

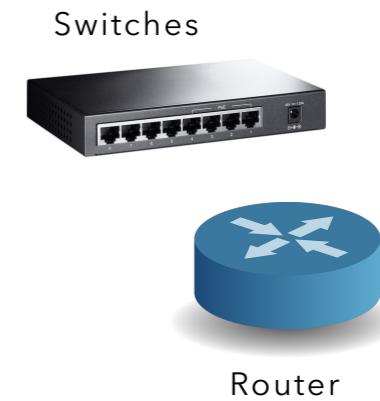
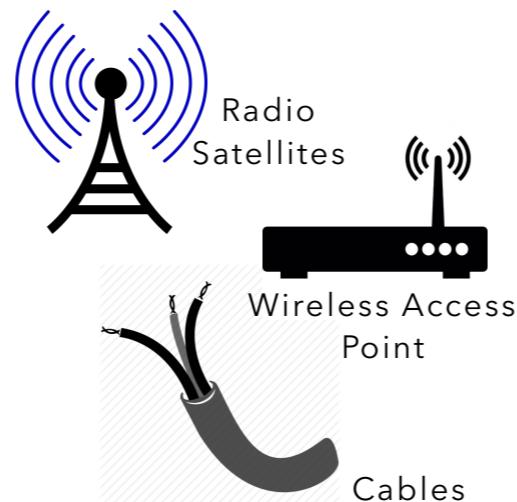
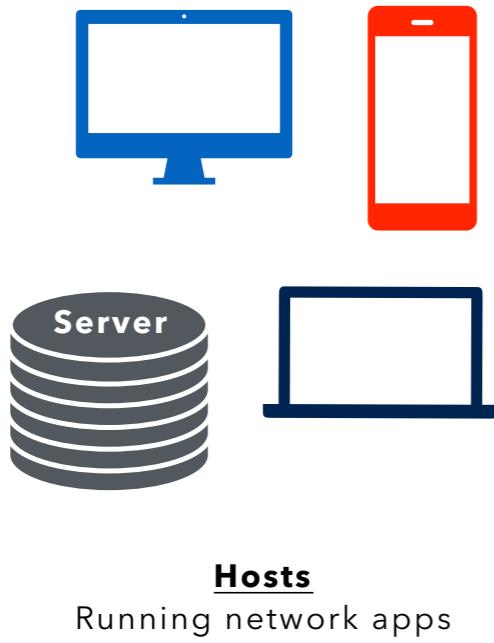
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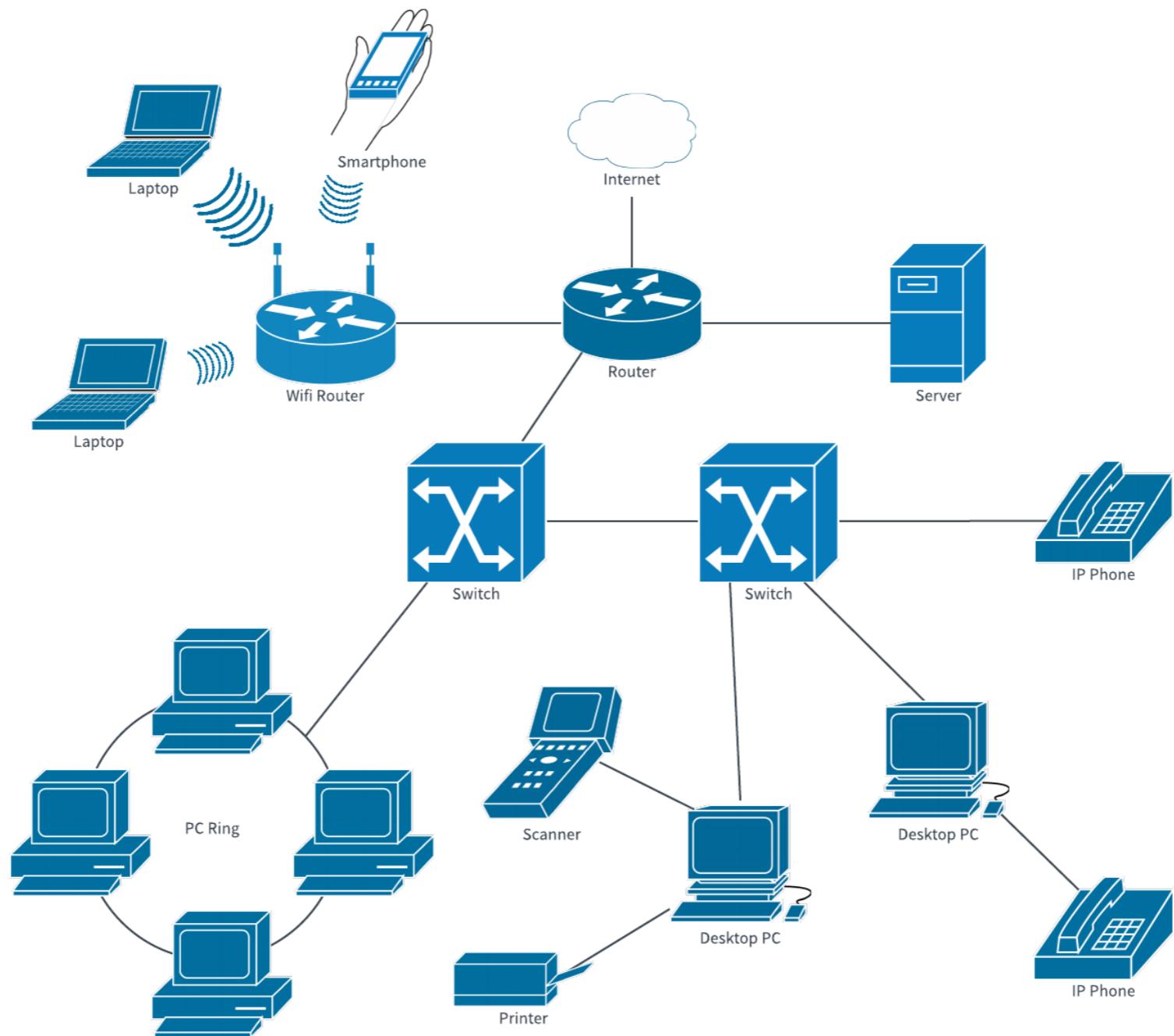
Natalie Agus
Information Systems Technology and Design
SUTD

