

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)

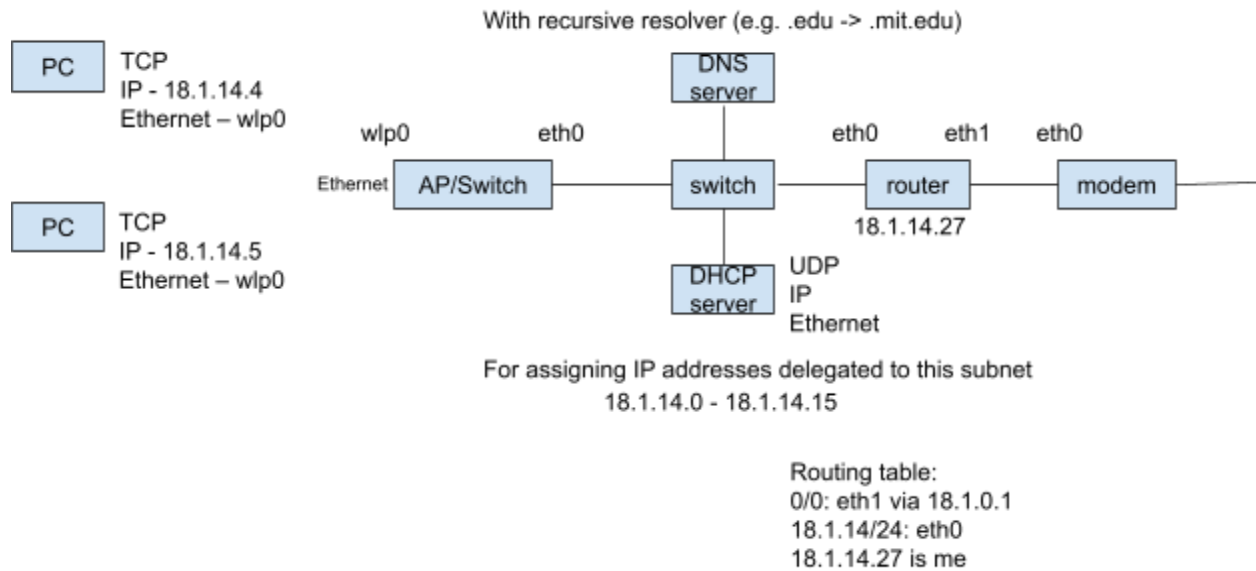
- Level 0.1: terminals + modems
 - Then, people started to want to have glass terminals at their home. Anything input into the glass terminals was transmitted to a computer at a different location through telephone lines
 - Glass terminals — serial port — **modulator/demodulator — telephone lines — modulator/demodulator** — 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 bytestreams, 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:

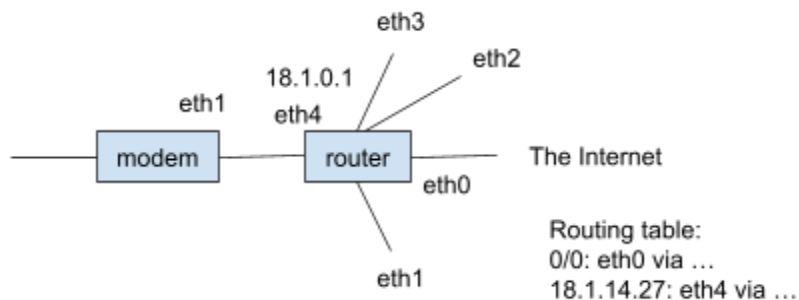
- 0/0: eth0 via 8.7.6.5
- 18.1.2.0/24: eth1 via 18.1.2.2
- 18.1.0.1/32: is me
- Level 5: home wireless network
 - The home switch is replaced by Wi-Fi (AP)
 - And then it gets harder for an ISP to assign an IP address to every device connected to the Wi-Fi in every its customers' home

Last time: level 5 home subnetwork

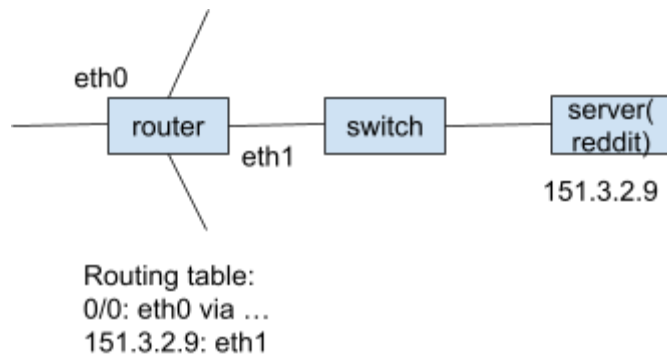
Home subnet:



