iastate.edu)



ifconfig

- Used to get statistics and set configuration info about network devices
- Common to distributions other than Red Hat (is used in Debian, for instance) so will probably be available even if you're not on your standard machines.
- To examine the settings and statistics for an interface, type

```
ifconfig iface  
/sbin/ifconfig iface
```



“ifconfig eth0” output

```
eth0      Link encap:Ethernet  HWaddr 00:0B:DB:67:18:CA  
          inet addr:129.186.139.204  Bcast:129.186.139.255  Mask:255.255.255.0  
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1  
          RX packets:982598  errors:0  dropped:0  overruns:0  frame:0  
          TX packets:114372  errors:0  dropped:0  overruns:0  carrier:0  
          collisions:9214  txqueuelen:100  
          RX bytes:238620678 (227.5 Mb)  TX bytes:45184277 (43.0 Mb)  
          Interrupt:9  Base address:0xdcc0  Memory:ff6e0000-ff700000
```

- “Hwaddr” is the MAC address NetReg needs
- “inet addr” is the IP address of the machine
- Note RX and TX (receive and transmit) statistics (useful in diagnosing interface problems)
- Info about ethernet card hardware appears in last line



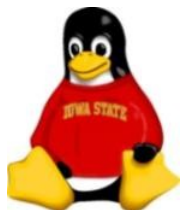
Activating and deactivating interfaces

- To activate an interface, type

```
ifconfig iface up
```

- To deactivate an interface, type

```
ifconfig iface down
```



Setting configuration with ifconfig

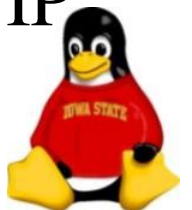
- Type

```
/sbin/ifconfig iface address netmask nn.nn.nn.nn
```

Example:

```
/sbin/ifconfig eth0 129.186.139.205 netmask 255.255.255.0
```

- Setting an address triggers an automatic “up”; to change IP, bring interface down, then set address
- Other options can be used to set Ethernet card settings, IP tunneling, point-to-point connections, etc.



route

- Which interface and gateway does a packet use to get to a particular host? The answer is in the routing tables.
- route edits the routing tables, determining which interface packets use to get to which network host.
- route is not always in the path; if not, try `/sbin/route`



Seeing the routing table

- Type

`/sbin/route`

Kernel IP routing table

Destination	Gateway	Genmask	Flags	Metric	Ref	Use	Iface
129.186.139.0	*	255.255.255.0	U	0	0	0	eth0
127.0.0.0	*	255.0.0.0	U	0	0	0	lo
default	router-129-186-	0.0.0.0	UG	0	0	0	eth0

- Items with a gateway of “*” are on the same subnet as this machine; they don't need a gateway to reach them.
- The default router must be on the local subnet, or on a subnet with an explicitly defined route.
- Note that the gateway is described by domain name, not IP number. Use `/sbin/route -n` to get IP numbers.



Adding routes and gateways

```
route add default gw 129.186.146.254
```

- sets gateway for all traffic not otherwise routed to 129.186.146.254

```
route add -net 192.168.0.* netmask  
255.255.255.0 dev eth1
```

- sets route to the network 192.168.0.* via device eth1
- Does NOT route traffic from the isolated net to other interface – you need **routed** to do that.



