The Internet P.1

(as hardware + software)

① End host systems connected by:
- ① comm links
- ② packet switches

runs IP (network layer)

routers and switches (link layer) allow packets to travels through "routes" or paths

transmit packets: packages of info at different rates (bits/sec)

② ISP: a network of packet switches & comm. links.

residential ISP provids broadband / fibre access through cable modem, wireless access, dial-up, etc.

③ for systems to communicate, we need protocols. End systems usually run: (TCP/IP)
- ① Internet Protocol (IP)
- ② trans. control protocol (TCP)
- ③ HTTP (web)
- ④ SMTP (email)

specifies format of packets that are sent and rcv. among routes and end systems

④ IETF develops these standards, these documents are called RFC

The Internet P2.

(as infrastructure providing services)

④ Internet as infrastructure that provides **services** to applications: P2P, web surfing, social networks (chat), games, file sharing, TV/streaming, remote login, etc.

possible by running Internet **API** on your system.

defines set of rules so that your code infrastructure can send data successfully throughout the Internet

} you can write any applications that can run on your end systems using Java or C or Python, etc, but we need a set of rules so that these hosts can communicate properly: use Internet APIs that implements specific **Protocols**

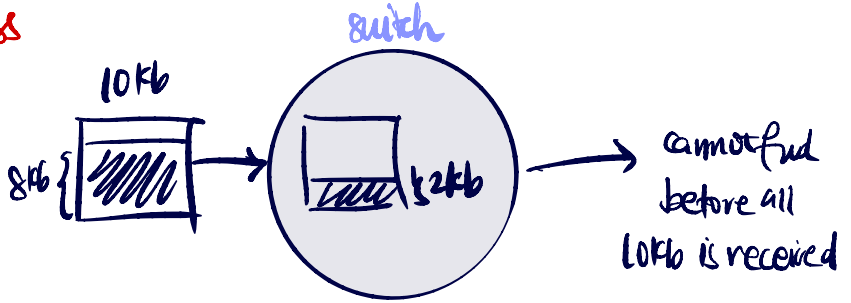
defines ORDER and FORMAT of packets sent and received

⑤ The network Edge & Core

Edge
coms, phones, printers, TVs, consoles, etc

Core

① packet switches
- ↳ break long messages into smaller chunks (packets)
- ↳ time taken: $\frac{L}{R}$ → L = packet length (b), R = trans. rate (b/s)
- ↳ how? store & forward transmission
  - $d_{AB} = \frac{NL}{R}$, if N routers in between A & B
  - switches must receive the ENTIRE packet bits before forwarding to the next destination.
  - causes queue delay
  - may have packet loss



② Forwarding table & routing protocols
each router has this → ISP's job to give
- ↳ each packet has IP addr
- ↳ router see IP, look at table & forward to adjacent router
- ↳ who sets the table: IP routing protocols (ⓕ) used to automatically set forwarding table in routers

⑥ Circuit and Packet switching

reserve all hardwares (resources) b/w end to end path, e.g.: telephone.

⊛ guaranteed transmission rate

The internet is this method, no guarantee over transmission rate. Resources shared among many hosts.

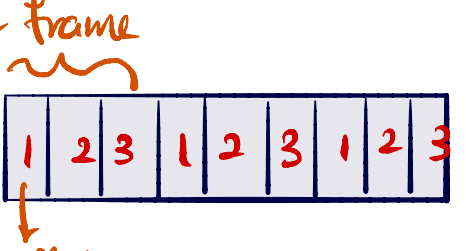
2 flavours of circuit switching:

① TDM : reserve over a "time" period

② FDM : reserve over a "frequency" domain

telephone : 4kHz bandwidth, ~300 – 3300 Hz

radio : 88 MHz – 108 MHz



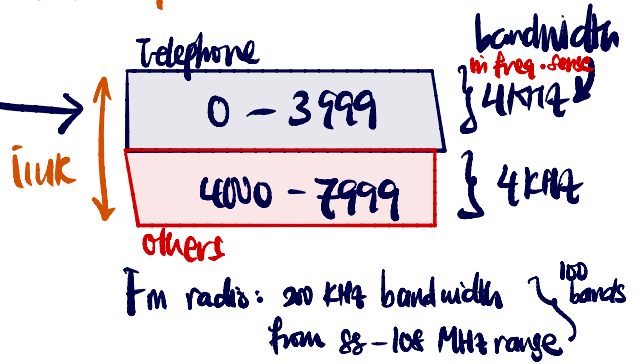
trans rate : x frames/s *

b bits/slot

(bandwidth in data transfer sense)