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WHAT MAKES THE INTERNET?



Packet Switches
Forward chunks of data
called "packets"



CONNECTING THEM TOGETHER

a process to add text/video/image / sound, any data into a carrier signal like, EM wave / optical / electrical signals

the modem

"mo units"

digital data into

EM waves / electrical

wireless

wired

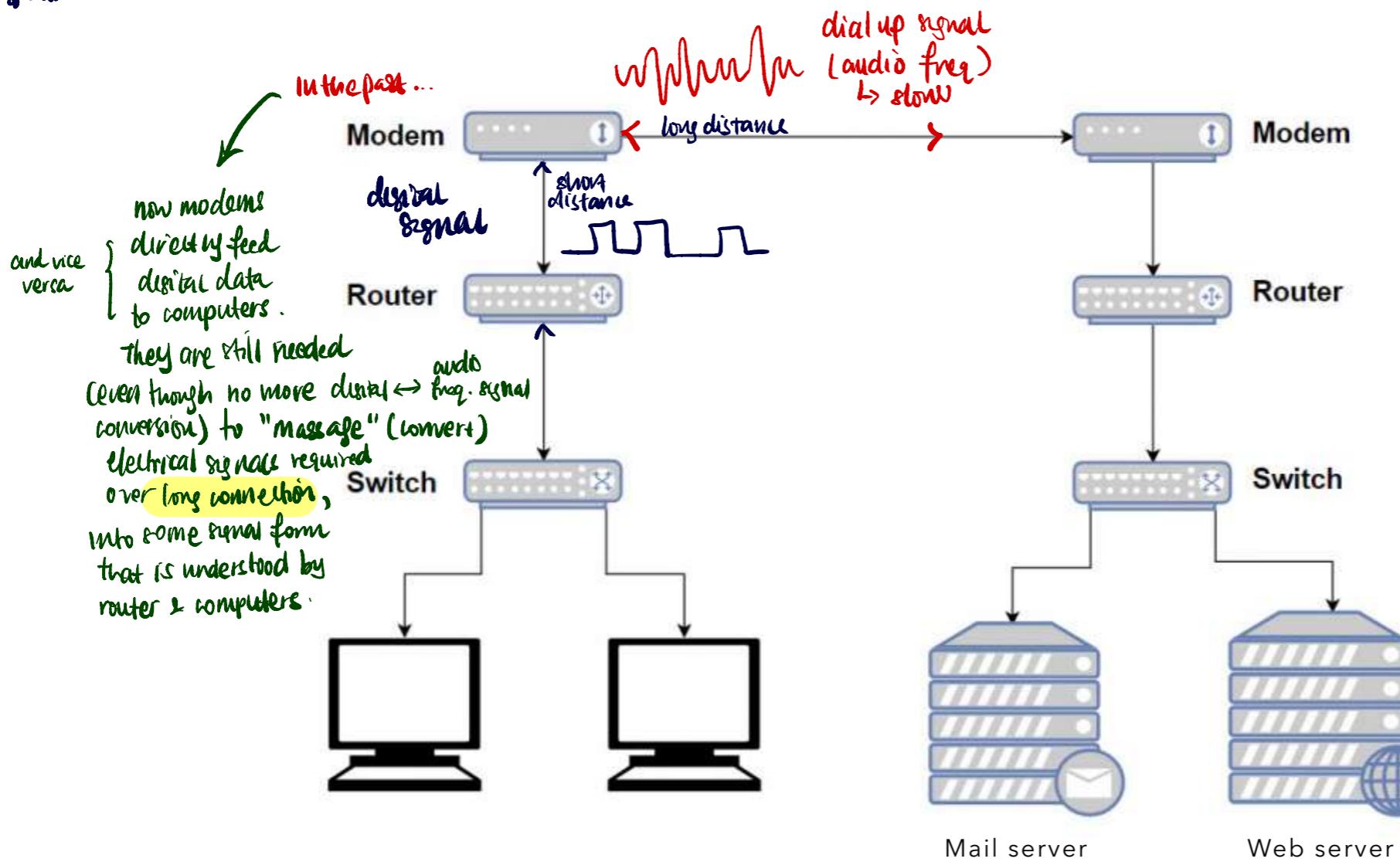
so the data can travel along the respective medium.

