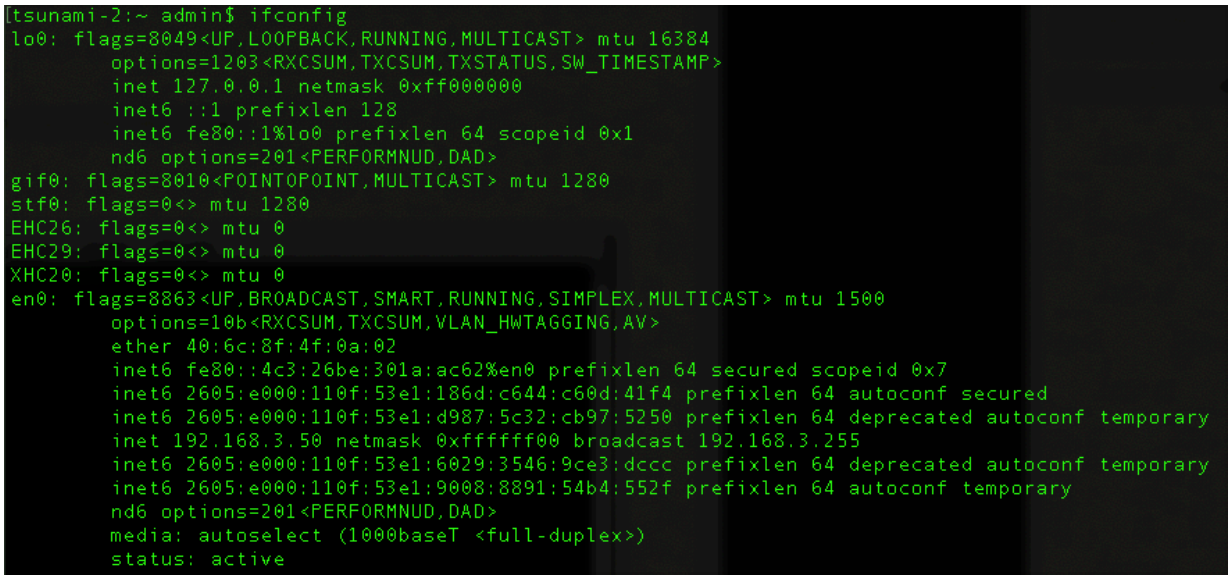
TC 3.0
Terminal commands module 3: Networks and the internet
n.b. many of these commands will work on mac or raspberry pi under terminal.
Some will also work under PC, depending on OS
topics covered: ifconfig, IP address, TCP/IP, subnet mask, DNS, routers, modems

IP addressing:
First command: **ifconfig**
enter **ifconfig** on your mac or pi:



so what does this tell us?

1. my address is either a complex IP6 address: 2605:e000:110f:53e1:9008:8891:54b4:552f or:
2. my address is a simpler IP4 address: inet 192.168.3.50 netmask 0xffffff00 broadcast 192.168.3.255

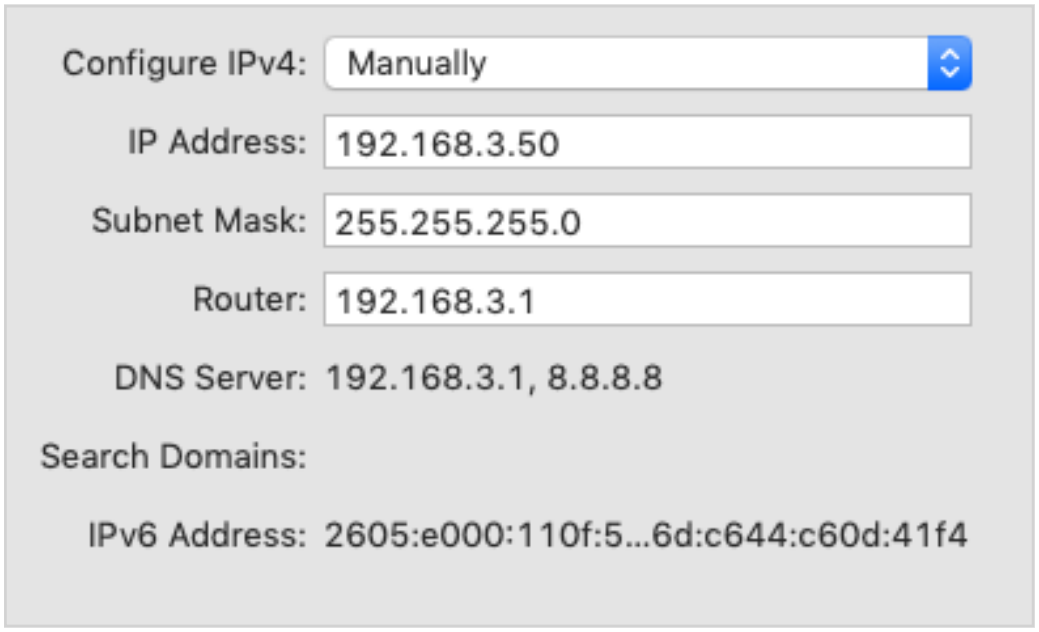
Let's look at the simpler one first:
IP4 or IPv4 is the older, first notation for internet addresses on the internet.
IP6 is the newer version of IP addresses since we are running out of IPv4 addresses. Notice the size, and the fact that numbers and letters are used. This is known as "hex" or hexadecimal, 16 numbers between 0 and f (0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f)
Hex means six, or a witch in German (no joke): "that witch put a hex on