eg : 10 bits/slot & 1000 frames/s

↳ 100 kbps transmission rate



circuit switching vs packet switching

current trend for internet usage

✓ good for real time services: video call, telephone, to avoid unexpected delays

✗ limited number of users

✓ more efficient, don't have to "reserve" the connection, eg: chat

✓ idle resources can be used by other people

✓ suitable for internet because our usage pattern is **BURSTY**

✓ unlimited number of users

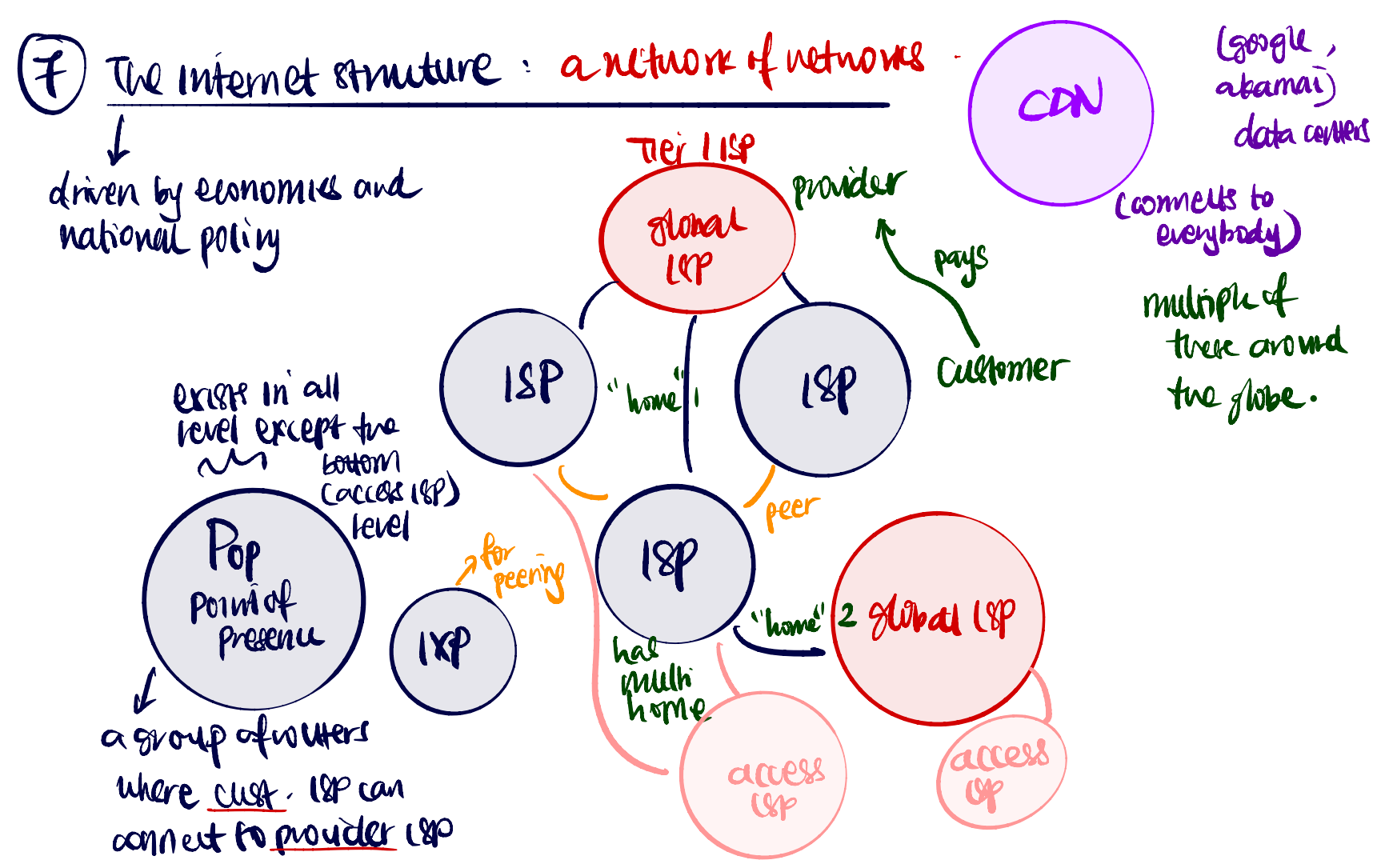
✗ delays can go to ∞ (like traffic jam)

* BTW, Netflix is fast because of CDNs, not circuit switching!

(7) The internet structure : a network of networks

↓

driven by economics and national policy



Who is Google?

→ a content delivery network → delivers contents (copied) directly, no need to ask server.