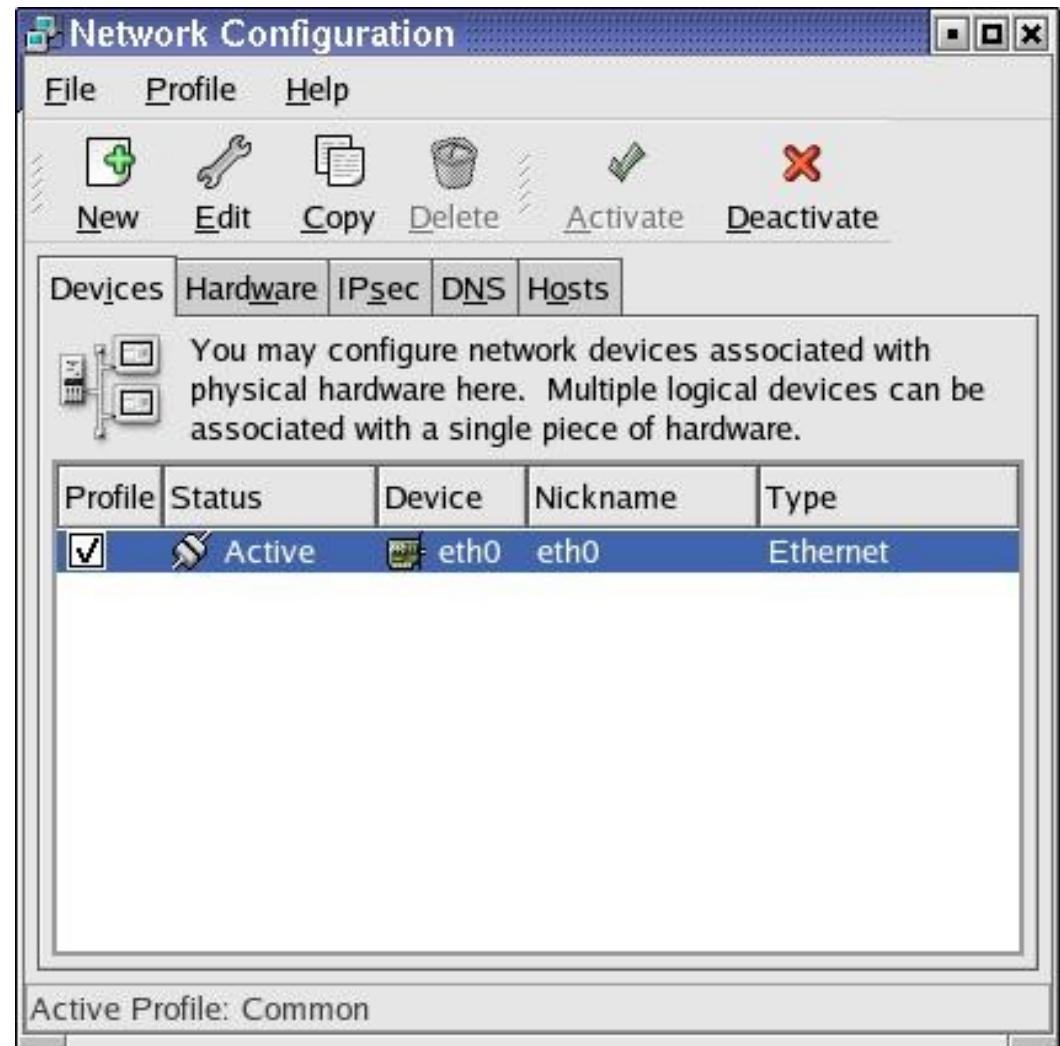
The Network Administration Tool

- *aka* `system-config-network`
- A GUI tool for doing network configuration
- Really just edits the appropriate files and runs scripts to start and restart interfaces, but some people find it useful because everything is in one big place.
- GNOME: System > Administration > Network
KDE: Start > System Settings > Network
Shell: type
`system-config-network &`



Configuring Devices

- From the Device tab you can activate or deactivate a network interface with the buttons at lower right
- To edit configuration for an interface, highlight and click Edit; to add an interface, click New



Configuring an Interface with SCN

- To set a static IP address, turn on “Statically set IP addresses” and enter values for address, subnet mask and default gateway address



Ethernet Device

General Route Hardware Device

Nickname: eth0

☒ Activate device when computer starts

☐ Allow all users to enable and disable the device

☒ Automatically obtain IP address settings with: dhcp

DHCP Settings

Hostname (optional):

☒ Automatically obtain DNS information from provider

☐ Statically set IP addresses:

Manual IP Address Settings

Address:

Subnet Mask:

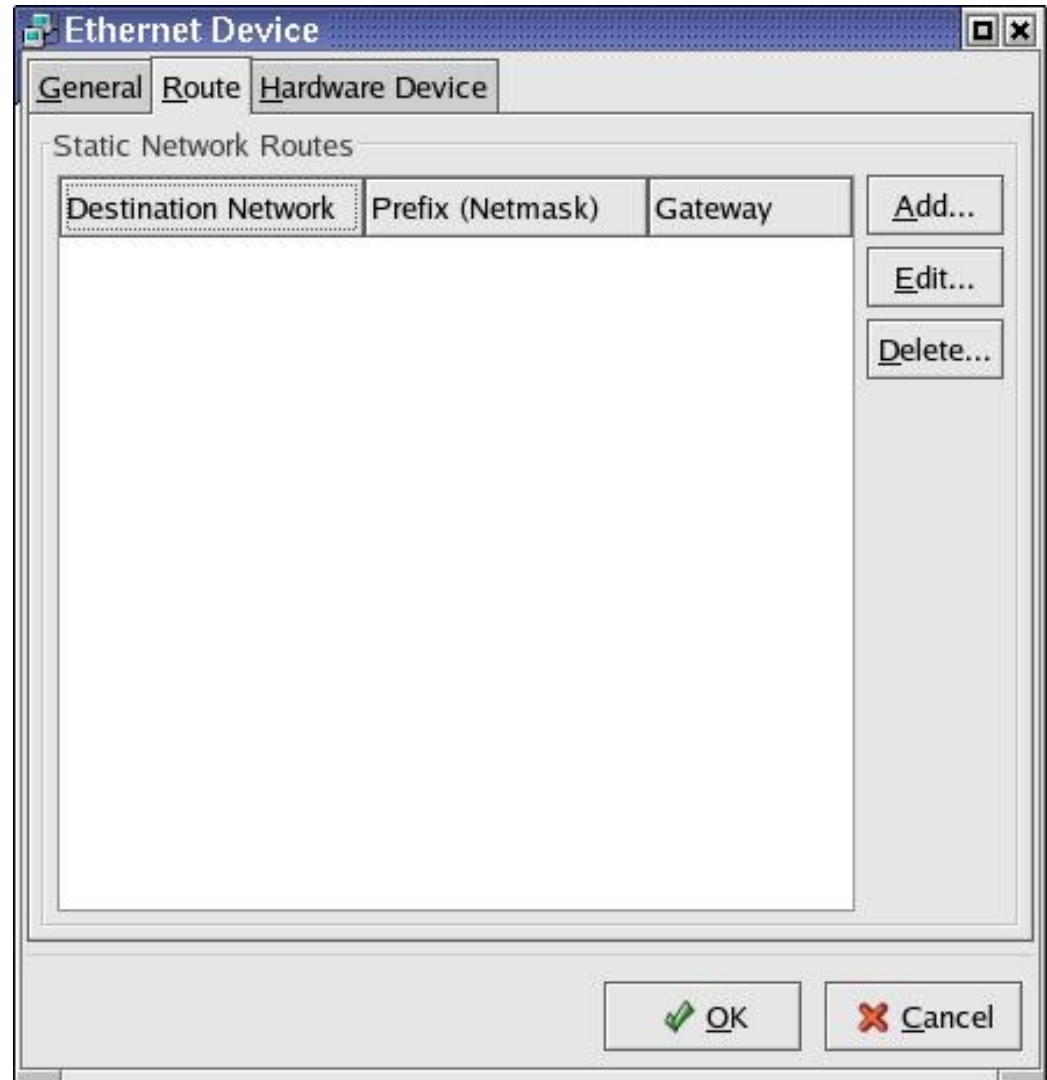
Default Gateway Address:

