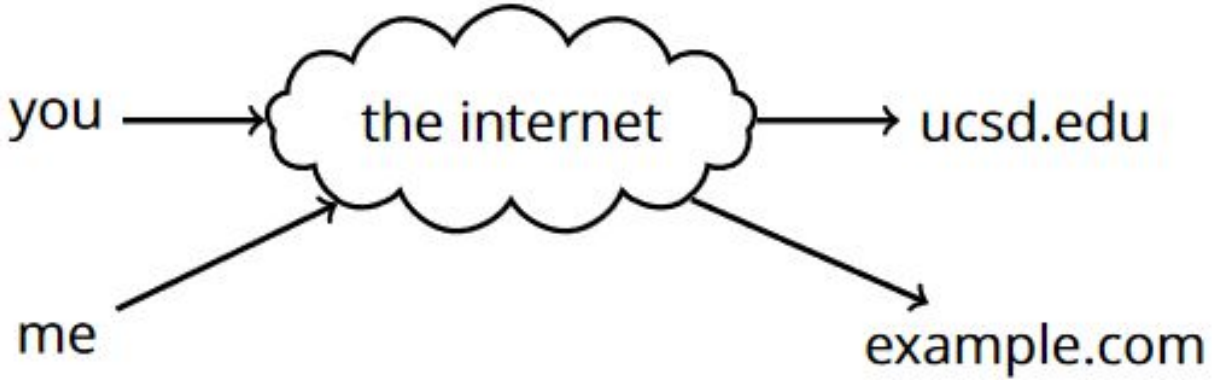
Networking and PA5

Hannah Davis,
with slides from Ariana Mirian and Nadia Heninger

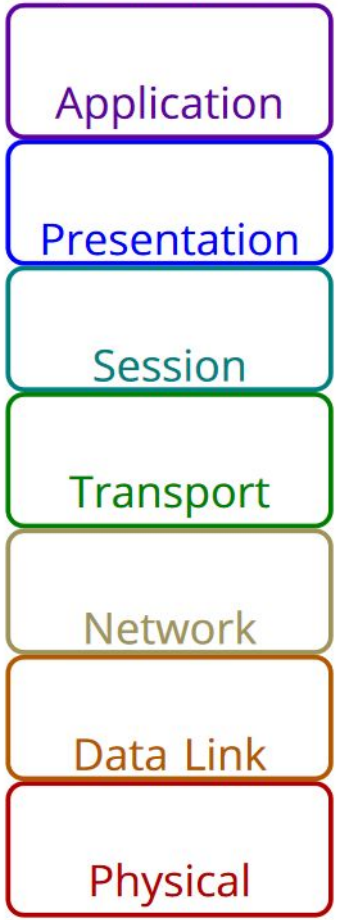


Original Idea:

- Network is dumb
- Simple, robust service
- Shift complexity to endpoints
- Acts like postal system (packet-based) rather than traditional phone system (circuit-based)

OSI Layers

(Open Systems Interconnection)



- End user layer
- HTTP, FTP, Skype, SSH, SMTP, DNS

- Syntax, byte order, compression, encryption
- SSL, SSH, MPEG, JPEG

- Connection establishment and maintenance
- APIs, sockets

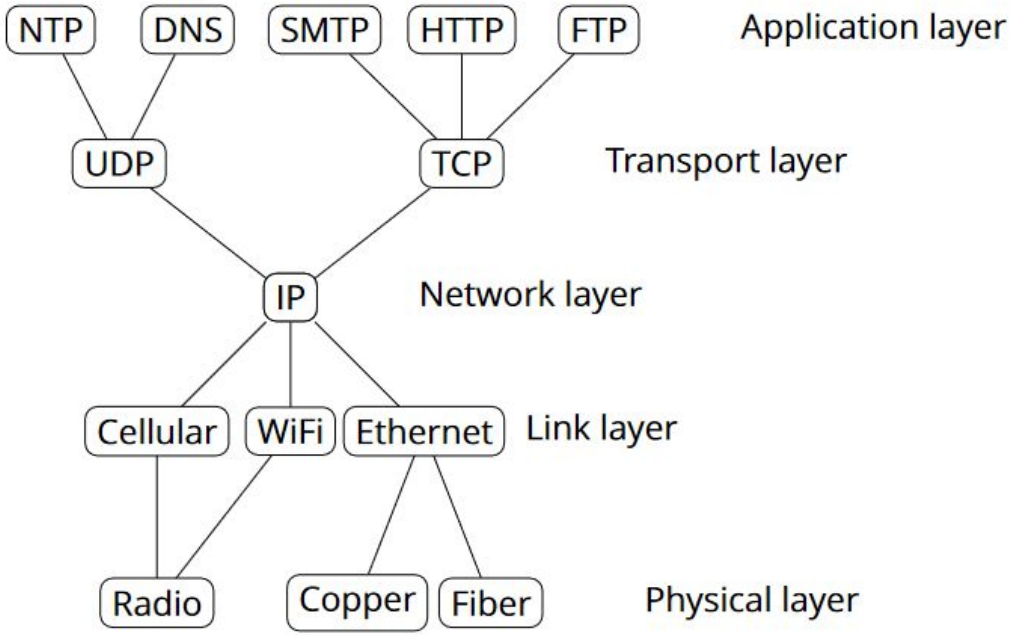
- End-to-end connections between processes
- TCP, UDP