me". Also a sign of the devil, if you are into that sort of stuff...
Decimal means ten, or how many fingers and thumbs you have (yes, that's where it comes from)
Hexadecimal means 6+10 or 16
Count:
0,1,2,3,4,5,6,7,8,9,a,b,c,d,e,f
IP stands for internet protocol, which means the address you might put on a letter, or in this case, a packet of data going to an address on the internet.
TCP means the message or letter itself. In the network version, TCP stands for transmission control protocol, and can include how the "letter" could be broken into pages (packets) that can fit into the envelope.
We use the term TCP/IP to mean the entire message (letter and envelope).

Subnet mask:
The next part is important, but written in a way hard to understand:
netmask 0xffffff00 broadcast 192.168.3.255

You may have seen something like this if you were in the dorms——

Here's why:
Imagine you are in a hotel that has 254 rooms in one hallway. Every time a person walks down the hall (with those loud wheeled carriers) every room wakes up.
Now imagine you divide the rooms into shorter hallways.
Subnetting is a way of taking all of the possible "rooms" or addresses and breaking them down into smaller "hallways".
So, a network that starts with a router at 192.168.3.1 like mine might have a subnet mask of 255.255.255.0:



You can see this much easier on the networks pane of the preferences on your mac, or under networks on the pi (less clear, but still there).
This network can have 254 addresses, or any combination of 192.168.3.x where x is any number between 1 and 254.
Now look at the elab network:
10.14.250.220 IP address
subnet mask: 255.255.0.0
router: 10.14.1.1

This network could have any number starting with 10.14.x.y, where x and y can be any number between 1 and 254.
So,
254 x 254 = 64,516 addresses possible in the elab alone.
Wait!
HPA has a network right now that is 255.0.0.0 . We call this a “flat” network since it has no subnetting or a “class A” network. The 192.168.3.x network is called a class C network. Class B networks are in between and rarely used.
This means 254 x 254 x254 machines on one hallway!
Lots of noise: 16,387,064 hosts

We use a different sort of notation called CIDR notation for networks that you might find useful, and there are calculators online to do this:
192.168.3.1 has a CIDR network name of 192.168.3.0/24
10.14.0.1 has a CIDR network name of 10.14.0.0/16

10.0.0.1 has a CIDR network name of 10.0.0.0/8
Don't worry about this now, but you might see it and wonder "what the heck?"

You might also see something on the netmask line (like in ifconfig) called "broadcast address":
netmask 0xffffff00 **broadcast 192.168.3.255**
See how the last bit says 255? this means your machine will broadcast to that many hosts on that network.

Routers and gateways
Most of the time, you will be working behind a router, which is any device that separates networks.
Your local network is called a LAN (local area network) while anything outside is known as the WAN or wide area network.
You may also see MAN, which is either a dude or a metropolitan network, a wireless network in a city.
You may also see wLAN which usually means wireless local area network.
A modem is something that separates two kinds of media, like in the old days when telephone lines (wires) connected networks (ethernet, usually). Modem means "modulate-demodulate" or "encode this stuff and then decode that stuff".
You might also hear the word modulate in speech, or in music, when a verse changes key.

