Today: The eras tour of home networking

- Level 0: terminals (in 1970s)
  - USB (universal serial bus)
  - In 1970s, each computer has several serial ports, and transmit bytes on each serial lines
    - E.g. the computer is connected to a teletype machine (tty) through a serial port
    - There is no backspace or edit what you wrote in on teletype machines
    - Later teletype machines were replaced by glass terminals (or glass tty). And glass terminals would allow editing and erasing
    - Glass terminals — serial port — computers

(Sections in color red are newly added in that level)

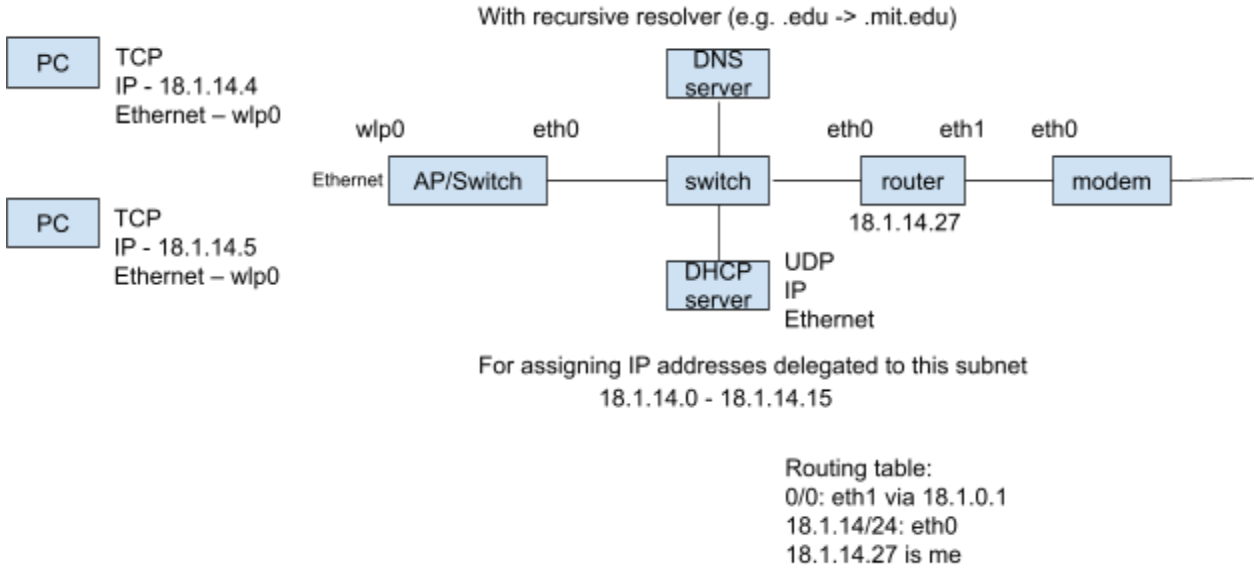
- Level 0.1: terminals + modems
  - Then, people started to want to have glass terminals at their home. Anything input into the glass terminals was transmitted to a computer at a different location through telephone lines
  - Glass terminals — serial port — modulator/demodulator — telephone lines — modulator/demodulator — serial port — computers
  - modulator/demodulator => modem (transform between bits and telephone signals)
  - (modem — telephone lines — modem) is an interposing (x-in-the-middle), and the glass terminals and computers on the two sides are not aware of these modems and telephone lines and consider they are directly connected to each other through a serial port.
- Level 1: Internet at home
  - Glass terminals were replaced by computers (PC) in home, and PCs were speaking TCP/IP.
  - PC — TCP/IP — SLIP — serial port — modem — telephone lines — modem — serial port — SLIP — TCP/IP — PC
  - SLIP tags a length on each IP datagrams so that given bytesteams, SLIP can cut them into datagrams
  - SLIP was later replaced by PPP
- Given level 1, if we abstract modems/computers on the path between a PC and the destination it want to talk to, it becomes this:
  - PC – TCP/IP – modem – ISP (which is actually – modem — (PPP7) — router — other network interfaces (e.g. eth0)) – Internet – router — remote network (reddit)
  - Each part of this graph needs to keep some states for having a TCP connection between PC and reddit:
    - PC and reddit each needs a TCP Socket
    - And the routers of ISP and reddit need to know next hops for datagrams
  - Then the PC would need to keep:
    - TCP Socket:
      - 18.1.2.7:55000 (src address:src port)
      - 151.3.2.9:443 (dst address:dst port)