- Addressing, routing between nodes
- IP

- Link management, frames
- Ethernet, WiFi

- Physical wires
- Photons, RF modulation

Internet Architecture



Using the internet: A worked example

You connect your laptop to a cafe wifi network and type ucsd.edu into your browser's URL bar. What happens?

Using the internet: A worked example

~~You connect your laptop to a cafe wifi network and type ucsd.edu into your browser's URL bar. What happens?~~

You are waiting masked and outdoors for a takeout order from a cafe, and while you're waiting you perch against the wall at a socially distant distance from everyone else, pull your laptop out, connect to the cafe's wifi network and type ucsd.edu into the browser's URL bar.

Using the Internet: a worked example

1. Your laptop uses DHCP (Dynamic Host Configuration Protocol)

   to bootstrap itself on the local network via WiFi over radio waves

Using the Internet: a worked example

1. Your laptop uses DHCP (Dynamic Host Configuration Protocol)

   to bootstrap itself on the local network via WiFi over radio waves

   - New host has no IP address, doesn't know who to ask

Using the Internet: a worked example

1. Your laptop uses DHCP (Dynamic Host Configuration Protocol)

   to bootstrap itself on the local network via WiFi over radio waves

   - New host has no IP address, doesn't know who to ask
   - Broadcasts DHCPDISCOVER to 255.255.255.255 with its MAC address

Using the Internet: a worked example

1. Your laptop uses DHCP (Dynamic Host Configuration Protocol)

   to bootstrap itself on the local network via WiFi over radio waves

   - New host has no IP address, doesn't know who to ask
   - Broadcasts DHCPDISCOVER to 255.255.255.255 with its MAC address
   - DHCP server responds with config:lease on host IP address, gateway IP address, DNS server information

Using the Internet: a worked example

2. Your laptop makes an ARP request to learn the MAC address of the local router.

Using the Internet: a worked example

2. Your laptop makes an ARP request to learn the MAC address of the local router.

- Every connection outside the local network will be encapsulated in a link-layer frame with the local router's MAC address as the destination.
- Your laptop encapsulates each IP packet in a WiFi frame addressed to the local router

Using the Internet: a worked example

2. Your laptop makes an ARP request to learn the MAC address of the local router.

- Every connection outside the local network will be encapsulated in a link-layer frame with the local router's MAC address as the destination.
- Your laptop encapsulates each IP packet in a WiFi frame addressed to the local router
- The router removes the WiFi frame and adds an Ethernet frame to forward them on its fiber connection to its upstream ISP, or to another part of the network.
- Each hop re-encodes the link layer for its own network.

Using the Internet: a worked example

3. Your laptop does a DNS lookup on ucsd.edu

- It learned the IP address of a DNS server from the router or had one already hardcoded in (8.8.8.8)
- The DNS request is tunneled through UDP packets which are themselves inside IP packets

Using the Internet: a worked example

3. Your laptop does a DNS lookup on ucsd.edu

- It learned the IP address of a DNS server from the router or had one already hardcoded in (8.8.8.8)
- The DNS request is tunneled through UDP packets which are themselves inside IP packets
- The DNS server responds with either “ucsd.edu has IP address x.x.x.x” or “I don’t know, but the nameserver at y.y.y.y might”
  - Follows a hierarchy upward: your ISP, then the .edu nameserver, then UCSD’s nameserver.
  - Eventually, get final IP address 132.239.180.101

Using the Internet: a worked example

4. Your laptop opens a TCP connection to IP address 132.239.180.101.

- Unlike UDP, has reliability.

Using the Internet: a worked example

4. Your laptop opens a TCP connection to IP address 132.239.180.101.

- Unlike UDP, has reliability.
- TCP is wrapped in IP which is wrapped in Ethernet

Using the Internet: a worked example

4. Your laptop opens a TCP connection to IP address 132.239.180.101.

- Unlike UDP, has reliability.
- TCP is wrapped in IP which is wrapped in Ethernet
- Each stop in the network checks its routing table against the destination IP address.
- E.g. sbcglobal.net-> att.net-> leve3.net -> cenic.net-> ucsd.edu

Using the Internet: a worked example

5. Your laptop sends an HTTP GET request across the TCP connection.

Using the Internet: a worked example

5. Your laptop sends an HTTP GET request across the TCP connection.

Using the Internet: a worked example

5. Your laptop sends an HTTP GET request across the TCP connection.

- If you're using HTTPS, it performs a TLS handshake and encrypts the request before splitting it into TCP packets.