OK Cancel



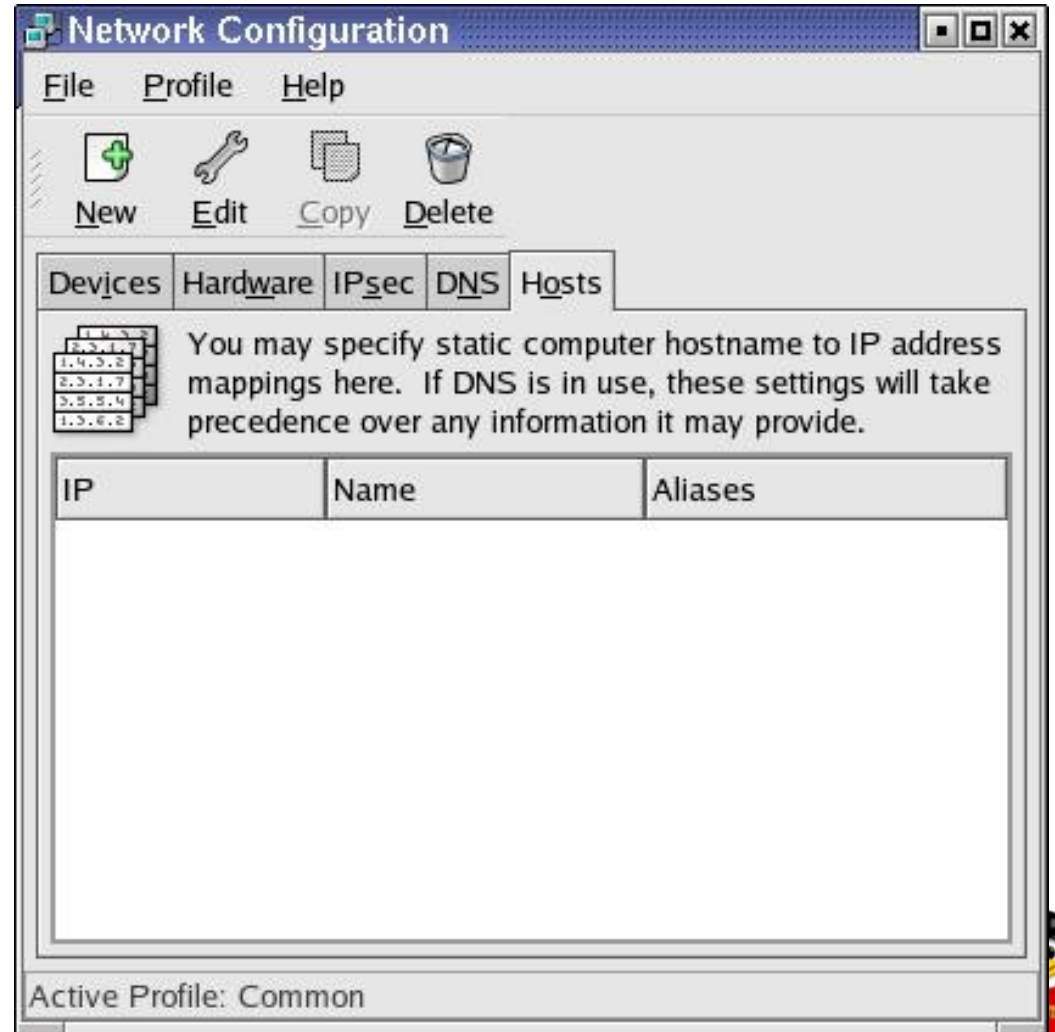
Modifying routing with SCN

- To add a route, click “Add” and enter the network, netmask and gateway addresses (as in the route command)