- ↳ data centers interconnected over private TCP/IP network
- ↳ separate from the public internet
- ↳ only carries traffic to and from Google servers
- ↳ "bypass" the upper tier internet, can connect to access ISP directly. (free)
- ↳ also connect to tier 1, 2 ISPs (paid)

basically, Google is its own network : fast

Netflix used CDNs, now they ↓ created their own

1. Limelight ↳ open connect optimized for large files.
2. Akamai
3. Cloud Front (Amazon)
4. Cloud Fare

∴ many businesses use CDNs.

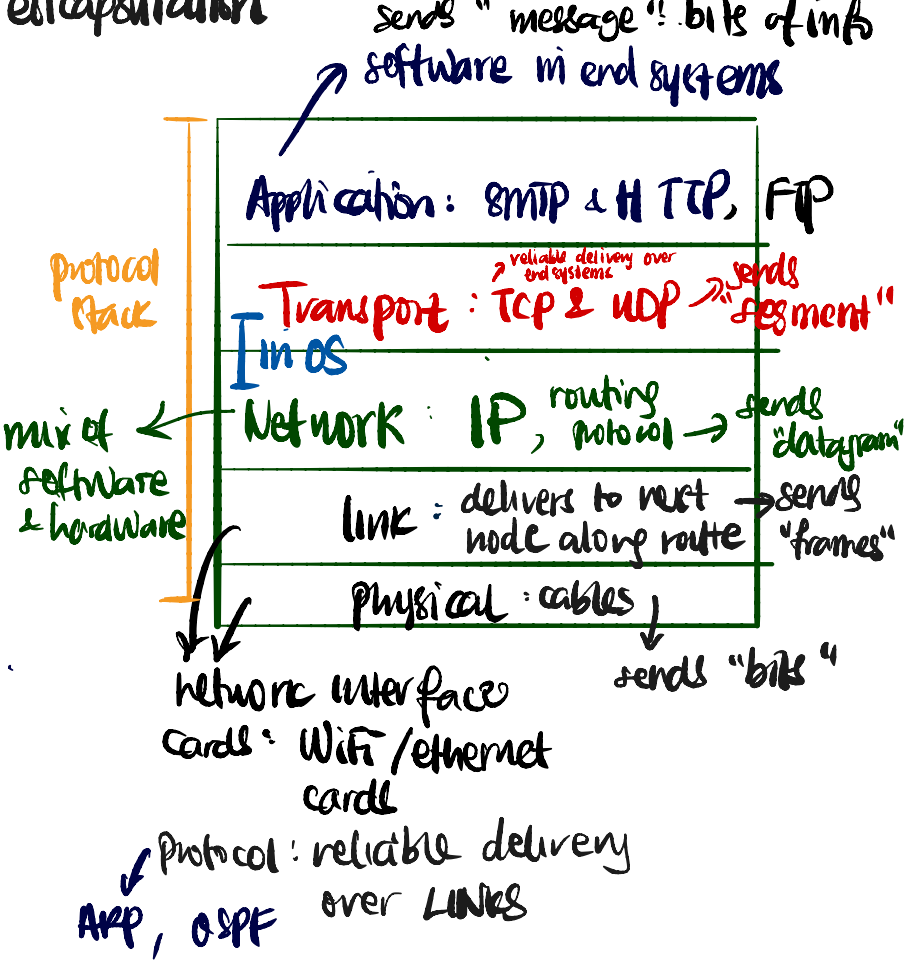
Layered Network Architecture : allows encapsulation

↳ complex system, hence needs this architecture

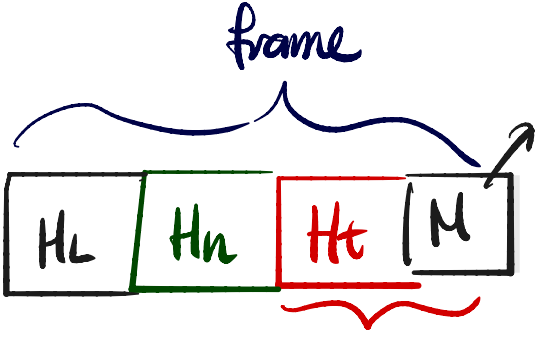
(*) analogous to plane boarding protocol → a complicated process with layered checkpoints

↳ reduce complexity into O(n) since each layer only provides services for the layer ABOVE it.