A VLAN is a virtual LAN, a means of separating traffic on a network logically instead of physically (like wiring).
Ask your parents or grandparents about modems, which is how we used to connect to the internet over phone lines.
How quaint...
You may have a cable modem at your house that converts from cable (big fat coaxial cable) to ethernet.
You might otherwise have a DSL modem, which is how the phone company delivers internet, called Digital Subscriber Line, converting phone signals or fiber to ethernet.
Either way, you'll likely have an address that looks like 192.168.0.x or 192.168.1.x
This is known as your gateway (see diagram above).

There can be multiple gateways on any network, you choose the one you want to use to go out on the internet.

Switches

Switches are the replacement for hubs, which were basically network extension devices, like an extension cord, so one port would connect to a larger network, and it would have multiple ports for devices to connect to.

The difference between hubs and switches is that hubs share all traffic on all ports, while switches separate traffic based on destination.

Smart switches enable you to create VLANs or virtual LANs to separate traffic. This is done by adding “tags” to packets which are then sorted along virtual lines, like only letting certain people into certain doors on a building. “Tagged” packets are only allowed through certain doors, imitating separate wires.

n.b. this is a version of software defined networking (SDN), that is becoming more popular. At the elab, we use an SDN to create the wireless network, which gives us more control, but is dependent on a computer to create the network.

Domain name servers

There is a DNS resolution program in your computer, one on the router (if enabled) and one at the ISP (internet service provider, where you get your internet connection).

Most of the time, you will enter the same address for gateway and DNS, but you can also add some popular ones on the internet:

8.8.8.8 is the google DNS server. Very fast, but they use the lookup information for marketing.

4.4.4.4 is the ATT DNS server. Also fast, no marketing so far.

There are 13 “root” servers on the internet that hold all of the DNS information for every registered computer on the planet (Mars has its own, run by NASA, so does the moon).

Once upon a time, a group of hackers tried to down the entire internet by flooding the root servers with traffic, using a DDOS or distributed denial of service attack.

They got 12 out of the 13 root servers before they were stopped.

cool.

Network speed testing

There are two aspects of this: your connection to the network, and the network to the internet.

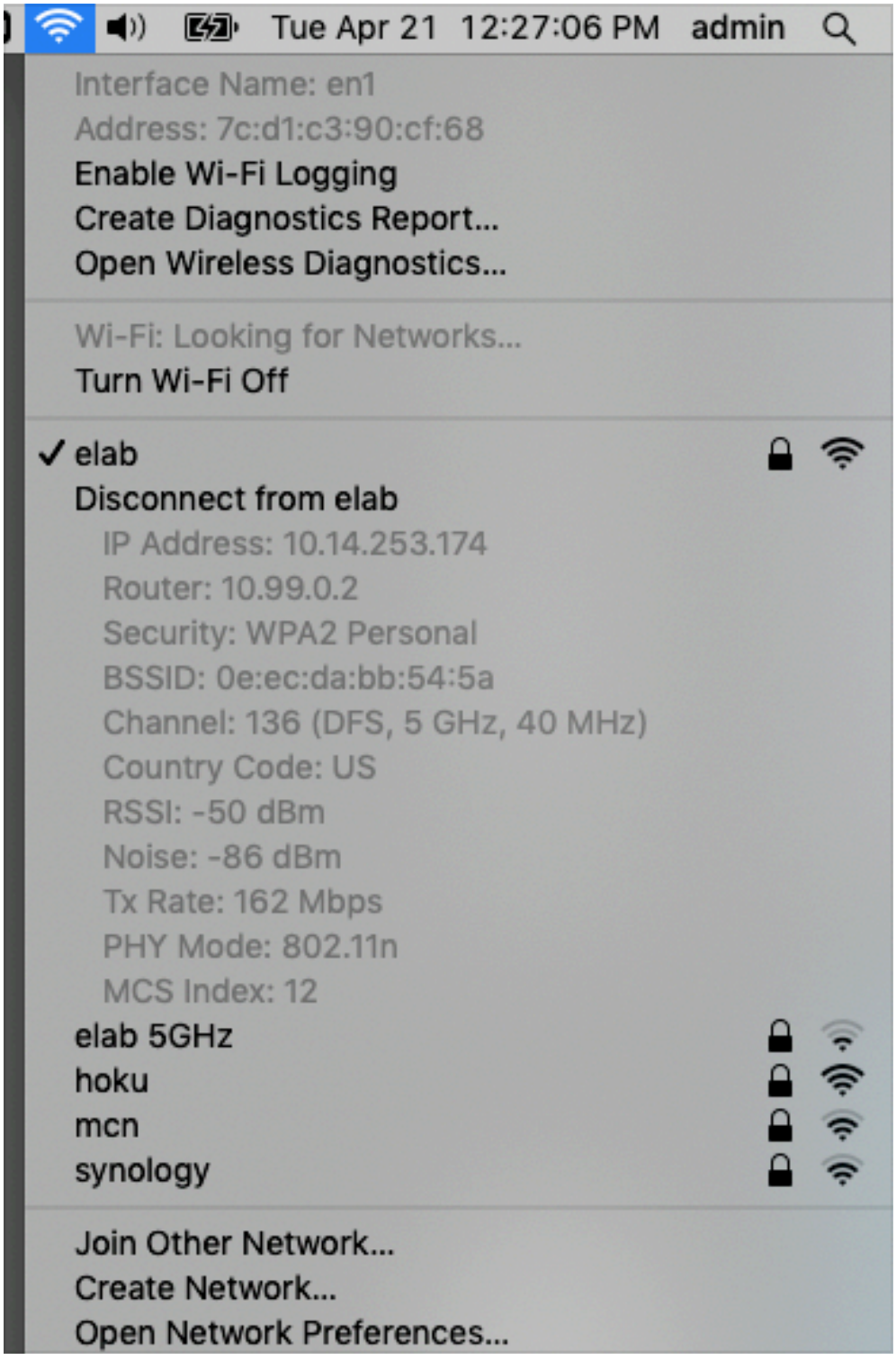
Wired:

If you are connected by a wire (e.g. ethernet) you can expect that the speed is limited only by the router and/or the internet connection to the internet. This could be an issue if:

1. cables are worn or damaged
2. your ethernet drivers are defective
3. there is physical damage to the ports on your computer, router or switch

Wireless:

This is more fun and nebulous. There is a solution: on a mac, hold option while touching the fan icon at the upper right:



There is a great deal here:

1. look at the network name, make sure this is the one you intend
2. IP address is the address given to you by the DHCP server on the router. DHCP is where a pool of addresses is “leased” to computers for temporary use. Notice that the third octet is 253.

Look for 253, 254 or other numbers like this to detect if you have a DHCP address.

3. Security: WPA2 Personal means the password authentication is held on the router, not at one central server (usually RADIUS), in which case you'd see WPA2 Enterprise. RADIUS is what we used to use in dial-up modem days, it stands for remote access dial in user services.
4. BSSID is the MAC address of the wireless card in the router or access point. This is important if you find you are joining a distant access point instead of the one you hoped for.
5. Channel and Country code are fixed by the access point and computer respectively. Note that the channel includes band, in this case 5 gHz. 2.4 gHz is the older wireless spectrum, which goes farther, but is slower. It is also susceptible to microwave ovens. 5 gHz is the newer faster network with shorter range, but higher speeds. The mHz (40 mHz) is the width of the channels used. Wider channels have higher speeds, but interfere more with other channels
6. RSSI is the signal strength (in minus numbers) so -50 is better than -70. Think of an elevator that goes underground or a submarine.
7. Noise is the same thing: smaller numbers are better, so -70 is better than -50.
8. Tx rate is transmission rate, the effective speed of your link. This may be faster than your internet connection, but it also impacts how fast you share files or download stuff on your local area network (LAN).
9. Related to this is PHY mode, which is the encoding on your wireless link, based on the iEEE 802.11 protocols: b is slowest at 11 mb/s, g is better (54 mb/s), n is even better, a is faster, and ac is the most common super fast one now, peaking at about 1300 mb/s.

What you might want to consider is trying this around your house or office and notice what changes, particularly if you have more access points, or MIMO (multiple in, multiple out) and band steering. More on this soon.

Two cool tools you might want to try out:
Google NameBench:
https://code.google.com/archive/p/namebench/downloads
Checks speed of your domain name servers to speed up your internet

system profiler:
system_profiler SPHardwareDataType
Gives you lots of cool secret info about your computer

———end of **Terminal commands module 3: Networks and the internet———–—**