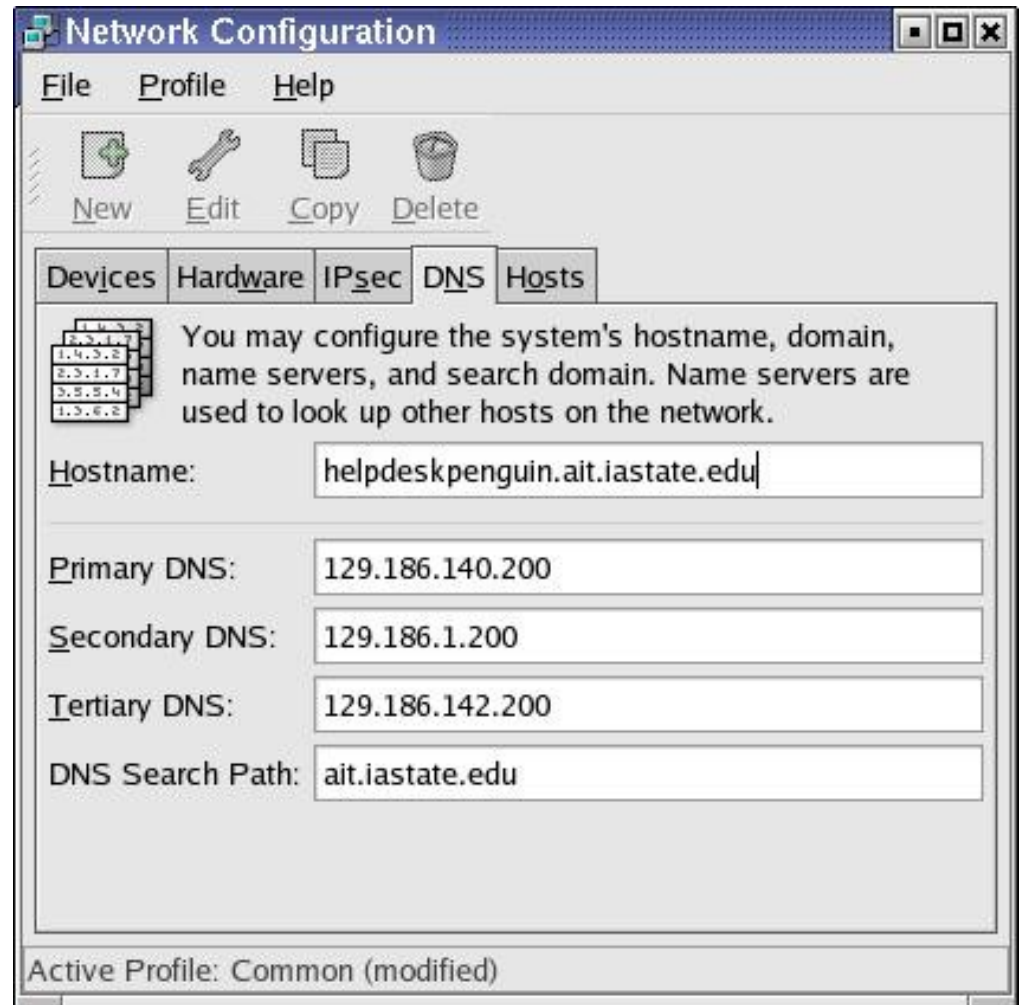
Managing /etc/hosts with SCN

- The Hosts tab is an interface to /etc/hosts. Click “New” to add a host, and enter IP number, name and aliases.



Changing DNS with SCN

- Set machine hostname with the Hostname field.
- Add up to three domain name servers in the Primary DNS, Secondary DNS and Tertiary DNS fields.
- To specify the search path(s), enter a Search Domain and click “Add”.



Debugging Tools

- ping – test connection to a machine
- host – get DNS information about a computer
- traceroute – follow the path of routers to a machine
- netstat – see what ports are open and what is connected to them



Ping

- Tests the connection to a machine

`ping hostname`

```
PING dfd94q.its.iastate.edu (129.186.144.80) from 129.186.139.205 : 56(84) bytes of data.  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=1 ttl=127 time=0.647 ms  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=2 ttl=127 time=0.640 ms  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=3 ttl=127 time=0.550 ms  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=4 ttl=127 time=0.594 ms  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=5 ttl=127 time=0.626 ms  
64 bytes from jeffnt.ait.iastate.edu (129.186.144.80): icmp_seq=6 ttl=127 time=0.685 ms  
  
--- dfd94q.its.iastate.edu ping statistics ---  
6 packets transmitted, 6 received, 0% loss, time 5042ms  
rtt min/avg/max/mdev = 0.550/0.623/0.685/0.051 ms
```

- Press <Ctrl/C> to stop pinging (it's not polite)



host

- `host` returns the DNS information about a domain name or an IP number.

```
vincent% host dfd94q.its.iastate.edu
```

```
dfd94q.its.iastate.edu has address 129.186.144.80
```

```
vincent% host 129.186.144.80
```

```
80.144.186.129.in-addr.arpa domain name pointer dfd94q.its.iastate.edu.
```

- `host -a` returns information about the DNS servers returning the information as well.



traceroute

- traceroute traces the path from your machine to a remote host.

`/usr/sbin/traceroute hostname`

```
#!/usr/sbin/traceroute www.uiowa.edu
traceroute: Warning: www.uiowa.edu has multiple addresses; using 128.255.56.81
traceroute to www.uiowa.edu (128.255.56.81), 30 hops max, 38 byte packets
 1  b11srl1-10-145.tele.iastate.edu (10.10.145.251)  0.467 ms  0.395 ms  0.829 ms
 2  b31gb1-lan254-128.tele.iastate.edu (129.186.254.131)  0.441 ms  0.554 ms  0.464 ms
 3  b31br2-437.gw.iastate.edu (192.245.179.154)  0.938 ms  0.737 ms  0.714 ms
 4  rtr-border-lc.uiowa.edu (198.49.182.17)  11.432 ms  11.547 ms  11.831 ms
 5  rtr-core-lc.uiowa.edu (128.255.2.130)  11.686 ms  12.065 ms  11.197 ms
 6  lime.weeg.uiowa.edu (128.255.56.81)  12.059 ms  12.668 ms  11.079 ms
```

- Each line is a "hop" or router. The three times on each line are times to return from that machine in milliseconds. An asterisk will appear if it is unable to connect before timeout.