Using the Internet: a worked example

5. Your laptop sends an HTTP GET request across the TCP connection.

- If you're using HTTPS, it performs a TLS handshake and encrypts the request before splitting it into TCP packets.
- Any future connections restart from step 3 with a new DNS request.

PA 5 introduction

- Scavenger hunt
- Begins tomorrow
- Starting point: your email
- Unzip the .tar file, and try to find hidden information
- The file will tell you what to submit
- Start early! It can be hard to tell how close you are to finishing.
- Be considerate of spoilers: try to use mainly OH and private Piazza posts for questions.
- Have fun!

Overview of tools you may need

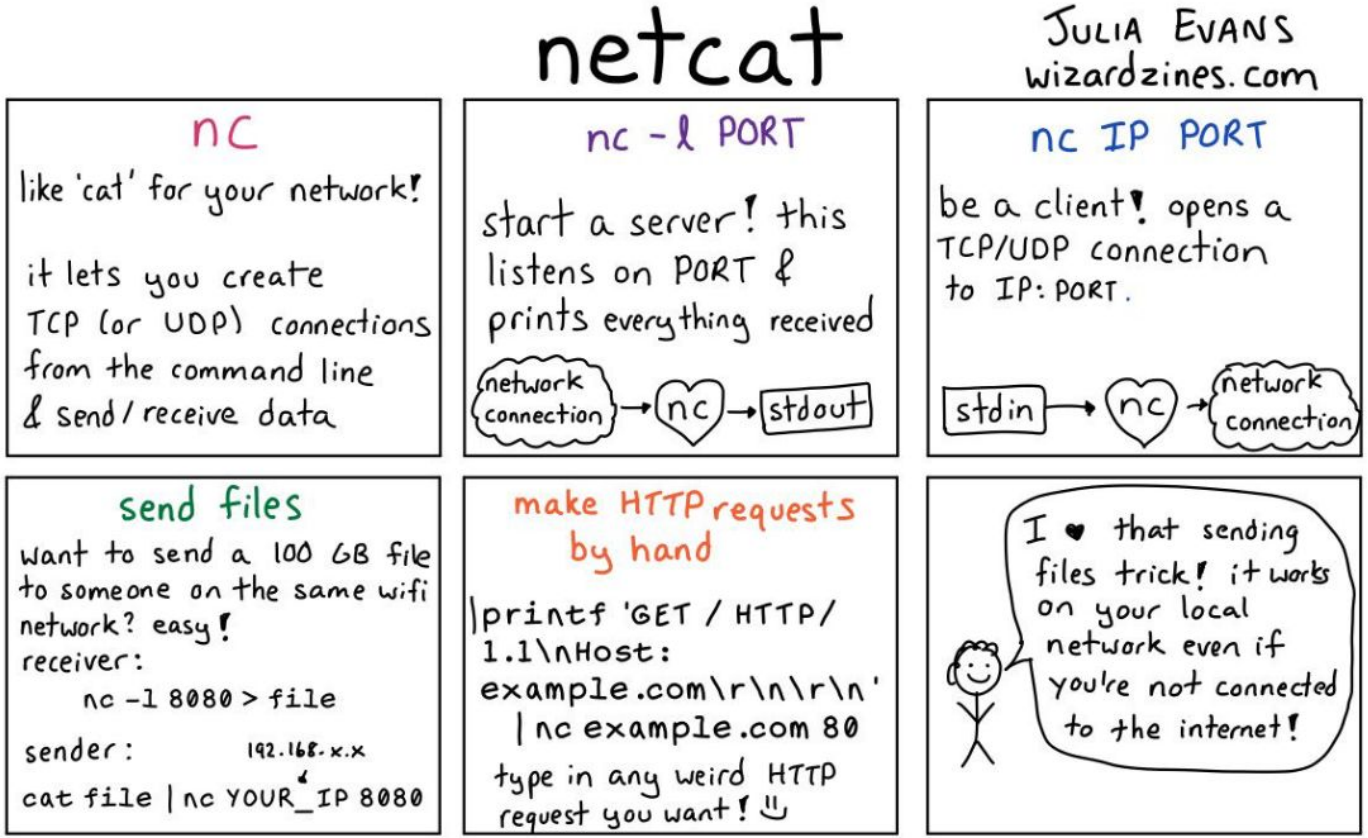
- nc
- nmap
- ssh
- tcpdump
- wget

Overview of tools you may need

- Nc – allows you to make connections locally
- Nmap – scan ports/IPs (locally and externally)
- Ssh – connect to servers
- Tcpdump – view traffic on machine
- Wget – download of files from internet

- All of these have “man” pages!

NetCat (shoutout to Julia Evans)



Happy hunting!