ISP:

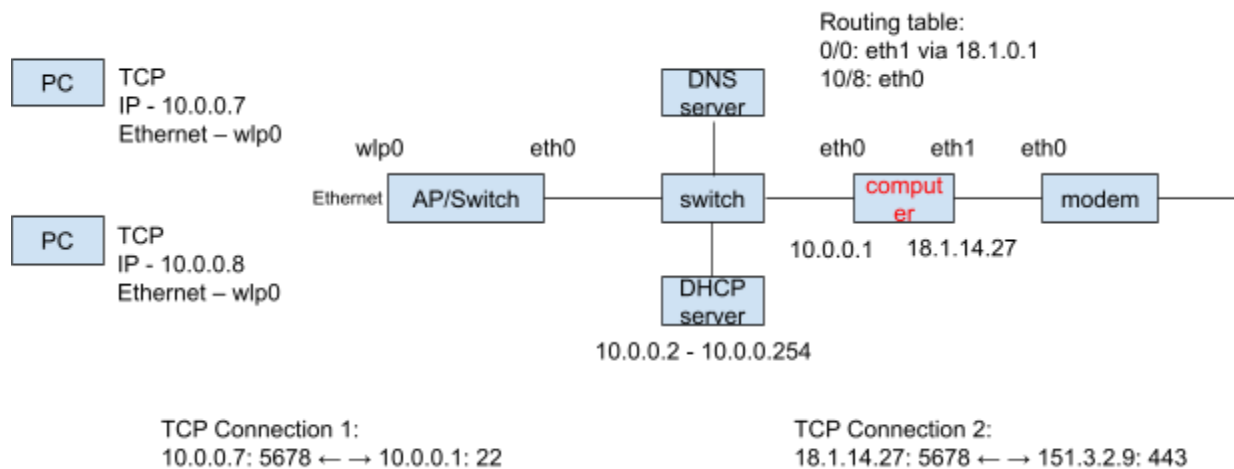


The reddit:



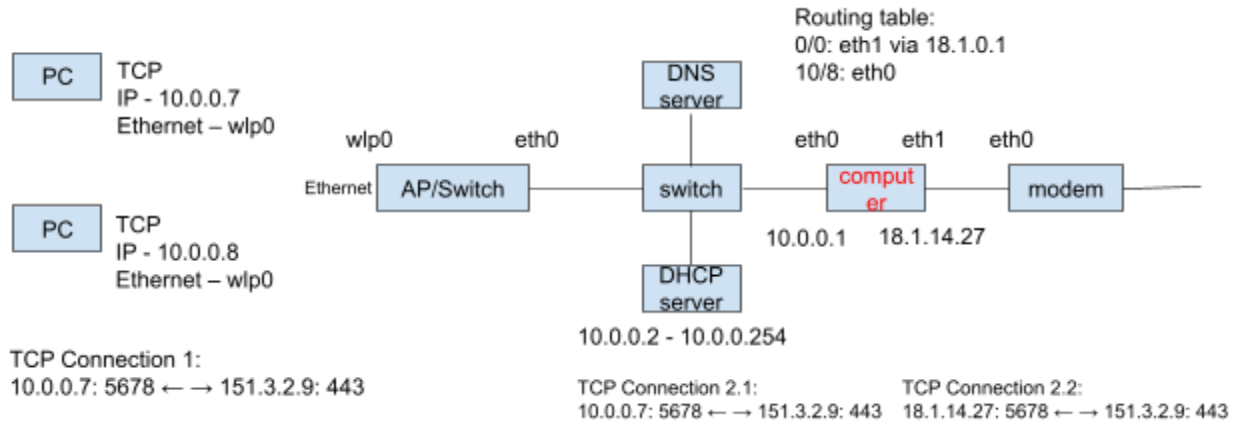
- If we live in the world of IPv6 (each hosts get assigned a unique IPv6 address):
 - As long as PC1 (18.1.14.4) and the reddit (151.2.3.9) stores the source and dst IP addresses of the TCP Connection in their socket, the TCP connection can be done
 - PC1: 18.1.14.4: 5678 $\longleftrightarrow$ 151.3.2.4:443: 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



- 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