Netstat

- Used to determine network connections by and to your machine.

netstat

Active Internet connections (w/o servers)

Proto	Recv-Q	Send-Q	Local Address	Foreign Address	State
tcp	0	256	mommy.ait.iastate.e:ssh	jlbq5.ait.iastate:49264	ESTABLISHED
tcp	0	0	mommy.ait.iastate:37248	du139-205.aitlabs.i:ssh	TIME_WAIT

Active UNIX domain sockets (w/o servers)

Proto	RefCnt	Flags	Type	State	I-Node	Path
unix	7	[]	DGRAM		964	/dev/log
unix	3	[]	STREAM	CONNECTED	5213642	
unix	3	[]	STREAM	CONNECTED	5213641	
unix	2	[]	DGRAM		1727409	
unix	2	[]	DGRAM		1244	
unix	2	[]	DGRAM		1198	
unix	2	[]	DGRAM		1097	
unix	2	[]	DGRAM		979	



Wireless (802.11?) Networking

- Linux does support wireless networking, BUT...
 - Not all wireless cards have Linux drivers
 - There are ways around this (on i386 machines) but only sometimes
- To avoid problems in configuration, check that the card you're looking at is supported before you buy
- To use PC Cards you must also have the PCMCIA support loaded (it's a service)



Adding a Wireless Card

- Choose System Settings -> Network
- Click Devices, then New.
- Choose Wireless connection and click Forward.
- Choose “Other wireless card”, click Forward.
- Choose your adapter from the list, click Forward three times, then click Apply.



Working with Wireless

- Once installed, a wireless card looks like a normal Ethernet card.
- IP address, DNS, etc. is set with `ipconfig`
- Channels, etc. set with `iwconfig`