carrier signal for broadband modems

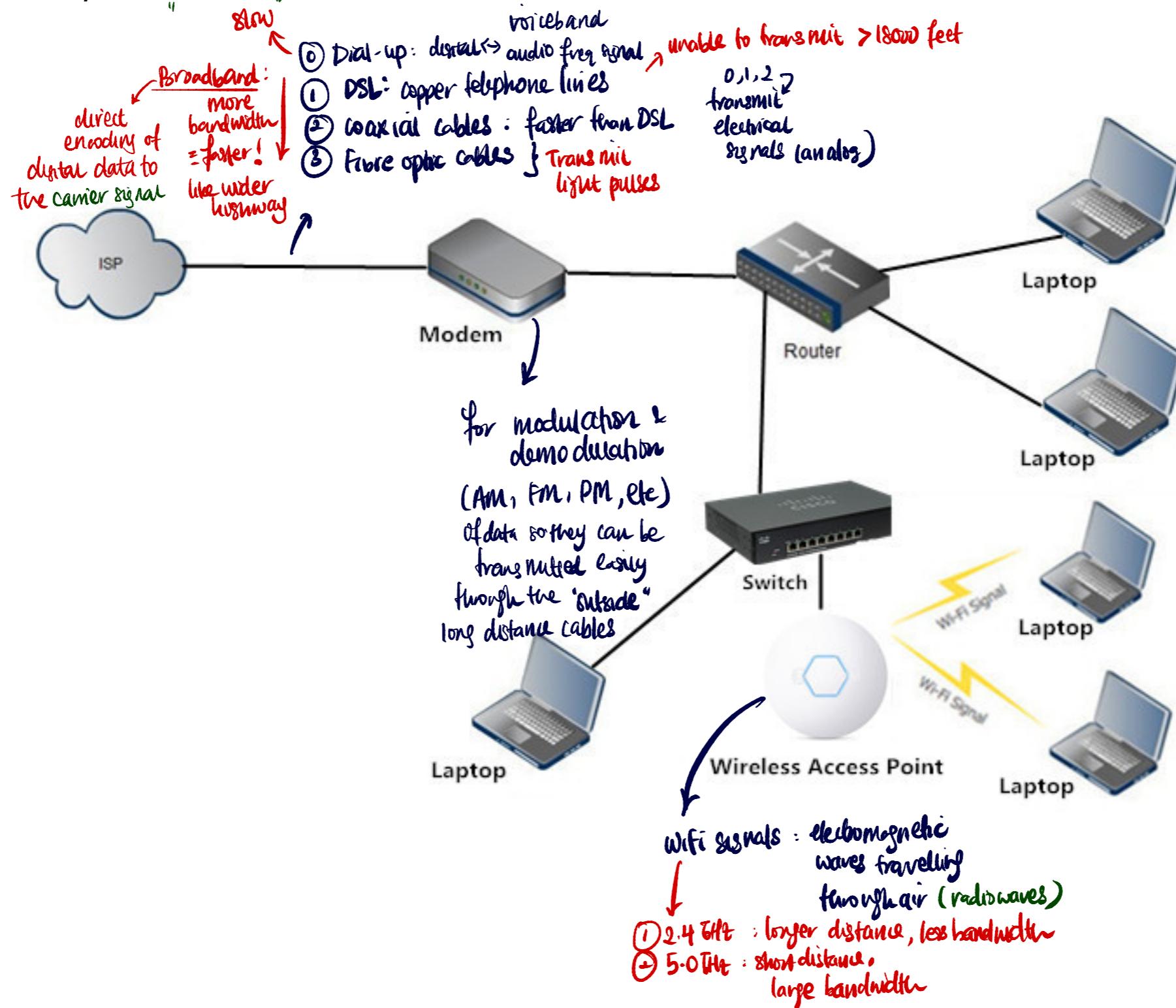
last time:
④ Used to modulate telephone signals (audio frequency) so digital info can be encoded in it
modulation - demodulation