↳ each network protocol belong to only ONE layer



9 Encapsulation



① each header added by each layer when going "down" the stack

② each header then peeled by each layer when going "up" the stack.

the IP: an "internet weaton" EPS

↓

for addressing and routing

IP doesn't guarantee reliable transmission ↗ this is TCP's job

↓

analogous to road names and house/building addresses, hence allowing you to route to destinations

10. The IP addressing : IPv4 : 4.29 billion unique addresses

- a set of four numbers : 32 bits length, 8 bits grouped

① 0.0.0.0 to 255.255.255.255 (range)
local address

Ex: 192.168.1.34 → you will typically see this in home device, local IP address.

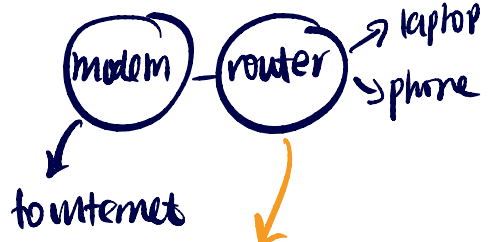
192.168.1 = network ID (unique in a network)
34 = host ID

(*) to get network ID, computer uses subnet mask : 255.255.255.0

(*) IP AND mask → gives you the group that you want

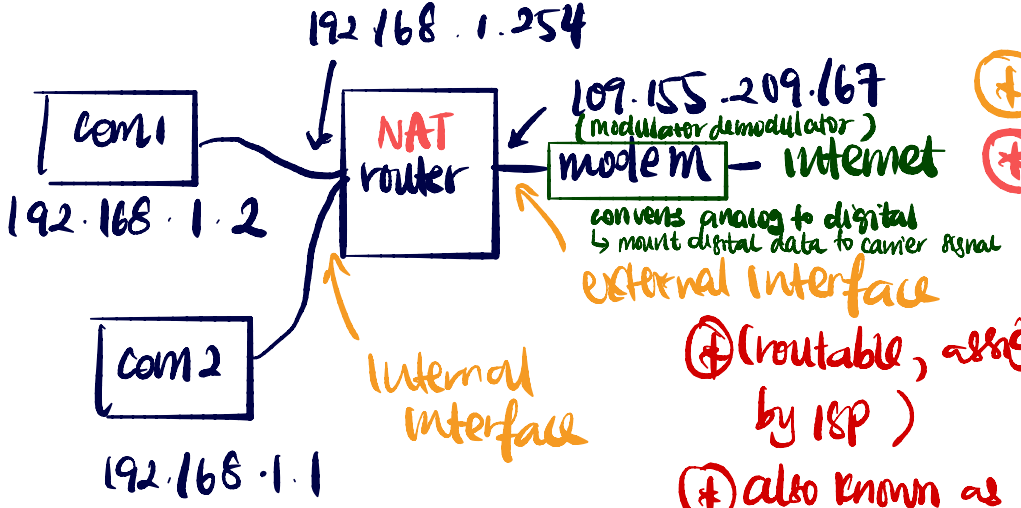
(+) class A : 255.0.0.0 (the org. that administer internet.), class B : 255.255.00, class C : 255.255.255.0

② gateway address
(a.k.a router address)



means if 192.168.1.34 is your IP, your router is :
→ 192.168.1.1

Public vs Private IP addresses (a)



- each interface in routers will have an IP
- internal & external
- no direct connection from com to internet. must go through routers, unless you do PAT forwarding
  - ↓
  - allow internal addrs to appear like public addrs.
- (routable, assigned by ISP)
- also known as public address
- given by IANA
- most ISP employs "dynamic" IP addresses to their customers

security advantage

192.168.0.0
↓
non routable IP addresses

Device getting IP address: (b)

↳ ① dynamic IP : DHCP protocol, built-in to your router.

a new device connected will broadcast for a request to get addrs, routers intercept this and give unassigned IP:

Eg: Private IP range → 10.000 to 10.255.255.255 : comcast / xfinity customer, router provided by ISP gives these addresses, also Apple on AirPort routers

→ 192.168.0.0 to 192.168.255.255

commercial routers : Linksys & D-Link

② static IP : must set a device to be fixed IPaddrs, or configure router to always give this address.

subnetting (:C)

- need to address 150 hosts
- you are given class C network: 192.168.123.0 → course from 192.168.123.1 to 192.168.123.254
  - .0 cannot be used, no host
  - .255, all zeroes and all ones are seen as invalid
    - will broadcast messages to all host
- If 150 hosts → 50 → 50 → 25 → 25 } physically separated
- need subnet mask: 255.255.255.192
  - gives four networks of 62 hosts each
  - 11000000 → 0100 0000 / 0000 0000
    - 1000 0000 (62 combo)
    - 1100 0000
- now we have
  1. 192.168.123.1-62
  2. 192.168.123.65-126
  3. 192.168.123.129-190
  4. 192.168.123.193-254