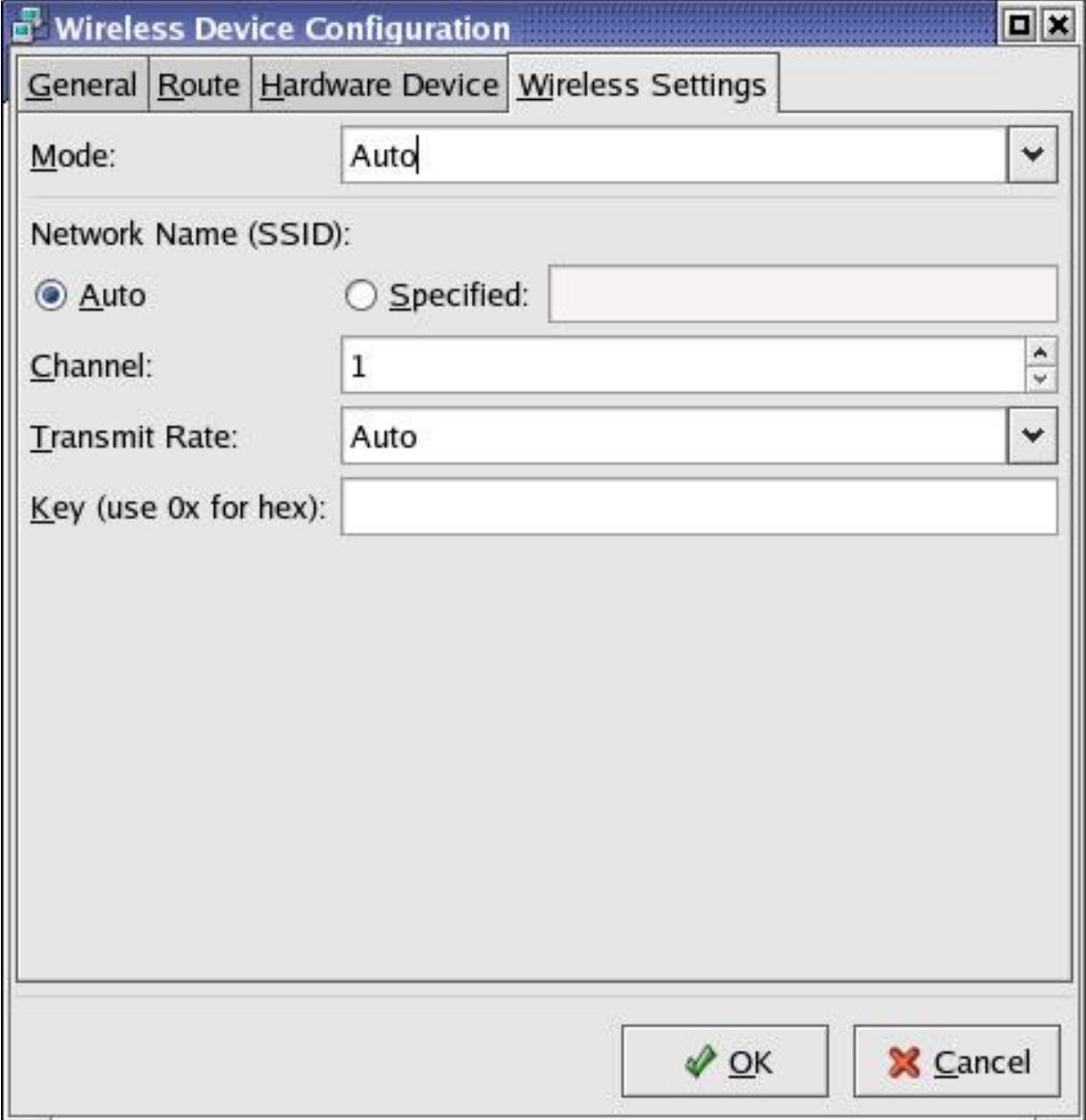
```
/sbin/iwconfig ethN options
```

See the `iwconfig` man page for options. Or you can do it all with `system-config-network` instead.



Wireless with SCN

- An extra tab appears when editing a wireless device
- For an encrypted network, enter name under SSID and key below



The image shows a 'Wireless Device Configuration' dialog box with four tabs: 'General', 'Route', 'Hardware Device', and 'Wireless Settings'. The 'Wireless Settings' tab is selected. It contains the following fields and options:

- Mode:** A dropdown menu set to 'Auto'.
- Network Name (SSID):** Two radio buttons: 'Auto' (selected) and 'Specified:'. The 'Specified' option has an empty text box next to it.
- Channel:** A dropdown menu set to '1'.
- Transmit Rate:** A dropdown menu set to 'Auto'.
- Key (use 0x for hex):** An empty text box.

At the bottom right, there are 'OK' and 'Cancel' buttons. A small yellow cartoon character is visible at the bottom right corner of the dialog box.

More wireless help

- The current Wireless HOWTO is located at

http://www.hpl.hp.com/personal/Jean_Tourrilhes/Linux/

- The pertinent section of the Red Hat Enterprise manual is at

<http://www.redhat.com/docs/manuals/enterprise/RHEL-4-Manual/sysadmin-guide/s1-network-config-wireless.html>



Ndiswrapper

- Support for NICs (particularly wireless) that don't have Linux drivers available
- Provides a Windows API-compatible layer letting the Windows NDIS driver work with Linux
- You'll need to compile from source and install manually
- <http://ndiswrapper.sourceforge.net>



rfswitch

- Many laptops allow you to switch the wireless adapter on and off to save power
- Unfortunately, some laptops use a software switch – which doesn't work with Linux!
- rfswitch gives you control of the radio in *some* laptops
- <http://rfswitch.sourceforge.net>

(Most Dell laptops use a hardware switch, so don't need this utility.)



IPv6

- The current version of IP (IPv4) has a problem; it only allows about 4 billion addresses (32 bits)
- IPv6 uses a 128 bit address, allowing 340282366920938463463374607431768211456 (three hundred forty undecillion) addresses
- There are also many other improvements in security and efficiency (IPsec is required, NATs are unnecessary...)



Linux Support for IPv6

- Supported (badly) in RHEL4, better in RHEL5; check for “file” `/proc/net/ipv6`
- Support can be added with `insmod ipv6`
- Some utilities support it, others not
- At ISU, IPv6 addresses are static only, no DHCP, and the associated IPv4 address must also be static
- Howto and status at <http://www.tldp.org/HOWTO/Linux+IPv6-HOWTO/>