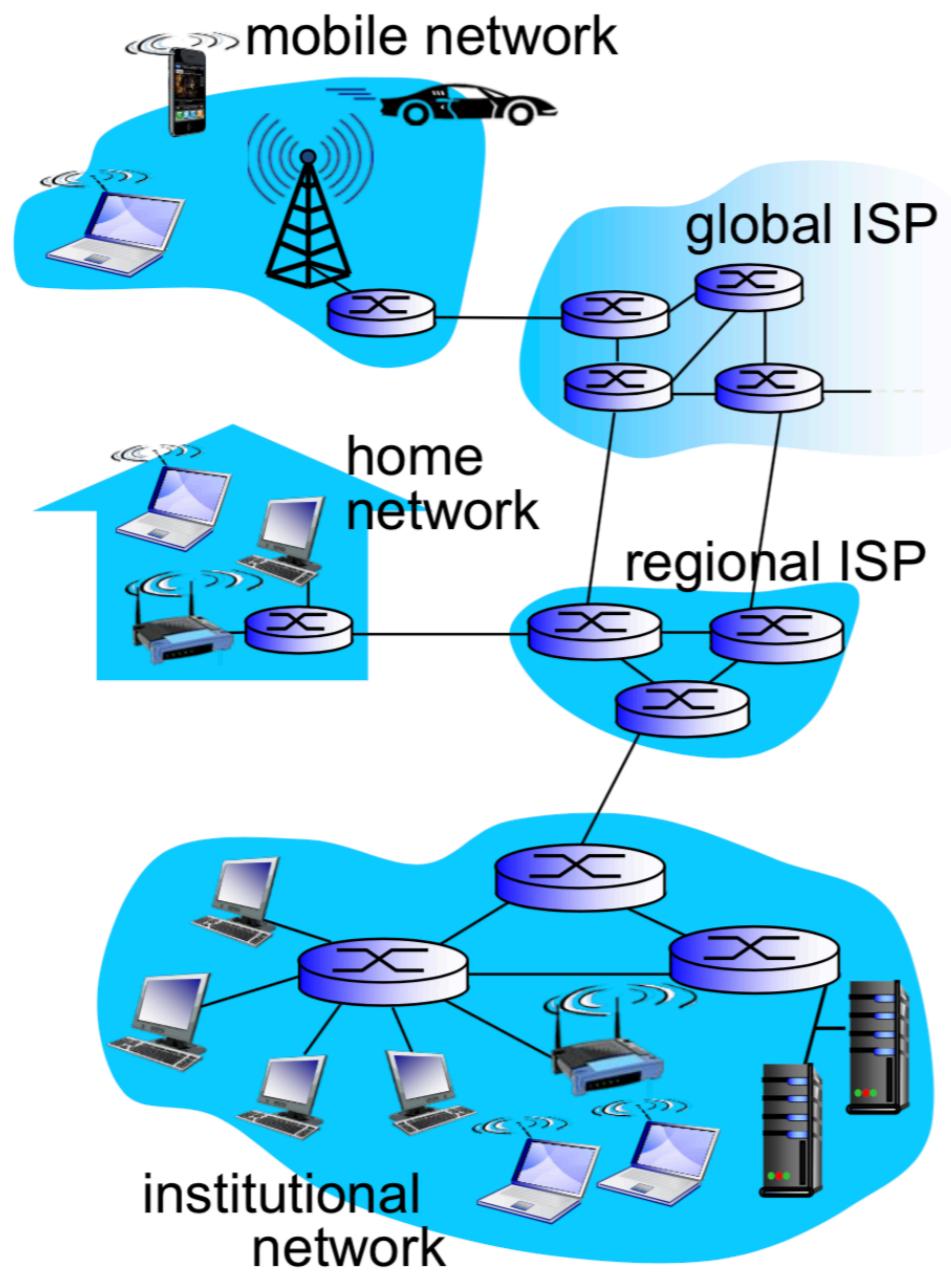
the carrier signal for dial-up modems

MODEM? ROUTER? SWITCHES?



YES, THAT WIRELESS ACCESS POINT...





ISP : Internet Service Provider

What does it do?

An organization that provides services for accessing and using the internet.

Example in Singapore

(regional ISP): M1, Starhub, Singtel, etc

Tier 1 network (global ISP):

AT&T, Sprint, Verizon, Tata Comms, etc

sprint

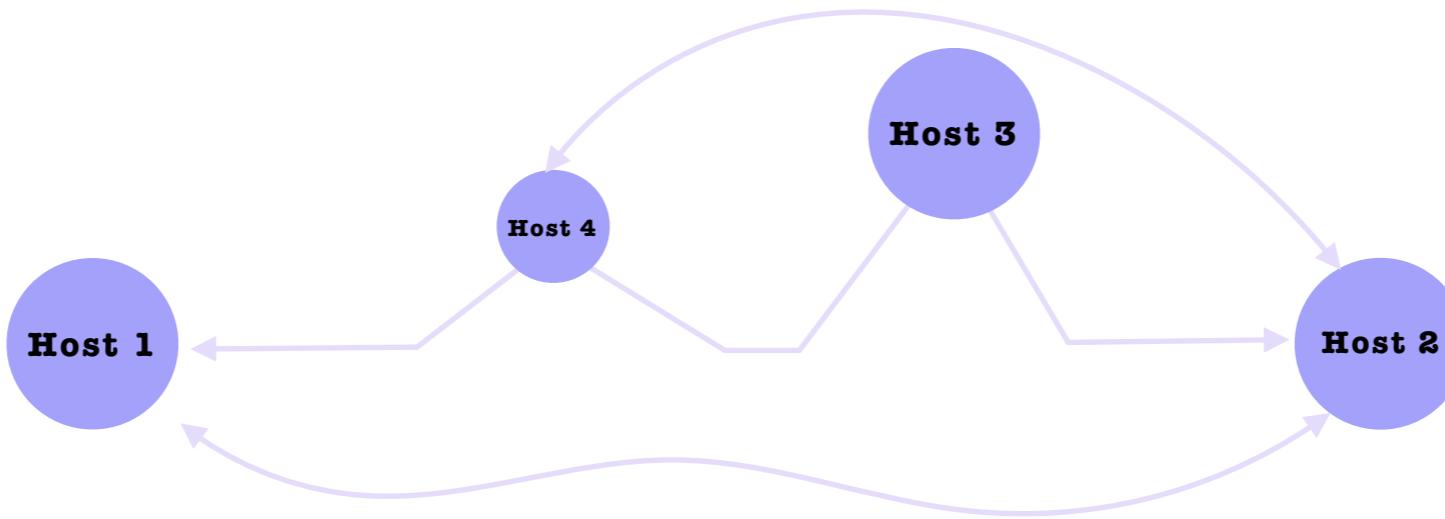
General View of the Internet

You need several things to connect a bunch of networks together to form the internet:

1. Internet standards that specifies **protocols** IETF RFC
HTTP, SMTP, TCP, UDP, IP, ARP, OSPF, etc
addr resolution shortest path
2. Infrastructures that provide services to user applications using **network API** circuit switching : TDM, FDM
in end systems attached to network services
packet switching
3. Infrastructures that allow **sharing** among many 5 Network layer model
4. A mechanism that supports **complex** interacting components
5. It also has to be **scalable**

(+) Tier 1, 2, and 3 ISPs { "layers" the connections,
(+) CDNs not $O(n^2)$ connections

1 . P R O T O C O L



Defines the set of rules: **format & order** on how to **send messages** through the internet

*each layer has
its own protocol*

Who sets it?