- And reddit has:
    - TCP Socket:
        - 151.3.2.9:443 (src address:src port)
        - 18.1.2.7:55000 (dst address:dst port)
- ISP needs to track how IP addresses should be routed:
    - ISP: (to the home PC) — modem — ppp7 — router — eth0 — internet
    - In the routing table:
        - 0/0: eth0 via 8.7.6.5 (8.7.6.5 is the address of its ISP)
        - 18.1.2.7/32: ppp7
- Reddit's router's routing table:
    - 0/0: eth0 via 14.14.14.14 (14.14.14.14 is the address of reddit's ISP)
    - 151.3/16: eth1
- Level 2: cable modem
    - modem also speaks Ethernet instead of SLIP/PPP7
    - ISP: (to the home PC) – modem — eth1 — router — eth0 — internet
    - And in the routing table of ISP's route (with address 18.1.0.1)r:
        - In the routing table:
        - 0/0: eth0 via 8.7.6.5 (8.7.6.5 is the address of its ISP)
        - 18.1.2.7/32: eth1
        - 18.1.0.1/32: is me
- Level 3: home network
    - Multiple PCs are connected to the same modem. All PCs are connected to different ports of a switch and the switch is connected to the modem. A switch keeps an ethernet to port mapping. (**A switch does not look at IP headers).**
    - PC1: 18.1.2.7 and PC2: 18.1.2.8 are connected to the same switch
        - PC1 – switch – modem
        - PC2 – switch – modem
    - And at the ISP's routing table:
        - 0/0: eth0 via 8.7.6.5 (8.7.6.5 is the address of its ISP)
        - 18.1.2.7/32: eth1
        - 18.1.0.1/32: is me
        - 18.1.2.8/32: eth1
- Level 4: home subnet
    - Level 3 is annoying because the ISP's routing table has an entry for both PC1 and PC2, and a "delegation" would make this easier.
    - At the home, there is a router between switch and modem:
        - PC1(18.1.2.7) – switch – (eth0) – router(18.1.2.2) – (eth1) – modem – (to ISP)
        - PC2(18.1.2.8) – switch – (eth0) – router(18.1.2.2) – (eth1) – modem – (to ISP)
    - At the home router's routing table:
        - 0/0: eth1 via 18.1.0.1 (ISP address)
        - 18.1.2.0/24: eth0 (home network)
    - At the ISP's routing table:

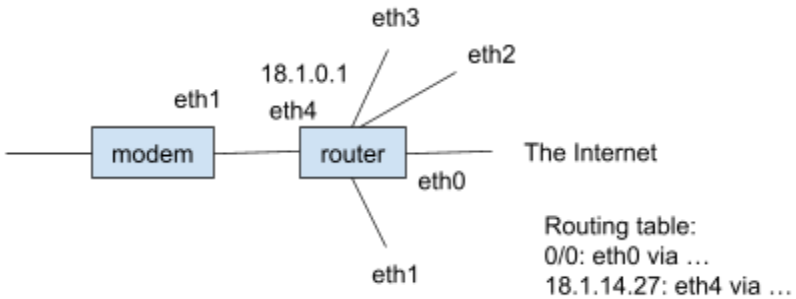
    - 0/0: eth0 via 8.7.6.5
    - 18.1.2.0/24: eth1 via 18.1.2.2
    - 18.1.0.1/32: is me
- Level 5: home wireless network
    - The home switch is replaced by Wi-Fi (AP)
    - And then it gets harder for an ISP to assign an IP address to every device connected to the Wi-Fi in every its customers' home

Last time: level 5 home subnetwork

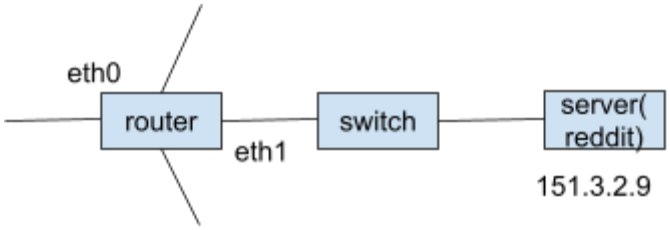
Home subnet:



ISP:



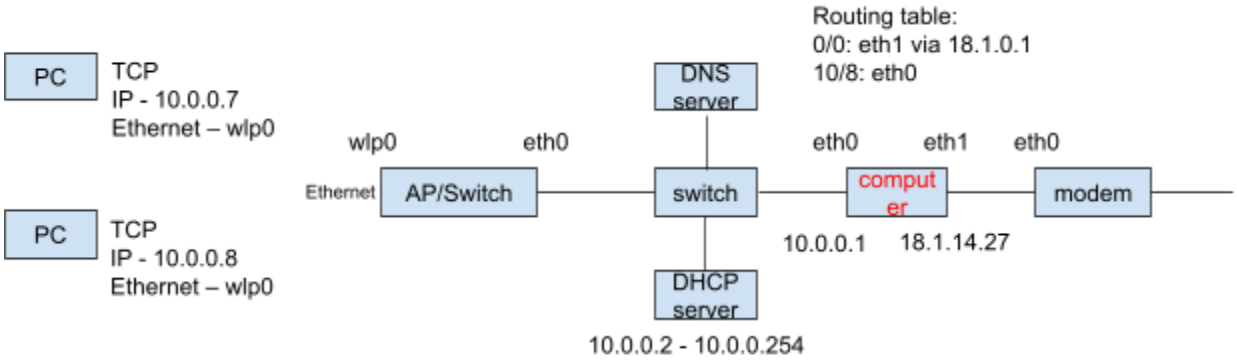
The reddit:



Routing table:
0/0: eth0 via …
151.3.2.9: eth1

- If we live in the world of IPv6 (each hosts get assigned a unique IPv6 address):
  - As long as PC1 (18.1.14.4) and the reddit (151.2.3.9) stores the source and dst IP addresses of the TCP Connection in their socket, the TCP connection can be done
    - PC1: 18.1.14.4: 5678 ← —> 151.3.2.4:443: reddit
  - DNS + DHCP + switch + router + modem used to be independent parts, but now they goes in to a “home router” you can buy from a shop

- Level 6: Proxy server/ jump host / bastion / socks5
  - Each subnets have a local range of IPv4 addresses

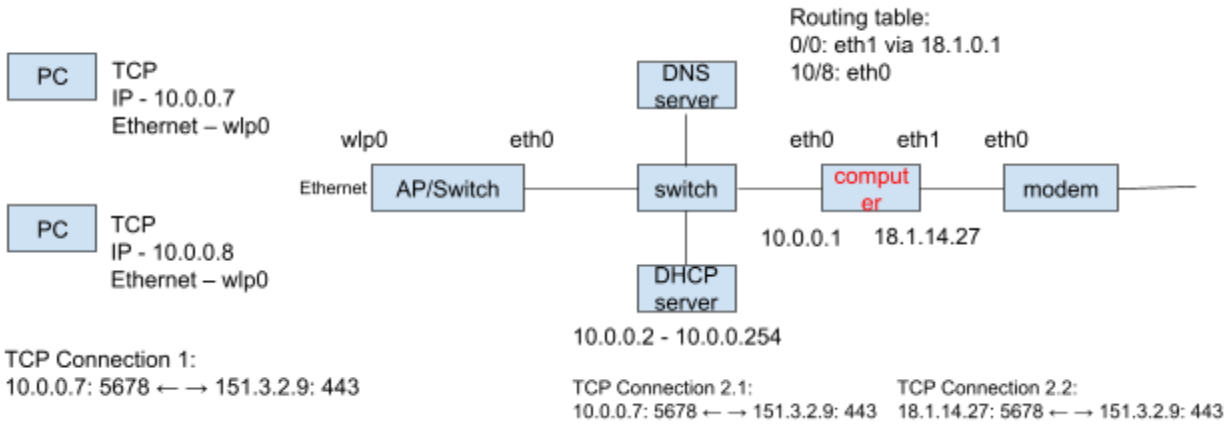


TCP Connection 1:
10.0.0.7: 5678 ← → 10.0.0.1: 22

TCP Connection 2:
18.1.14.27: 5678 ← → 151.3.2.9: 443

  - The computer relays the bytes between TCP connection 1 and TCP connection 2.
  - But this is annoying for asking every new PC to also set up the proxy

- Level 7: Transparent Proxy



- The PC does not know the existence of the proxy
- And the proxy computer acts as if it is the reddit server in the home subnet, and relay the connection out with its own public IP address

- Level 8: network address/port translation (NAT)
  - For the proxy, it no longer reconstruct the byte stream, but only do translation on the IP address and port to appear in the public network