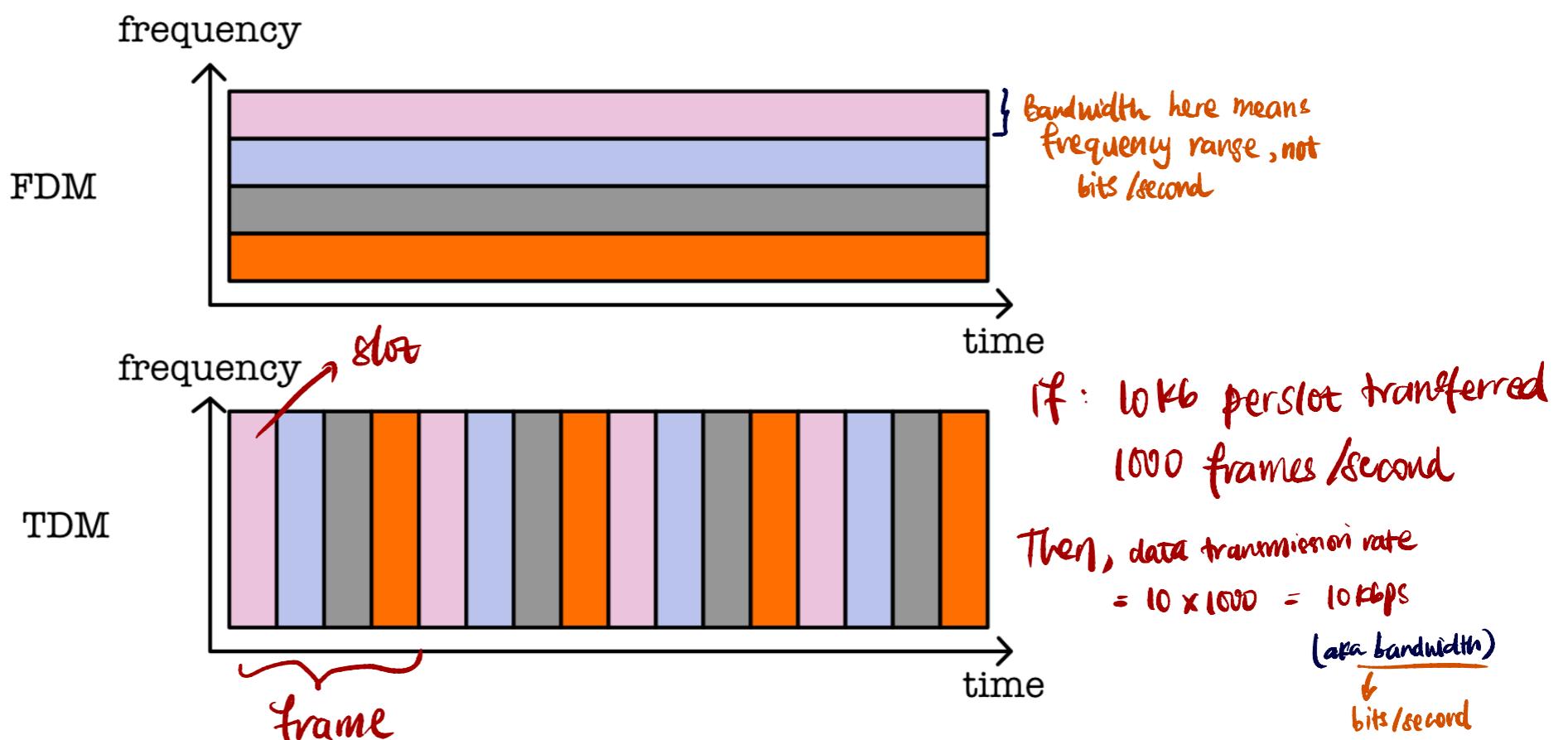
The **IETF** (Internet Engineering Task Force) publishes formal documents called **RFC** (Request for Comment) that contains protocols

2 . SHARING : CIRCUIT SWITCHING

A fixed, **dedicated** fraction of the link for each user. Good for continuous, streamline usage.

Method 1 : Time Domain Multiplexing (**TDM**)

Method 2 : Frequency Domain Multiplexing (**FDM**)

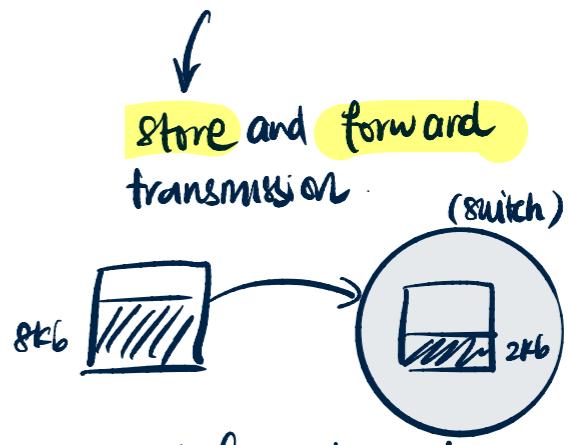


2. SHARING: PACKET SWITCHING

Packets occupy link **on demand**. Better for **bursty data**.

Good for this type of scenario:

- 1 Mbps link, shared among 10 users
- Users will use 100Kb/s if they're active
- but active only 10% of the time



Eg: Cannot forward packet before all 10kb data is received

What is the probability that all of them are active at the same time?

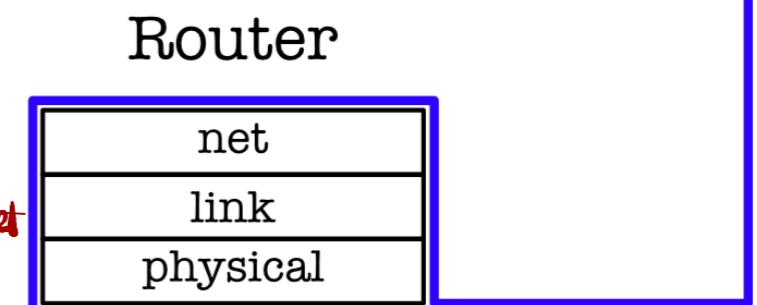
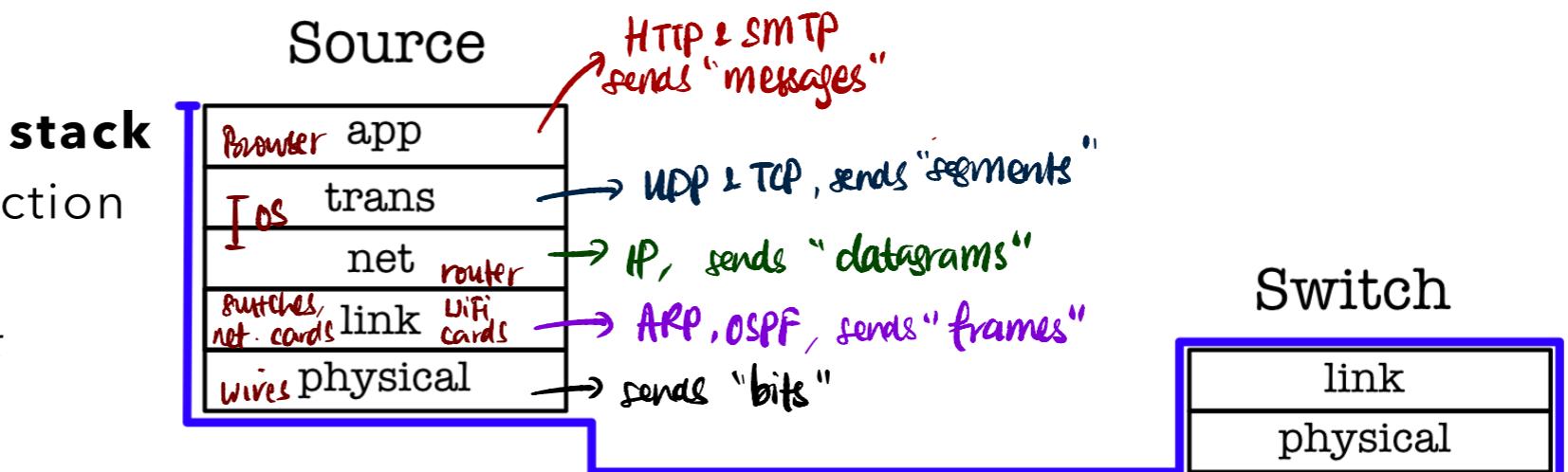
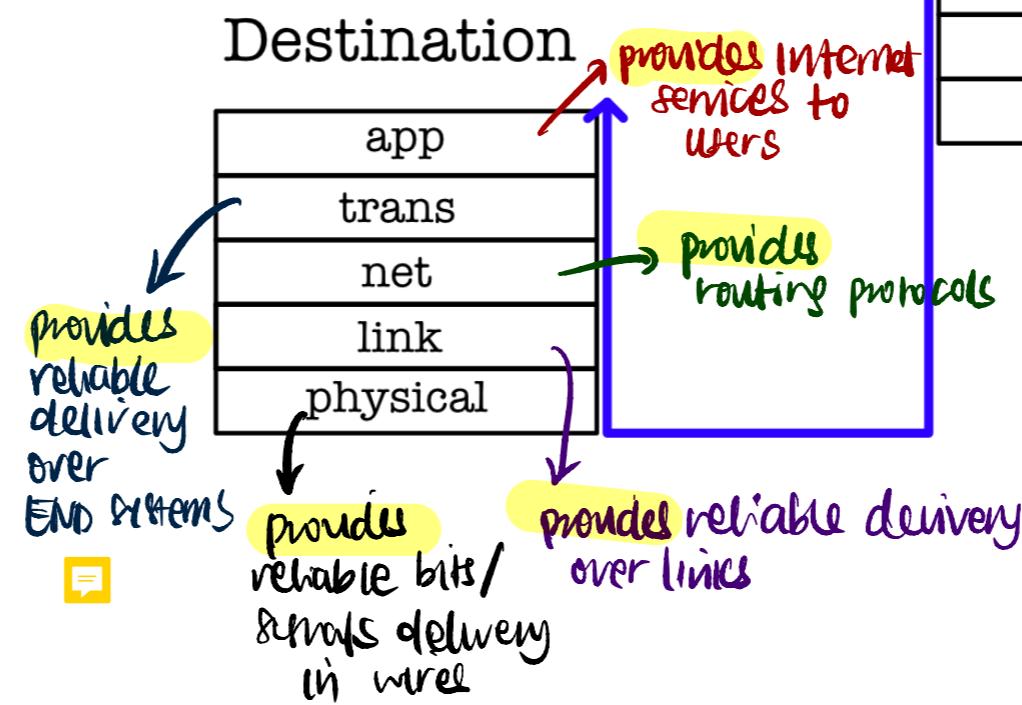
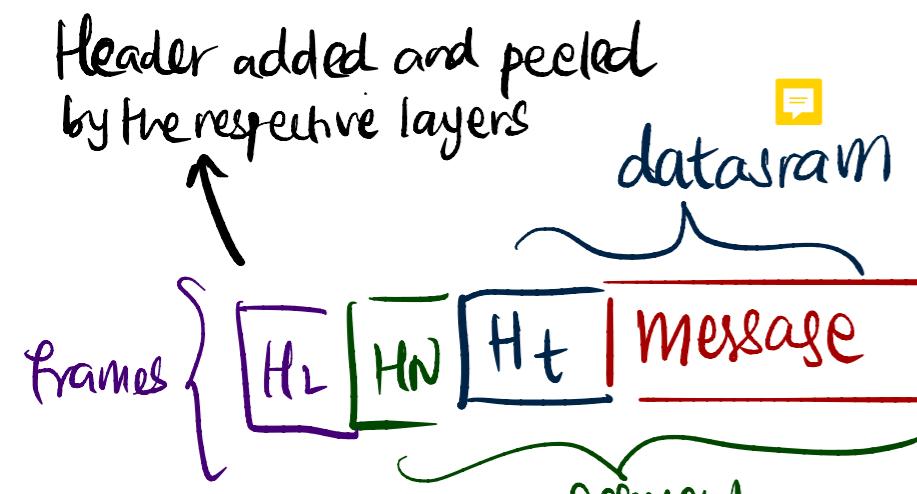
$$P_{active=k} = \binom{N}{k} P_a^k 0.9^{N-k}$$

$$P_{active=10} = \binom{10}{10} 0.1^{10} 0.9^{10-10} = 0.1^{10}$$

3. LAYERING

The **internet protocol stack (layers)** reduces interaction between modules. Modularity alone is not enough.

Avoiding complex interactions between network components.



• WHY IS LAYERING IMPORTANT?

Cons of **complex interactions** between so many different modules (network components):

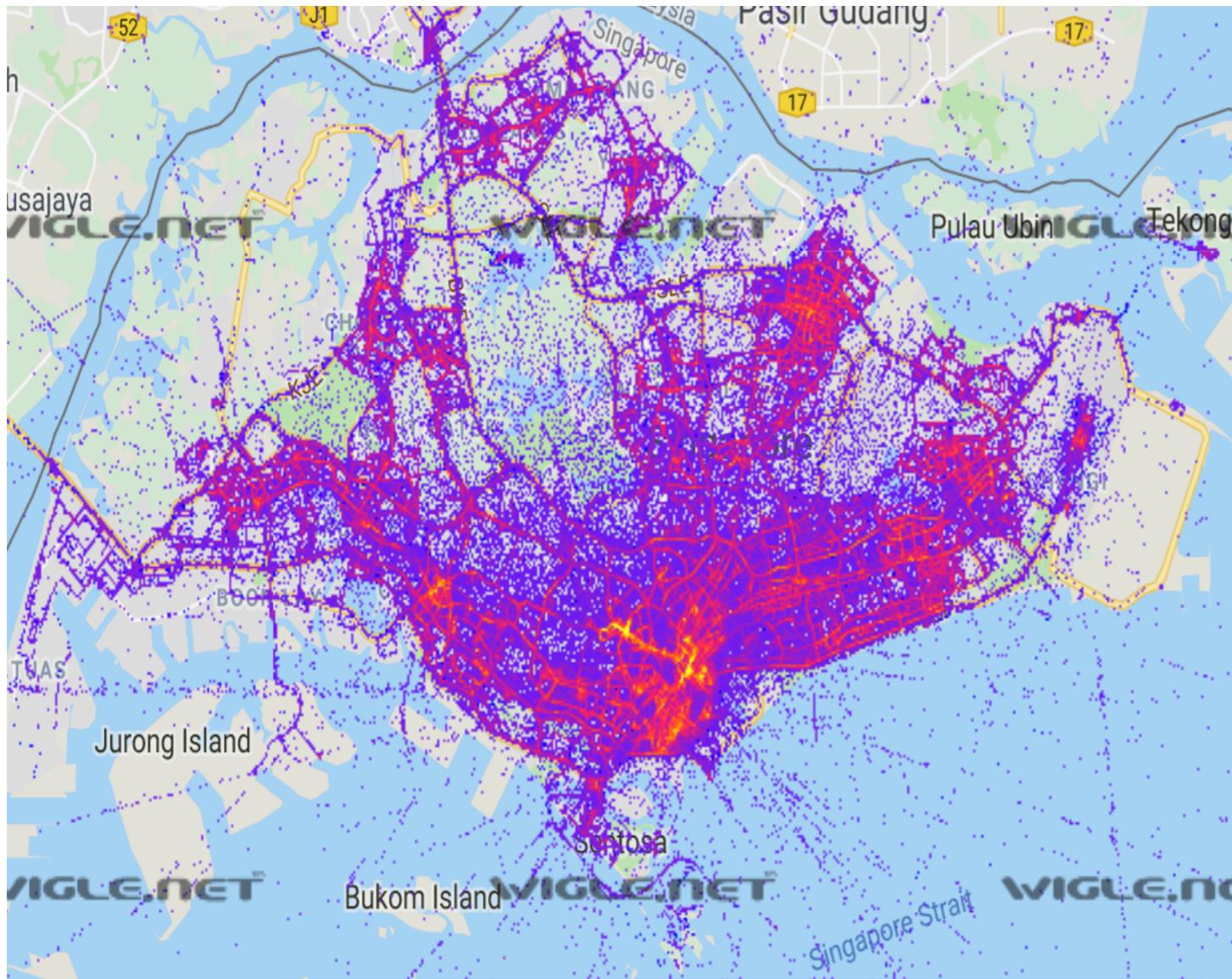
1. You have **N^2** possible interactions, difficult to debug **and**
2. **Might lead to emergent behavior** Eg: priority inversion

↙ (often undesirable)

a condition that arises
as a result of interaction
among parts, but is not
possessed by the individual parts

The number of possible interactions with N layers is N-1.

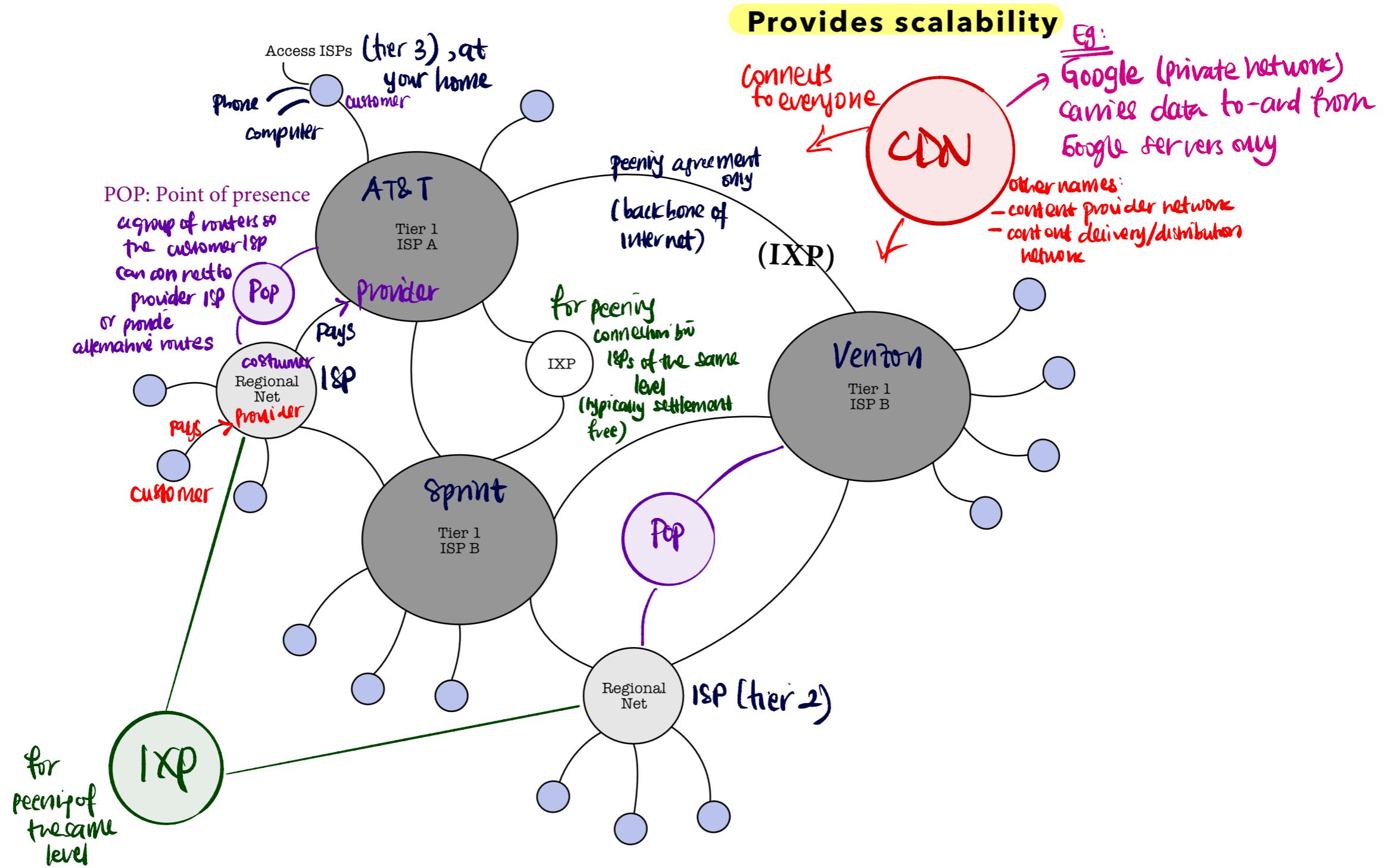
4. INTERNET HIERARCHY



Hierarchical structure supports **scalability**. There's really a lot of people that are using the internet, and this number is **growing, explosively**.

See: <https://wigle.net>

4. INTERNET HIERARCHY



4. INTERNET HIERARCHY

Provides scalability

